THE BLUE REVOLUTION

Aquaculture to Augment Farmers' Income

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ABBREVIATIONS

ARDL	Auto Regressive Distributed Lag
BCD	Basic Customs Duty
CACP	Commission for Agricultural Costs and Prices
CAA	Coastal Aquaculture Authority
CAGR	Compound Annual Growth Rate
CS	Central Sector Schemes
CSS	Centrally Sponsored Schemes
CVD	Countervailing Duty
DBT	Department of Biotechnology
DES	Department of Economics and Statistics
DGFT	Directorate General of Foreign Trade
FAO	Food and Agriculture Organisation
FIDF	Fisheries and Aquaculture Infrastructure Development Fund
FISHCOPFED	National Federation of Fishers Cooperatives Ltd
FMPIS	Fish Market Price Information System
FPR	Fisheries Priority Ratio
FRED	Federal Reserve Economic Data
GCA	Gross Cropped Area
GDP	Gross Domestic Product
GIS	Geographic Information System
GoI	Government of India
GSVA	Gross State Value Added
GVA	Gross Value Added
HCES	Household Consumption Expenditure Survey
HDPE	High Density Poly Ethylene
IFDS	Integrated Fisheries Development Scheme
IOT	Internet of Things
IRR	Internal Rate of Return
LMIC	Low- and Middle-Income Countries

MoAFW	Ministry of Agriculture and Farmers' Welfare
MoSPI	Ministry of Statistics and Programme Implementation
MPEDA	Marine Products Export Development Authority
NFDB	National Fisheries Development Board
PACS	Primary Agricultural Credit Societies
PM-KISAN	Pradhan Mantri Kisan Samman Nidhi
PMMKSSY	Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana
PMMSY	Pradhan Mantri Matsya Sampada Yojana
RAS	Re-circulatory Aquaculture System
RBI	Reserve Bank of India
SAS	Situation Assessment Survey
UVE	Unit Value of Exports
WITS	World Integrated Trade Solution

FOREWORD

Globally the aquaculture sector is booming where India has emerged as a major producer and exporter. India is currently the second-largest producer of aquaculture products, next only to China, and the gross value added (GVA) of fisheries and aquaculture sector has grown at an impressive average annual growth rate (AAGR) of nearly 8.7 percent between Financial Year 2014-15 (FY 15) and FY 24 (MoSPI, 2025). This sector contributes 1.24 percent to India's overall gross domestic product (GDP) and 7.4 percent to the agricultural gross value added (GVA) in FY 24, while providing livelihoods to nearly 30 million people directly and indirectly in India. India's total production of fisheries (both inland and marine) increased almost three-fold with a AAGR of 5.5 percent in the last two decades, i.e., from 6.6 MMTs in 2005-06 to 19.5 MMTs in 2024-25 (MoFAHD, 2025). However, inland fisheries have driven the bulk of this growth, expanding by 384 percent in the same period, compared to 170 percent increase in marine fisheries. This makes it the fastest-growing sub-sectors within agriculture and allied activities, offering significant potential for employment generation and high labour absorption. Integrating aquaculture into farming systems presents a viable pathway to augmenting rural incomes, promoting efficient natural resource use, and enhancing nutritional security. Aquaculture not only supports livelihood diversification but also plays a critical role in increasing the overall profitability of farming systems. However, despite its potential, the sector remains underleveraged in many parts of India due to a range of structural and institutional constraints.

This report, **"Blue Revolution in India: Aquaculture to Augment Farmers' Income"**, emerges from a critical need to understand the opportunities and bottlenecks in harnessing the full potential of the fisheries and aquaculture sector value-chain. It adopts a mixed-method research approach to examine the value-chain of aquaculture and its role in transforming rural livelihoods. The report identifies the drivers of sectoral growth including demand, seed production, export growth and assesses the role of aquaculture to augment farmers' income by secondary data analysis and case studies across regions.

The report also analyses the different institutional models such as Farmer Producer Organizations (FPOs), cooperative models, and public-private partnerships in the value-chain. Furthermore, the report evaluates the macro-policy framework, including budgetary allocations, trade policies, and export incentives that shape the growth of the aquaculture sector. The role of flagship government programs such as the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) is critically examined to assess how public investment can crowd in private participation and expansion of aquaculture.

By bringing together primary field insights, stakeholder consultations, and secondary data analysis, the report offers evidence-informed policy recommendations. At a time when Indian agriculture must shift toward high-value, climate-resilient, and market-linked production systems, aquaculture offers a compelling case. I hope this report will serve as a valuable resource for policymakers, practitioners, researchers, and development partners working in the aquaculture sector.

Shekhar Aiyar
Director and Chief Executive
ICRIER

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EXECUTIVE SUMMARY

India's agriculture and allied sector grew at an average annual growth rate (AAGR) of 4 percent in GVA terms from Financial Year 2014-15 (FY 15) to FY 25. Within the agriculture and allied sectors, fisheries have emerged as the fastest-growing segment, termed a key "sunrise sector," registering a staggering 8.7 percent AAGR in gross value added (GVA) during FY 15 to FY 24 at 2011-12 prices. Within fisheries sector, the share of inland fisheries has risen from 52 percent in 2001-02 to 75 percent in 2024-25 (DoF, 2025). Notably, inland aquaculture particularly shrimp farming has been a major driver of this growth. Given the rapid growth of fisheries and aquaculture within agriculture and allied sectors, this report focuses on the aquaculture sector to examine its potential and constraints in augmenting farmers' income. Aquaculture has increasingly emerged as an important livelihood strategy in the Global South, including India, with the capacity to improve income stability for smallholder farmers facing declining returns from traditional crop agriculture (Chapter 1).

Placing India's experience in the global context, the report shows that China remains the dominant producer of fisheries, accounting for 39.7 per cent of global production in the triennium ending (TE) 2023, followed by Indonesia (10.1 per cent) and India (7.1 per cent). India's fisheries production reached 19.5 MMT in FY 2025 comparable to China's production levels in the early 1990s, highlighting both progress and untapped potential (FAO, 2025, latest data available). Over the past two decades, inland fisheries production in India has increased more than four-fold, from 3.21 MMT in 2002–03 to 14.7 MMT in 2024–25. India ranks third in total fisheries production but second in inland aquaculture, after China. Despite ranking second globally in inland aquaculture, India accounts for only about 15 per cent of global production, compared to China's dominant 56 per cent share in value, indicating a significant gap in productivity and scale. Frozen shrimp has emerged as the single most important driver of India's fisheries exports, while aquaculture growth remains spatially concentrated—particularly in Andhra Pradesh, which contributes 34 per cent of inland fisheries production and 44 per cent of national fisheries GVA in 2023–24 (Chapter 2). The uneven regional spread of aquaculture raises the policy challenge of replicating this cluster model across other states.

The Autoregressive Distributed Lag Model (ARDL) estimates the key drivers of the GVA in the fisheries sector, with the dependent variable being the logged difference of GVA at constant 2011-12 prices for 1990-2022[1]. The significant variables are per capita income, fish seed production in the country, export boost and government support through Blue Revolution and PMMSY schemes. The report traces that the evolution of India's aquaculture sector is defined by four distinct phases in India. The first phase (1979-1990) saw the expansion of government pilot projects. The second phase (1990-2010) focused on artificial breeding techniques like Ovaprim, which significantly improved spawning efficiency and fish seed quality. Fish seed production increased from 490 million in 1973-74 to 21 billion in 2005-06, with HDPE (high-density polyethylene) water tanks reducing transportation costs and mortality rates for carp fingerlings. The third phase (2011-2017) marked a major structural shift with the introduction of *L. Vannamei* shrimp farming, or

[1] Period is selected based on availability of data for all variables.

the "shrimp boom." This shift was driven by the import of specific pathogen-free (SPF) *L. Vannamei* brood stock from Taiwan in 2001, and commercial farming took off after Coastal Aquaculture Authority (CAA) approval in 2009. This policy change allowed Indian shrimp farmers to shift from black tiger shrimp (*Penaeus monodon*) to the more disease-resistant *L. Vannamei*, resulting in exponential growth in shrimp farming. The number of inland shrimp hatcheries units surged from 24 in 2009 to 312 by 2017, and production capacity increased dramatically from 615 million post-larvae (PL) to 71,055 million PL. The fourth phase, spanning 2017-2025, is characterized by large-scale government interventions, which spurred the aquaculture growth including the Blue Revolution Scheme (2015-16 to 2019-20), which allocated Rs. 3,000 crores for aquaculture development, infrastructure modernization, and technological innovation. The PMMSY (2020-21 to 2024-25), extended till 2025-26, has earmarked Rs. 20,050 crores to enhance fish production, cold storage, processing facilities, and market linkages (Chapter 3).

The report further conducts the value-chain analysis of aquaculture sector in CISS-F framework (competitiveness, inclusivity, sustainability, scalability and finance) to identify the gaps in the sector. The domestic value chain of inland fisheries in India, particularly for wet markets, remains highly fragmented with multiple layers of intermediaries, leading to inefficiencies and lower price realization for producers. The share of frozen fillet exports (less than 1 percent of production) from India has declined, primarily due to limited processing infrastructure and insufficient value addition for species like *carps, tilapia, and pangasius,* despite their high demand in global markets. In contrast, the export-oriented shrimp value chain is relatively more organized, with higher levels of traceability and compliance with international standards. In terms of competitiveness, the report examines the unit value of exported shrimp (UVE) from India since the commercialization of inland fisheries from 1995-96 to 2024-25 and compares it with global shrimp prices showing that Indian shrimp is globally competitive. Ecuador has emerged as India's foremost competitor in the global shrimp export market, commanding a dominant 27 percent share in value and ranking first worldwide, while India follows with a 19 percent share in 2024 (ITC Trade Map, 2025). Between 2013 and 2024, India's share in global shrimp exports increased from 14 percent to 19 percent in value. However, Ecuador's growth has been significant, rising from just 7 percent to 27 percent during the same period. This intensifying competition is likely to become even more challenging with the recent increase in import duties by the United States, which is the largest export destination for Indian shrimp. On August 27, 2025, the United States of America, India's single largest shrimp export market (48 percent share in value) imposed an additional 25 percent penalty tariff on Indian shrimp, raising the total tariff burden to 50 percent. This followed the imposition of a 25 percent reciprocal tariff on July 30, 2025, over and above existing anti-dumping and countervailing duties of about 8.26 percent. As a result, the effective tariff on Indian shrimp exports to the US has escalated sharply from 33.26 percent to 58.26 percent. Hence Indian seafood exporters need to diversify their export markets (Chapter 4).

In terms of inclusivity of the value-chain, the study also highlights that small, medium, and large-scale farmer involved in freshwater fish farming (*carp, catla, rohu*) or shrimp aquaculture in inland farming face challenges related to competition for resources and informal lease market. Through analysis of literature in this area, the study shows that there is a lack of access to resource and finance for inland fisheries and aquaculture. The role of cooperatives and Fish Farmers Producer Organisations (FFPOs) can play a crucial role in the context, through group leasing to improve income situation of farmers. In terms of scalability, the study reveals that aquaculture growth is regionally concentrated for both geographical and economic factors, which has potential for expansion. The study analyses the regional concentration of inland fisheries and hatcheries across coastal states, particularly in Andhra Pradesh. However, the report also highlights the potential to expand based on the inland water resource availability and salinity affected regions. In India, out of total 6.74 million hectares (Mha.) salinity-affected subsoils (SAS), 1.2 Mha. are in north-western India. According to Central Soil Salinity Research Institute (CSSRI), Karnal study, SAS in India is expected to increase from 6.74 Mha. to 16.25 Mha by 2030. These salinity-affected lands, often unsuitable for traditional crop agriculture, hold immense potential to be transformed from wastelands to wealth lands. There is also a need to increase technology adoption for resource use efficiency. In this regard, Recirculating Aquaculture Systems (RAS) and biofloc technology can enhance productivity, particularly in states with water scarcity and for sustainable bio-secure aquaculture. On finance front, the report analyzes the central and state budgets across various sections of the aquaculture value chain over the last decade. It examines the share of expenditure allocated to fisheries in relation to the total agricultural expenditure, referred to as the Fisheries Priority Ratio (FPR). This analysis examines four states—Andhra Pradesh, West Bengal, Odisha, and Haryana—representing three leading aquaculture producers and an emerging landlocked aquaculture state to assess the extent and effectiveness of their expenditure priorities in the fisheries sector. West Bengal has a downward trendline, i.e., a decreasing priority of expenditure on fisheries compared to total agriculture expenditure from 2011-12 to 2024-25, which explains the low growth rate of gross state value added (GSVA) from fisheries sector at compound annual growth rate (CAGR) of just 3.1 percent at 2011-12 prices. While Andhra Pradesh, Odisha and Haryana show high growth rates of GSVA from fisheries at 14.6, 9.1 and 7.7 percent respectively accompanied by an increasing trendline of FPRs. The report shows a positive correlation between higher priority for expenditure on fisheries over time and the GSVA from fisheries over the same period. On private expenditure, integrated contract farming models functions in aquaculture value-chain from feed to farm management to export. Major challenges are increase in feed expenses, challenges in land leasing, lack of expansion of cold storage infrastructure and lack of regional integrated value-chains. The success of the Andhra Pradesh aquaculture model can be attributed to the vertical integration of its value chain, significant value addition across production and processing stages, and the development of robust post-harvest infrastructure that ensures quality, traceability, and market competitiveness.

The report further traces the role of aquaculture to augment farmers' income. At the agricultural household level, empirical analysis using unit-level data from the Situation Assessment Survey (NSS-SAS) shows that farmers engaged in inland fisheries have 47 percent higher income compared to non-inland fisheries farmers. Based on review of secondary case studies and field visits, we estimate the profitability of aquaculture versus paddy-wheat and other crop farming from the case studies of PMMSY across different aquaculture species and states. It provides an analysis of the profitability of aquaculture compared to crop-based systems, drawing on empirical data from key producing states. Annual net returns from aquaculture crops are significantly higher than crop culture across the states. However, there is heterogeneity in income gains across regions and aquaculture species, ranging between 2.3 to 10 times (Chapter 5). Shrimp aquaculture particularly gives even higher profitability vis-à-vis crop culture. But it requires higher capital requirements and significant biological, financial, and market risks. The chapter addresses the financial challenges facing aquaculture farmers, particularly in terms of capital expenditure for pond preparation, aerator purchase which constitute a significant portion of fixed costs. It suggests that promoting FFPOs and cooperatives model could help mitigate these financial challenges, providing small farmers with better access to financial resources and investment in productivity-enhancing technologies.

Finally, the report outlines policy recommendations for developing the aquaculture sector, including improving financial support mechanisms, expanding market access, and enhancing infrastructure (Chapter 6). As PMMSY nears its planned end in FY 26, it's time to assess what has worked and what hasn't. While, the policy architecture has enabled early adopters in many states, it must now evolve to create a national ecosystem for sustainable growth of inland aquaculture. To fully unlock the potential of this sunrise sector, India must adopt a five-pronged strategy. First, it must incentivize the scale up of modern modern aquaculture technologies such as cage culture, Biofloc systems, and Recirculating Aquaculture Systems (RAS) to improve productivity and sustainability. Second, there is a need to promote private sector and FFPOs-led investments in processing infrastructure and value addition, especially for inland fisheries. Third, facilitating easier access to working capital and expanding insurance coverage will be critical to mitigate risks and enhance resilience. Fourth, strengthening backward linkages with quality seed and feed supply chains is essential to ensure consistency and efficiency in production. Finally, investing in robust training and extension systems tailored to aquaculture will equip farmers with the knowledge and skills needed. If done right, India's “Blue Revolution” could become an engine of inclusive growth—generating income, employment, and export gains.

CHAPTER 1
INTRODUCTION

Livelihood diversification is a crucial strategy for rural households to enhance economic resilience and mitigate income shocks (Ellis, 2008). Rural communities depend on a combination of farming, wage labour, and small-scale enterprises. The role of fisheries, particularly inland aquaculture, in supporting rural livelihoods has gained prominence. Studies have shown that integrating small indigenous fish species into traditional carp farming systems can significantly enhance farm incomes while requiring minimal additional investment (Oboh, 2022; Hossain, Khan, Saha, & Dey, 2022). Research has demonstrated that species diversification in fish farming reduces production risks and enhances market stability by catering to niche consumer preferences. Bunting et al. (2014) highlighted the economic benefits of integrating small-scale fish culture into irrigation schemes, where the inclusion of indigenous fish species in farm ponds improved net farm income and raised the internal rate of return (IRR) to 77.3 percent from 53.7 percent from traditional cropping and livestock activities. Challenges such as limited credit availability, lack of scientific knowledge, and inadequate brood stock management continue to constrain the growth of small-scale fisheries. Addressing these barriers through improved breeding programs, institutional credit support, and extension services can strengthen the role of fisheries in rural economic development (Duarah & Mall, 2020; Bunting et al., 2014).

The Food and Agriculture Organization of the United Nations (FAO) defines aquaculture or aquatic agriculture as farming and rearing of aquatic animals like fish, molluscs, crustaceans and aquatic plants including seaweed through interventions at any stages in farming process. In 2023, global fish production reached at 229.2 million metric tonnes (MMTs), out of which 60 percent is aquaculture (FAO 2025) and 40 percent is capture fisheries. Aquaculture and capture fisheries each can be of two types: marine and inland. Largest share is of marine capture fisheries (35 percent), followed by marine aquaculture (33 percent), inland aquaculture (27 percent) and inland capture (5 percent). Globally, the share of inland aquaculture, which is our focus in this report, has increased from 3 percent of total fisheries production in 1980 to 27 percent in 2023, the trend is distinct in India where the share increased from 16 percent to 57 percent during the same period (see Annex 1). The global concern regarding depletion of marine resources has shifted the focus on aquaculture, both inland and marine. This has opened up significant opportunities for the poor farming communities in the developing countries as well. This report focusses on the potential of aquaculture to augment farmers' incomes in India.

Aquaculture has emerged as a viable supplementary livelihood option, in areas where land availability is limited or climatic conditions are unfavourable for traditional crops (Béné, et al., 2016). For smallholding farmers aquaculture provides additional income while ensuring food security, making it an effective tool for poverty alleviation (Ahmed & Lorica, 2002). Studies highlight that integrating fish farming with other agricultural activities optimizes resource use, increases productivity, and diversifies income sources (Brummett, Lozard, & Moehl, 2008). Aquaculture is accessible to marginalized groups, including landless farmers and women, who can participate in fish rearing activities, contributing to inclusive economic growth (Kawarazuka & Béné, 2010).

The expansion of freshwater and coastal aquaculture in South and Southeast Asia, sub-Saharan Africa, and Latin America has provided financial security to smallholder farmers (FAO 2020). About 62 million people worldwide are engaged in the primary sector of commercial fisheries and aquaculture (FAO 2022). Aquaculture adoption augments income, increases consumption expenditure, and nutrition outcomes

(Parrao, et al., 2021). In Bangladesh, small-scale fish farming has significantly contributed to rural household income, reducing poverty levels and improving nutritional outcomes (Belton, et al., 2011). In Vietnam and Thailand, aquaculture is a major income-generating sector as well, supported by strong government policies and international market linkages. In sub-Saharan Africa, the adoption of tilapia and catfish farming has been promoted as a means of increasing household income and improving food security (Brummett & Williams, 2000). Latin American countries, such as Ecuador and Brazil, have experienced rapid expansion in shrimp farming, contributing significantly to national exports and rural employment (Rodrigues, Abdallah, & Gasalla , 2019). Challenges such as inadequate access to credit, weak extension services, and environmental concerns remain prevalent in many developing countries (FAO 2022). India has more than 86 percent of marginal and small farmers so aquaculture can play a key role for their economic resilience.

Aquaculture has contributed to economic growth but concerns over its environmental impact have been widely discussed in academic literature. Issues such as water pollution, habitat destruction, and excessive antibiotic use pose significant sustainability challenges (Naylor, et al., 2000). Intensive shrimp farming, particularly in South and Southeast Asia, has led to mangrove deforestation and coastal ecosystem degradation (Primavera, 2006).

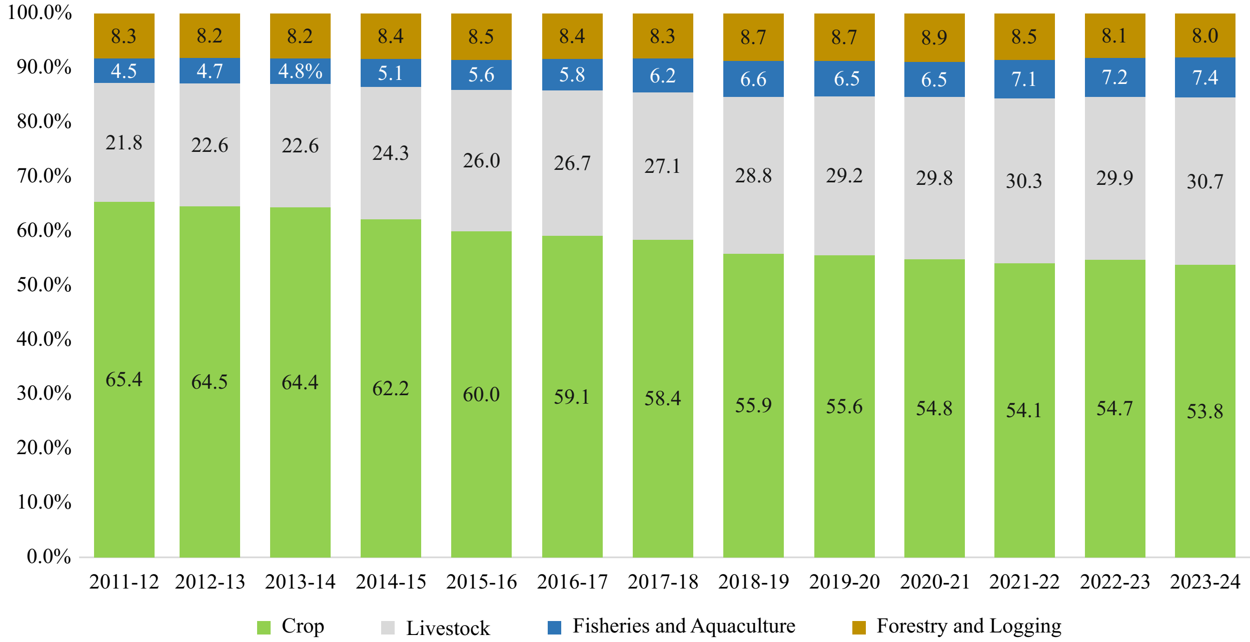
In this context, the report analyses the factors driving the growth of the fisheries sector in India, focusing on technological advancements, evaluation of government policies, and institutional reforms in enhancing productivity, especially in inland aquaculture. It explores how these advancements have contributed to increased productivity and market integration for small-scale fish farmers by improving value chain efficiencies in production, processing, and marketing. This report also assesses how participation in inland fisheries has diversified income sources for small and marginal farmers, and how this compares to traditional agricultural practices in terms of profitability and environmental sustainability. Through these insights, the report identifies key strategies to enhance the sector's growth and contribution to national economic development and food security.

Growth of Fisheries Sector in India

Fisheries sector (comprising all types) is among the fastest-growing industries globally, playing a crucial role in economic development (Tacon, 2020). The sector contributes significantly to food and nutritional security, national income, and livelihoods, supporting about 30 million fishers and fish farmers at the primary level and twice as much workforce in the value chain. Beyond providing a vital source of protein, fish is rich in omega-3 fatty acids and bioavailable micronutrients essential for human health. India, is the third-largest producer of fish products globally at 19.5 million metric tons (MMTs) in the FY 25 (GoI, Handbook on Fisheries Statistics , 2023). India's agriculture and allied sector registered an average annual growth rate (AAGR) of gross value added (GVA) of 4 percent from FY 15 to FY 25, with the fisheries sector expanding at a much faster pace with AAGR of 8.7 percent from FY 15 to FY 24, whereas crop sector rose by AAGR of only 2.3 percent over the same period. Given the growing potential and importance in the country's economic landscape, the sector is identified as the "sunrise sector" in India (GoI, 2022)

On the global stage, India is ranked seventh in overall fisheries exports, accounting for 3.9 percent of global exports in 2023 by quantity (FAO 2025). However, India's share in the global shrimp export market is far more significant, at 19.3 percent in total export value in 2024, making it the second-largest shrimp exporter after Ecuador. In FY 25, India exported 1.7 MMTs of fisheries products worth USD 7.45 billion (MPEDA, Marine Products Exports Development Authority, 2025), with frozen shrimp being the leading export commodity, contributing 43.7 percent of the total quantity and 69.5 percent of the total export value. Fisheries sector, particularly inland aquaculture has immense potential to augment farmers' income through diversification of livelihood (Belton 2014). The share of GVA of fisheries in GVA of agriculture and allied sectors has increased from 4.5 percent in 2011-12 to 7.4 percent in 2023-24 while the share of crop husbandry has continuously fallen over these years (**Figure 1-1**).

Figure 1-1: GVA Shares by Economic Activity under Agriculture (2011-12 to 2023-24) at Constant Prices of 2011-12



Source: National Income Accounts 2025, Ministry of Statistics and Program Implementation (MoSPI), Government of India (GoI)

Among the top 10 states in terms of GSVA of fisheries in India, Andhra Pradesh registers the highest compound annual growth rate (CAGR) of GSVA at 14.3 percent from 2011-12 to 2023-24 followed by Odisha (9.6 percent), Chhattisgarh (9.1 percent) and Bihar (7.4 percent) against a national CAGR of 7.6 percent. West Bengal, Tamil Nadu and Kerala register CAGR around 3 percent.

Key Objective and Methodology:

The primary objective is to assess the role of aquaculture and inland fisheries in augmenting farmers' income and diversifying rural livelihoods. Given the structural constraints of traditional agriculture, the study explores how fisheries can serve as a sustainable and high-value alternative for small and marginal farmers. In order to understand and empirically map this objective delineated above, we look at the fish economy from various angles to understand its dynamics better. Some of these exploratory angles are listed below:

1. **Assessing the Contribution of Fisheries to the Agricultural Economy:** Examine the role of aquaculture and inland fisheries in livelihood diversification and analyse their impact on income generation and employment in rural areas.

2. **Understanding Aquaculture Trends and Sectoral Challenges:** Evaluate global and Indian aquaculture production patterns and identify key challenges such as infrastructure gaps, disease management, and access to quality inputs.

3. **Analysing the Growth Drivers of the Blue Revolution in India:** Examine national and state-level trends in fisheries development and assess the role of government policies, technological advancements, and institutional interventions in driving sectoral growth.

4. **Aquaculture Value-Chain Analysis:** Using the CISS-F framework[2] focusing on Competitiveness, Inclusivity, Scalability, Sustainability, and Finance, the report evaluates the aquaculture value-chain and its potential to augment farmers' income.

5. **Evaluating the Economic Viability of Aquaculture-Based Livelihoods:** Analysing the role of aquaculture to augment farmers' income from secondary survey data and case studies. This section also compares the economic viability of aquaculture production in comparison to paddy-wheat cultivation across selected states.

6. **Providing Policy Recommendations:** Evaluates the policies in this sector and suggests measures to improve infrastructure, financial access, and market linkages, to enhance the role of aquaculture in augmenting farmers' income.

Database

The analysis in this report is based on a comprehensive review of secondary data sourced from various national and international databases and publications. For global production and trade the report uses data from FishStatJ, a portal of the Food and Agriculture Organization (FAO), ITC Trade Map portal and World Integrated Trade Solution (WITS) of the World Bank. Domestic data on fisheries production, state-specific variables, and sectoral performance has been gathered from a variety of sources, including the Fisheries Statistics published by the Government of India (latest year 2023), National Income Accounts from the Ministry of Statistics and Programme Implementation (MoSPI), and respective state fisheries department websites.

Key reports from the Coastal Aquaculture Authority (CAA), annual publications on fisheries statistics, Fish Market Price Information System (FMPIS), and various rounds of the National Sample Surveys (MoSPI), secondary market reports, and literature survey provide insights into the structure and dynamics of the Indian fisheries sector. The analysis also integrates data from the Union and State budget documents to understand fiscal allocations for the sector. For domestic export related statistics, data has been obtained from the Directorate General of Foreign Trade (DGFT) and the Marine Products Export Development Authority (MPEDA). The report also leverages financial data from the Reserve Bank of India (RBI) and the National Fisheries Development Board (NFDB) website to understand the financial health of the sector. For agricultural cost data, the study refers to the Directorate of Economics and Statistics (DES) of the Ministry of Agriculture and Farmers' Welfare (MoAFW) and Commission for Agricultural Costs and Prices (CACP) reports. Additionally, unit-level data from the Situation Assessment Survey (SAS) 2018-19 has been utilized to examine the role of inland fisheries in augmenting income for agricultural households. Secondary case studies have been incorporated to explore the economic and social impact of aquaculture, particularly in relation to rural livelihoods.

Organisation of the report

The part of the report is organized into six chapters. Chapter 1 outlined the objectives of the study and discusses the role of fisheries in livelihood diversification and its contribution to the agricultural economy. Chapter 2 examines aquaculture trends, challenges, and global and Indian production, providing an overview of production patterns, sectoral challenges, and key emerging trends. Chapter 3 delves into the Blue Revolution in India, analysing the drivers of growth at both the all-India and state levels. Chapter 4 presents an aquaculture value-chain analysis within the CISS-F framework, assessing efficiency, bottlenecks, and opportunities for value addition. Chapter 5 evaluates the role of aquaculture in augmenting farmers' income, examining economic viability, market access, and income-enhancing strategies. Chapter 6 provides the policy suggestions to strengthen the sector and maximize its potential in supporting rural livelihoods and agricultural growth.

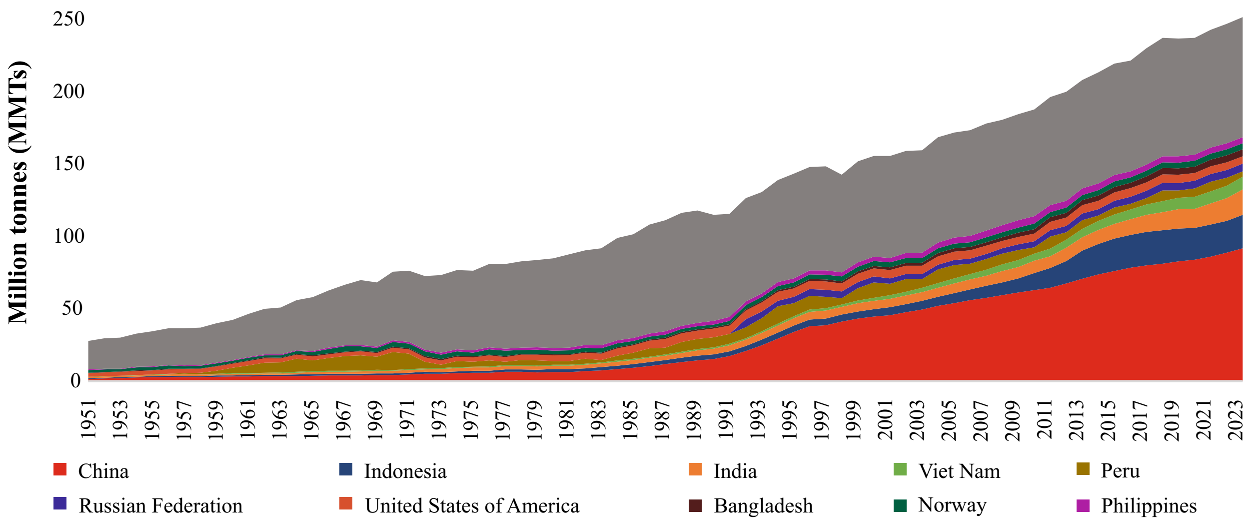
[2] The CISS-F framework—Competitiveness, Inclusivity, Sustainability, Scalability, and Finance—serves as a structured approach for analysing the value chain of inland fisheries

CHAPTER 2
GLOBAL AND DOMESTIC LANDSCAPE

2.1 Global Fisheries Production

Global production of fisheries has grown at a CAGR of 3.4 percent over the last seven decades reaching 227.9 million tonnes (MMTs)[3] in 2023. China is the leading producer with 39.7 percent share of global production in triennium ending 2023 (TE 2023) followed by Indonesia (10.1 percent), India (7.1 percent), Vietnam (3.8 percent), and Peru (2.4 percent) (FAO, 2025). Top 10 countries produced 73.7 percent of all production in TE 2023. There have been significant changes in country shares in global production from 1950 to 2023. Most significant perhaps is the increase in China's share from meagre 4.8 percent in 1950 to 39.7 percent in 2023, an increase of 34.9 percentage points (**Figure 2-1**). China's aquaculture transformation started in the 1980s, when the government prioritized fish farming as a means of rural income generation and food security (Wang, Cheng, Li, Xie, & De Silva, 2014). The inflection point for fisheries development in China can be easily attributed to 1979 when the government introduced two sets of regulations for protecting aquatic resources and consequently giving a push for the need to develop aquaculture in the country. In contrast, India's growth in aquaculture effectively accelerated from 2011 onwards, largely driven by shrimp farming expansion with the import of broodstock from Taiwan in 2001 for experimentation purposes and approved for commercial use in 2009. In FY 25 India produced 19.5 MMTs of fisheries where China was in 1991 (FAO, 2024). Indonesia, India, Vietnam, Peru and Russia also witnessed increase in share while the share declined for countries like USA, Norway, Japan, Canada, UK and France.

Figure 2-1: Country-wise Production of Fisheries by Quantity (1950-2023)



Source: FishStatJ, Food and Agriculture Organization of the United Nations (FAO)

Note: Data on production includes aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Excluding these groups total quantity adds up to 185.4 MMTs (FAO, 2025); Data expressed in live weight equivalent

[3] Data cover fish, crustaceans, molluscs, aquatic mammals, other aquatic animals, products (corals, pearls and sponges) and aquatic plants (seaweed and other algae) taken for commercial, industrial, recreational and subsistence purposes from inland waters, brackish and marine areas (FishStatJ FAO 2025, General Notes)

India, with a 7.7 percent share in global production in 2023, also exhibits significant growth, positioning itself as a major player in global aquaculture. In both the countries, China and India, growth in aquaculture is primarily driven by intensification of inland and coastal aquaculture, increased investment in shrimp and freshwater fish farming, policy support, and improvements in hatchery and feed technologies. Despite this positive trajectory, India's growth remains far below China's, suggesting potential for expansion. Overall, the data highlights a major structural shift in global aquaculture production, with China and India emerging as dominant forces while traditional leaders like Japan, the US, and the UK experience decline. This trend underscores the importance of technological innovation, policy support, and investment in sustainable aquaculture practices for retaining competitive edge in the global seafood market.

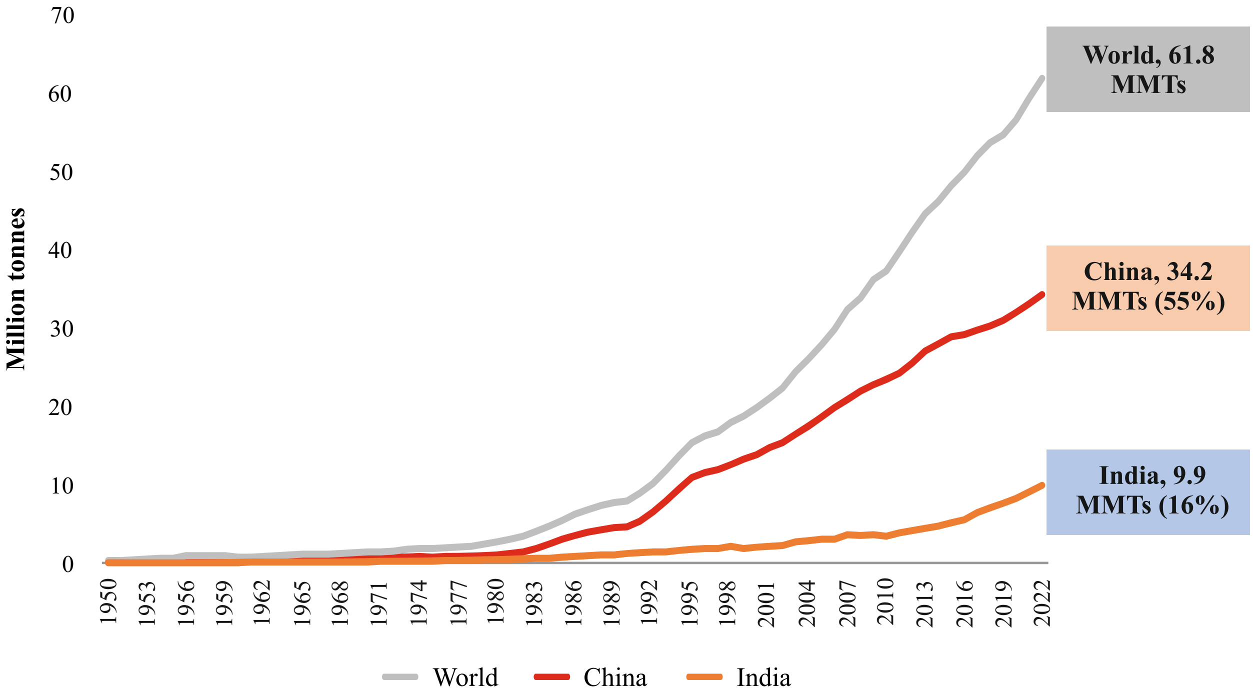
2.2 Global Inland Aquaculture Production

The global inland aquaculture production has shown a significant upward trajectory since the 1980s, reaching 61.8 million metric tonnes (MMTs) in 2023 (FAO, 2025). China is the clear global leader in inland aquaculture, accounting for 55 percent of the world's total inland aquaculture production. In 2023, China produced 34.2 MMTs, a significant proportion of the global inland aquaculture output of 61.8 MMTs. This dominance reflects China's established infrastructure, technological advancements, and large-scale aquaculture practices that have been developed over decades.

India, on the other hand, represents just 16 percent of global inland aquaculture production at 9.9 MMTs in 2023. Despite its large population and growing focus on aquaculture, India's production is still far behind China's (**Figure 2-2**). One of the factors behind China's growth is expansion of domestic seed industry. Development of a robust seed industry is a core requirement for aquaculture development. China's Ministry of Agriculture in 1991 established a committee for improved varieties of aquatic products. According to data from the China Fisheries Statistical Yearbook, the fry[4] number of freshwater fish increased from 59.5 billion in 1981 to 1.25 trillion in 2019 while the fry number of marine fish increased from 167 million in 1996 to 11.44 billion in 2019. China also invested heavily in the research and development infrastructure for developing the aquaculture industry. China's investment expenditure in scientific research increased threefold, from USD 146 million in 2009 to USD 420 million in 2019 (Hu et al., 2021). Aquaculture development in China has been classified into four stages (Wang, Cheng, Li, Xie, & De Silva, 2014). First, **Recovery period** (from 1949-1957) in which government investments in infrastructure and liberalization of land markets contributed to growth. Second, **Slowdown period** (1958-1965) in which the 'egalitarianism' or equality push dissuaded the producers. Third, **Stagnant period** (1966-1976) in which the sector stagnated because of the 'Cultural Revolution'. Lastly, **Rapid development period** (1978 until 2000s) in which high priority was given to the fisheries sector by the government benefitting both inland and marine aquaculture. The government's push was decentralized as in encouraging the local governments for developing aquaculture keeping in mind the local conditions and sustainability. The "Agriculture Law of the People's Republic of China" came in 1993 and reformed the aquaculture extension services in the country. China has established town-level aquaculture promotion agencies based on local aquaculture conditions which resulted in an increase in the number of technology promotion agencies from 2841 in 2002 to 12547 in 2003 (Fisheries Administrative Bureau of the Ministry of Agriculture and Rural Affairs (FAPRC), 2004). China transformed the landscape of extension services in the country. In 1981 there were only 431 aquaculture extension stations with 4246 technical extension staff. By 2016, the stations increased to 13463 with 39779 technical staff. By 2015, 20 percent of the total aquaculture area in the country was under the guidance of extension stations (Wang, Ji, & Zhang, 2020).

[4] Fry refers to the early life stage of fish that have recently hatched from eggs and have absorbed their yolk sac. At this stage, a fry is small, delicate, and require specialized care, such as controlled water conditions and appropriate feed, to ensure survival and growth. As they develop, fry transition into fingerlings, a more mature stage before reaching adulthood. (See **figure 3.10** for phases of fish seed development)

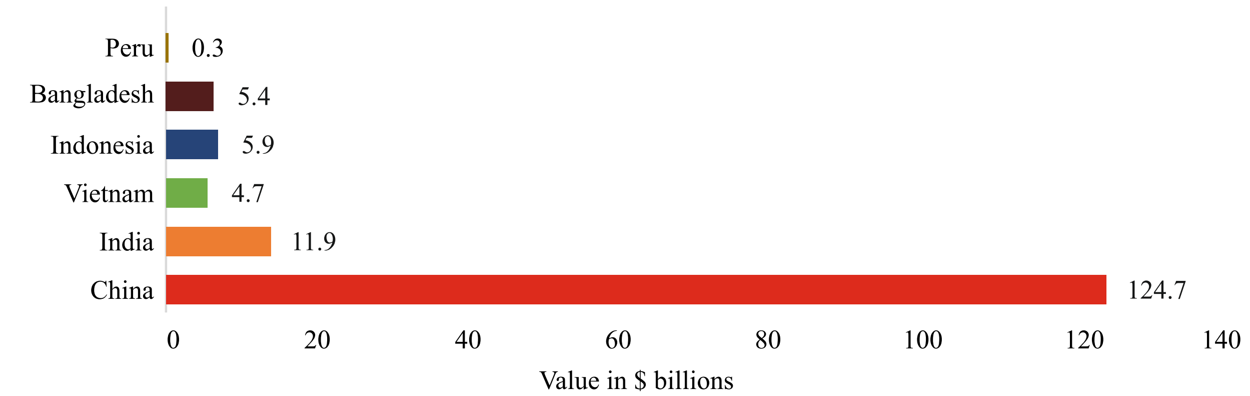
Figure 2-2: Global Inland Aquaculture Production by Quantity (1950-2023)



Source: FishStatJ, FAO (2025) Note: Data expressed in live weight equivalent; excludes aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.

Figure 2-3 illustrates the economic value of inland aquaculture across six aquaculture-producing nations-China, India, Vietnam, Indonesia, Bangladesh and Peru in 2022. China has a hegemonic position in inland aquaculture production, generating a total value of USD 124.7 billion (68 percent). India ranks second in inland aquaculture production value (USD 11.9 billion), surpassing Vietnam, Indonesia, and Bangladesh in this segment, but way below that of China. Aquaculture has become a crucial sector for small farmers in Asia, offering significant contributions to food security, rural livelihoods, and economic growth. Aquaculture in Bangladesh has experienced rapid growth and has become a key driver of poverty reduction and socio-economic development. The sector has provided livelihoods for millions of people, many of whom are small-scale farmers, offering a reliable income source and an alternative to traditional farming. The commercialization of the aquaculture value chain has significantly transformed the sector, particularly through expansion of feed mills and hatcheries (Hernandez, et al., 2018). Major varieties of fisheries in Southeast Asia and South Asia are carps, shrimp, pangasius, catfish, tilapia, and milkfish.

Figure 2-3: Value of Inland Aquaculture Produce for Major Countries in 2022

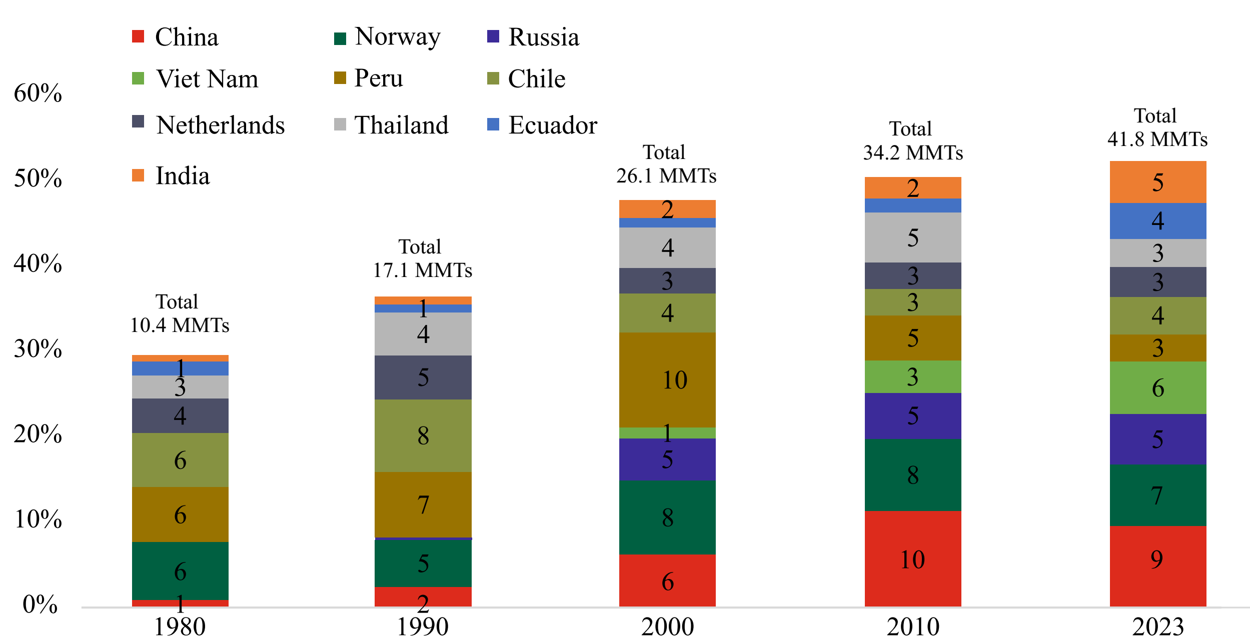


Source: FishStatJ, FAO (2025)

2.3 Global Trade of Fisheries

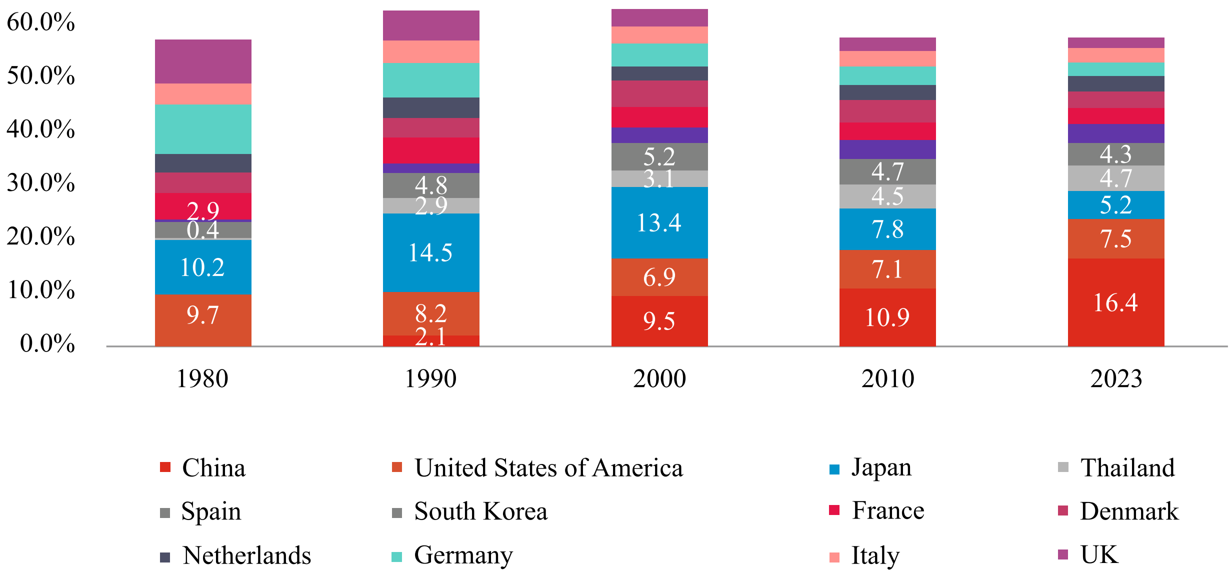
Global exports of fisheries have increased five-fold from 7.92 MMTs in 1976 to 41.85 MMTs in 2023 (FAO 2025). In TE 2023, by quantity, China stood as the largest exporter of fisheries products at 3.72 MMTs with an 8.9 percent share in total global exports followed by Norway (7.1 percent), Vietnam (5.5 percent), Russia (5 percent), India (3.9 percent), Peru (3.9 percent), Chile (3.8 percent). Compared to production, the exports of the commodities are less concentrated within top 10 countries having a share of 48.4 percent share of total exports as compared to 73.7 percent share in production (**Figure 2-4**). India ranks fifth in total fisheries and aquaculture products exports with 1.91 MMTs and holds a share of 4.6 percent in global exports in 2023. On the import side, major demand is coming from China, Japan, USA and European Union countries (**Figure 2-5**). In value terms, China is the largest exporter (USD 21.6 billion) and second-largest importer (USD 18.5 billion) making it a net exporter of fisheries whereas US is the biggest net importer (USD 28.1 billion). The biggest net exporter is Norway with exports of USD 15.5 billion and imports of only USD 0.7 billion, followed by Ecuador (ITC Trade Map 2025). India imports only USD 0.2 billion of fisheries and exports valued at USD 7.5 billion.

Figure 2-4: Country-Wise Share of Major Exporters of Fisheries by Quantity



Source: FishStatJ, FAO (2025). Note: Stack for remaining share comprises exports from other countries

Figure 2-5: Country-Wise Share of Major Importers of Fisheries by Quantity

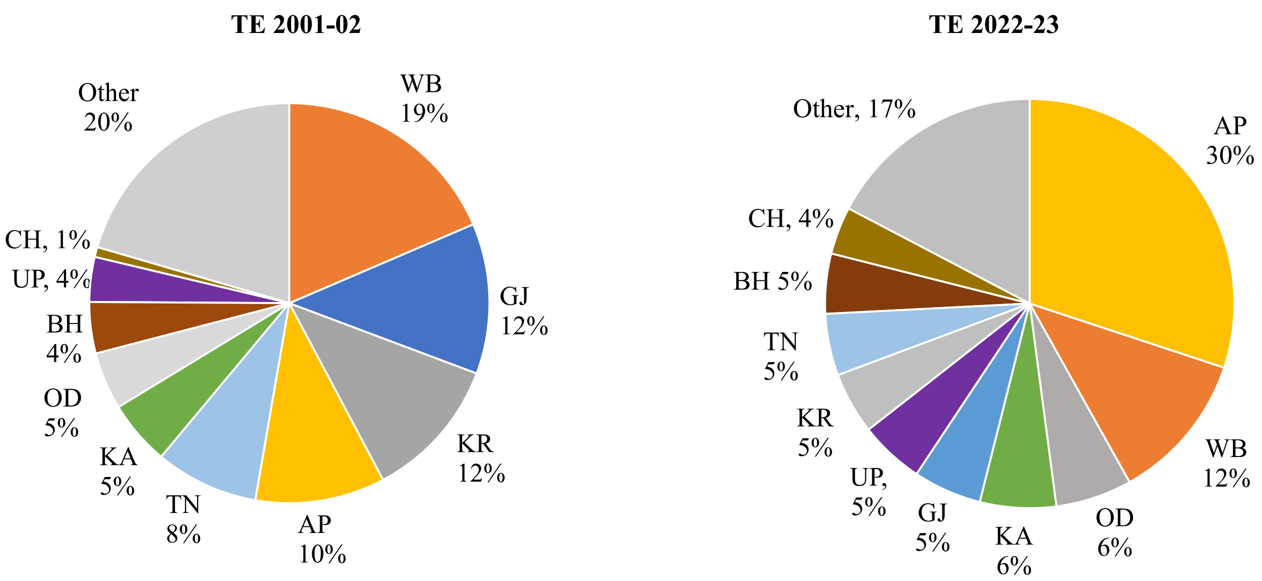


Source: FishStatJ, FAO (2025). Note: Stack for remaining share comprises exports from other countries
Note: Data as per the reporting country; Quantity is measured in national units, converted to tonnes. Quantities refer to the net weight of the commodities, i.e., excluding the weight of the container and any liquid added for preservation or flavour.

2.4 Domestic Production

India's total production of fisheries (both aquaculture and capture) increased almost three-fold with a CAGR of 5.1 percent in the last two decades, i.e., from 2002-03 to 2022-23 from 6.2 MMTs to 17.5 MMTs (MPEDA) which has now increased to 19.5 MMTs in 2024-25 (PIB Press Release 2025). However, inland fisheries have driven the bulk of this growth, expanding by 384 percent in the same period, compared to 170 percent increase in marine fisheries. This shift reflects a substantial change in the composition of India's fisheries sector. In 2005-06, India's inland fisheries accounted for 58 percent share of total production while marine fisheries comprised the rest. By 2024-25, inland fisheries have dominated the sector, constituting 75 percent of the total production. This transition underscores the growing importance of inland fisheries in India's overall fisheries output, driven by factors such as the expansion of aquaculture, better resource management, and technological advancements in inland fish farming. India's production is dominated by major carps (*rohu, mrigal,* etc) collectively accounting for 58 percent share of total production in 2022-23. Shrimp production has become a critical component of India's fisheries sector, driven by the growth of shrimp farming, particularly in states like Andhra Pradesh, which has seen a rapid increase in production, processing and export. This increasing role of inland fisheries also provides a significant opportunity for rural livelihood enhancement and income augmentation among small farmers. However, there are significant variations in state-wise production, reflecting the regional disparities in aquaculture development over time. For TE 2022-23[5], major states such as Andhra Pradesh (30 percent), West Bengal (12 percent), Odisha (6 percent), Karnataka (6 percent), and Gujarat (5.4 percent) together contributed 59 percent of total production. Andhra Pradesh, in particular, has seen a substantial increase in its share rising by 20 percentage points from TE 2001-02 to TE 2022-23. Similarly, Odisha and Karnataka have also seen moderate increases of 1.4 and 1 percentage points, respectively. On the other hand, states like West Bengal, Gujarat, Kerala, and Tamil Nadu have experienced declines in their share of total production, with West Bengal and Gujarat seeing reductions of 6.7 and 6.8 percentage points, respectively in the same period. This regional shift highlights the growing dominance of Andhra Pradesh in inland fisheries, especially in shrimp production, which has driven much of the state's growth post 2009. (**Figure 2-6**).

Figure 2-6: State-wise Share in Domestic Production of Fisheries (for TE 2001-02 and TE 2022-23)

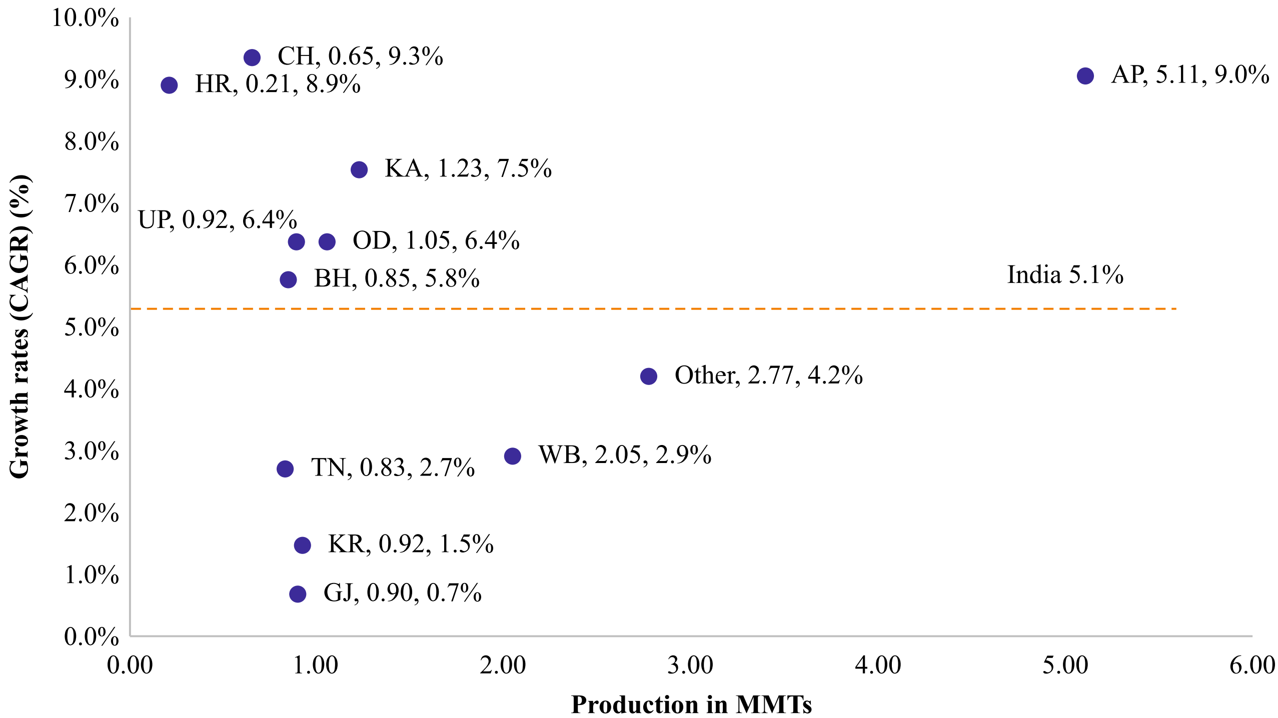


Source: Handbook on Fisheries Statistics (various years)

Over the two decades from 2002-03 to 2022-23, production has expanded in several states, with Andhra Pradesh (9 percent), Odisha (6.4 percent), Karnataka (7.5 percent), Uttar Pradesh (6.4 percent), Bihar (5.8 percent), and Chhattisgarh (9.3 percent) achieving compound annual growth rates (CAGR) above the national average of 5.1 percent (**Figure 2-7**). This suggests a geographical diversification of aquaculture growth, with emerging states witnessing significant expansion in production. The high growth in states like Chhattisgarh and Bihar indicates increasing investment and policy support in non-coastal regions, reflecting a shift towards inland aquaculture.

[5] Comparable state-wise production data is available only till 2022-23 in the Handbook of Fisheries Statistics 2023, which is the latest release from Ministry of Fisheries, Animal Husbandry and Dairying, GoI.

Figure 2-7: Fisheries Production (for 2022-23) and Growth (CAGR for 2002-03 to 2022-23) for Major States



Source: Handbook on Fisheries Statistics (2023, latest data available)
Note: First figure against state code is fisheries production in 2022-23 and second figure is CAGR 2002-03 to 2022-23 in percent

Based on the production levels in 2022-23 and the CAGR (2002-03 to 2022-23), the states in fisheries production can be categorized into four key groups, reflecting their current contribution and growth potential. High growth is defined as a CAGR above the national average of 5.1 percent.

1. High Production - High Growth (Dominant and Expanding States)

These states not only contribute significantly to total production but are also growing at a rapid pace, consolidating their position as aquaculture hubs.

Andhra Pradesh (AP)- Production: 5.11 million tonnes, CAGR: 9.0 percent

Karnataka (KA) - Production: 1.23 million tonnes, CAGR: 7.5 percent

- Andhra Pradesh remains the undisputed leader in Indian fisheries production, accounting for nearly 30 percent of total national production by quantity and 40 percent by value. Its high CAGR (9.0 percent) reflects technological advancements, large-scale commercial aquaculture, and strong policy incentives. The CAGR of inland fisheries in Andhra Pradesh from 2002-03 to 2022-23 has been 10.3 percent in contrast to 4.3 percent for marine fisheries. The share of inland fisheries is 88 percent in 2022-23 which is an increase of 18 percentage points from 2002-03. Karnataka has also emerged as a key player with significantly high CAGR, above the national average. However, marine fisheries production is dominant in the state holding a 60 percent share. The state has been benefiting from diversified fisheries and expanding private sector involvement.

2. Low Production - Low Growth (Stagnant or Lagging States)

These states have both low production and low growth, indicating structural limitations, policy constraints, or lack of technological adoption, which hinder expansion.

Gujarat (GJ) - Production: 0.90 million tonnes, CAGR: 0.7 percent

Tamil Nadu (TN) - Production: 0.83 million tonnes, CAGR: 2.7 percent

Kerala (KR) - Production: 0.92 million tonnes, CAGR: 1.5 percent

- Gujarat's extremely low CAGR (0.7 percent) suggests severe stagnation, despite having a long coastline and access to marine resources. Tamil Nadu, though a coastal state with strong seafood export potential, has not witnessed significant growth, possibly due to limited inland aquaculture adoption, regulatory hurdles, or high production costs. Kerala, traditionally strong in marine fisheries, has struggled to transition to large-scale aquaculture, due to land constraints and environmental regulations.

3. Low Production - High Growth (Emerging States Catching Up)

These states, while currently having relatively low production, are experiencing high growth rates, indicating their future potential to become key contributors.

Chhattisgarh (CH) - Production: 0.65 million tonnes, CAGR: 9.3 percent

Bihar (BH) - Production: 0.85 million tonnes, CAGR: 5.8 percent

Odisha (OD) - Production: 1.05 million tonnes, CAGR: 6.4 percent

Uttar Pradesh (UP) - Production: 0.92 million tonnes, CAGR: 6.4 percent

Haryana (HR) - Production: 0.21 million tonnes, CAGR: 8.9 percent

- These states represent the next wave of aquaculture expansion, benefiting from increasing government support, improved hatchery and feed infrastructure, and growing farmer participation in inland aquaculture. Chhattisgarh leads with a remarkable CAGR of 9.3 percent, reflecting its strong policy focus on freshwater fish production. Odisha and Uttar Pradesh have also leveraged their water resources and government-backed schemes to accelerate growth. Bihar's growth (5.8 percent) is noteworthy, indicating that states without a strong historical presence in aquaculture are rapidly scaling up production.

4. High Production - Low Growth (Mature but Slowing States)

These states already have significant production levels, but their growth has slowed down, possibly due to market saturation, policy stagnation, or infrastructural limitations.

West Bengal (WB) - Production: 2.05 million tonnes, CAGR: 2.9 percent

- West Bengal, despite being one of the largest fish-producing states, is growing below the national average (5.1 percent), suggesting that it is not expanding at the same pace as emerging states. The lack of significant technological advancements, competition from faster-growing states, and possible land-use constraints limiting its expansion. While it remains a major fishery hub, its future growth trajectory has been stagnant in the last five years. The state did not witness commercial shrimp cultivation, and 80 percent of production is major carps. The state has had history of paddy shrimp farming in brackish water of the Sundarbans delta, highly suitable for shrimp culture. Commercial shrimp cultivation in West Bengal did not expand significantly due to several structural and institutional constraints. Despite having vast brackish water resources and a long history of traditional shrimp farming, the state lagged behind in large-scale commercial expansion. One of the primary reasons was the lack of early technological interventions and private sector investment, which played a crucial role in Andhra Pradesh's success. While the intensification of shrimp farming took off in the early 1990s, following the establishment of a commercial tiger shrimp hatchery in Andhra Pradesh through a joint MPEDA and Department of Biotechnology (DBT) initiative, West Bengal did not experience similar advancements. Another key factor was the absence of commercial hatcheries for shrimp seeds in the region. The successful integration of hatcheries with farming operations in Andhra Pradesh ensured a steady supply of high-quality shrimp seed, which was crucial for large-scale production. In contrast, West Bengal remained dependent on natural seed collection from estuaries, which was not only unsustainable but also inconsistent in quality and supply. This reliance on wild seed limited the expansion of intensive shrimp farming and lack of export orientation resulted in low fisheries growth (ICAR report, 2021; Rajani et al.,2022).

Table 2-1: Composition of Inland Fisheries Across Categories (in million tonnes) 2022-23

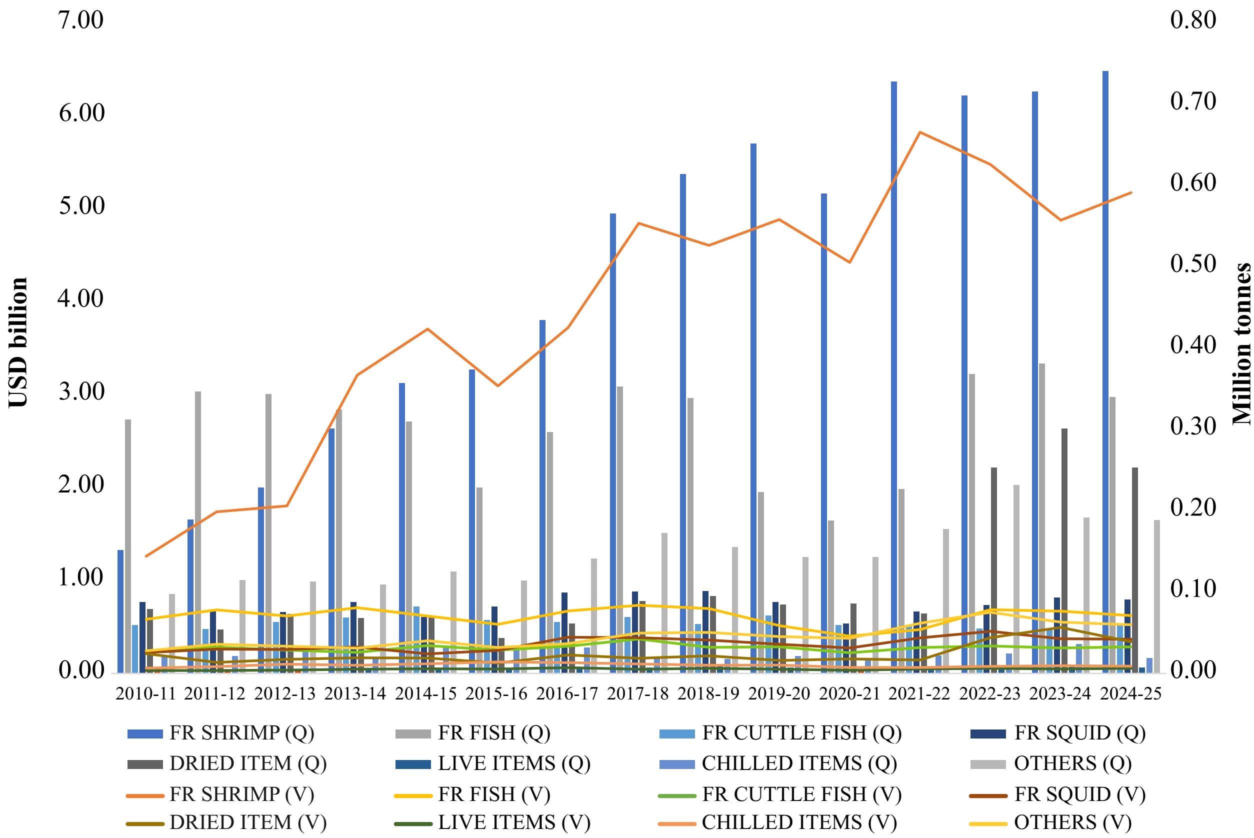
States	Major Carps	Minor Carps	Exotic Carps	Murrels	Catfishes	Other freshwater fishes	Total
High Production – High Growth (Dominant and Expanding States)							
Andhra Pradesh	2.21	0	0.14	0.08	0.32	1.75	4.5
	(49.25)	(0.00)	(3.06)	(1.86)	(7.04)	(38.79)	(100.00)
Karnataka	0.25	0.03	0.15	0.01	0.01	0.05	0.5
	(51.52)	(6.09)	(29.41)	(1.01)	(2.64)	(9.33)	(100.00)
Low Production – High Growth (Emerging States Catching Up)							
Odisha	0.5	0.05	0.11	0.01	0.02	0.02	0.7
	(71.66)	(7.12)	(15.26)	(0.73)	(2.62)	(2.62)	(100.00)
Low Production – Low Growth (Stagnant or Lagging States)							
Gujarat	0.05	0.001	0.00	0.001	0.001	0.14	0.2
	(23.08)	(1.03)	(0.00)	(2.56)	(1.54)	(71.79)	(100.00)
High Production – Low Growth (Mature but Slowing States)							
West Bengal	1.29	0.02	0.2	0.01	0.04	0.06	1.6
	(80.35)	(1.25)	(11.89)	(0.69)	(2.32)	(3.50)	(100.00)
All India	6.6	0.34	1.09	0.25	0.57	2.6	11.6
	(57.03)	(2.97)	(9.38)	(2.21)	(4.91)	(22.06)	(100.00)

Source: Handbook on Fisheries Statistics (2023, latest data available)
Note: Data on species-wise inland water fish landings; percentage share in parentheses

2.5 Export Trends and Global Competitiveness of India

In TE 2023, India's share in global fisheries export was 3.9 percent by quantity with frozen shrimps comprising 44 percent of exports followed by frozen fish (20 percent), dried items (15 percent), frozen squid (5 percent), frozen cuttle fish (3.5 percent) and others (11 percent). The total export value for fisheries from India was USD 7.45 billion in 2024-25. Export value of frozen shrimps stood at USD 5.18 billion contributing 70 percent to the total export value (**Figure 2-8**).

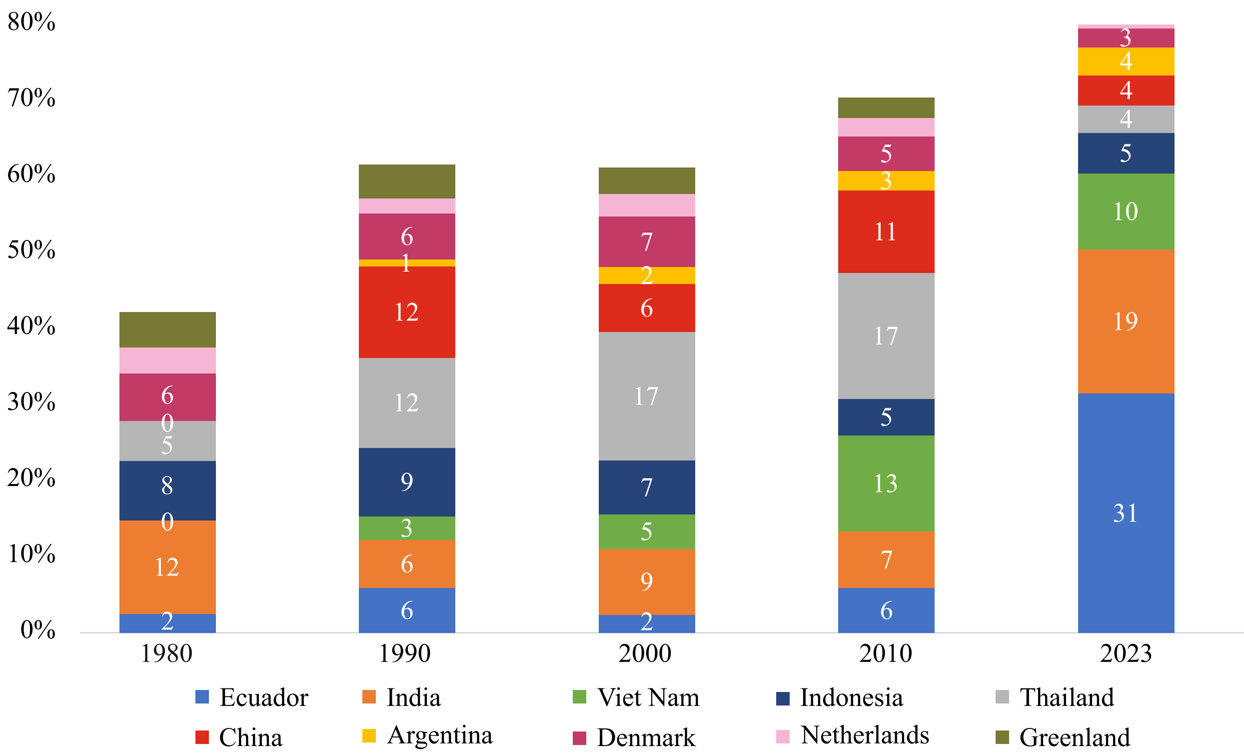
Figure 2-8: Volume and Value of Indian Exports of Marine Products (2010-11 to 2024-25)



Source: MPEDA 2025
Note: FR stands for Frozen. Q for Quantity and V for Value

For the last two decades from 2005-06 to 2024-25, Indian fisheries exports value has grown at a CAGR of 7.9 percent. The exports of fisheries products kicked off in 2010-11 when the quantity exported grew by 20 percent and the value grew by 34 percent from the previous year. From 2010-11 to 2024-25 the export quantity has grown by 109 percent and value by 161 percent. The product bifurcation of the export gives an interesting picture. During the initial phases frozen fish was the major exported item. In TE 2002-03 frozen fish constituted 44 percent of the total exports of 0.44 MMT, followed by frozen shrimp (28 percent) and frozen squid (9 percent). However, in TE 2024-25 frozen shrimp has the largest share in the fisheries exports with 68 percent by value, followed by frozen fish (9 percent) and dried items (5 percent). India ranks second in the global export market of frozen shrimps with a share of 19 percent in 2023 behind Ecuador which is at 31 percent market share in quantity. From 2000 to 2022, India's share in global shrimp exports rose from 9 percent to 19 percent, while Ecuador witnessed an even sharper increase, expanding its share from 2 percent to 31 percent during the same period (**Figure 2-9**).

Figure 2-9: Major Players in Global Shrimp Exports



Source: FishStatJ, FAO (2025)

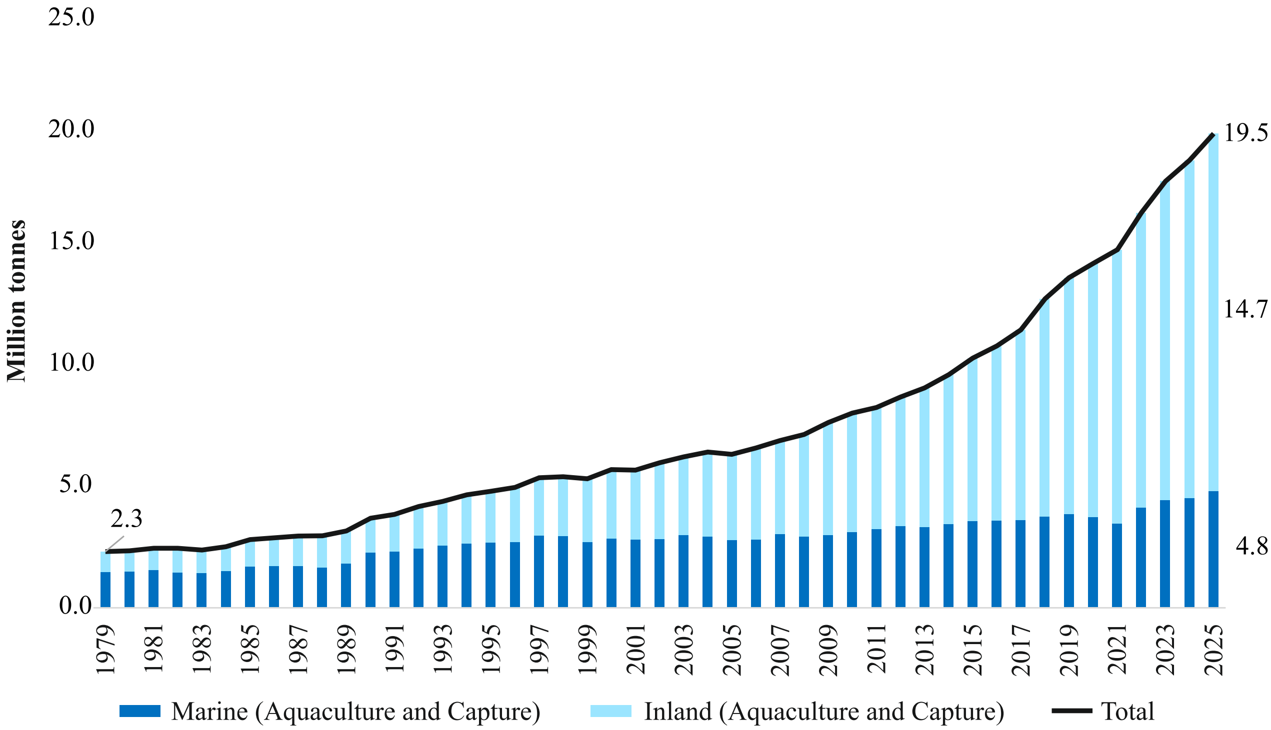
In India, frozen shrimps and fishes drive the seafood exports. However, in value terms frozen shrimp has the maximum share in the export throughout because of its high value in the international market. As for overseas markets in TE 2024-25, the USA is the major importer of Indian seafood in value terms, with an import worth USD 2.6 billion, accounting for a share of 34 percent. China ranked as the second largest export destination country for India with an export volume of 0.41 MMTs worth USD 1.4 billion, accounting for 24 percent share in quantity and 18 percent share in value. The European Union particularly Spain and Belgium is the third largest importer with 12 percent share in quantity and 15 percent share in value. This highlights the EU's steady demand for high-quality seafood from India, particularly frozen shrimp, which remains a staple in European consumption. Southeast Asia including Vietnam, Thailand, Malaysia is the fourth largest export market for India with an export volume of 0.38 MMTs (22 percent) valued at USD 1.04 billion (14 percent). Overall, the shift towards frozen shrimp and the growing export markets, particularly the USA, China, the EU, and Southeast Asia, reflect the increasing competitiveness and value of India's seafood sector. Hence, boosting the export value chain by making it inclusive holds immense potential for augmenting small and medium farmers' income.

India is emerging as a dominant trade partner in fisheries products from inland aquaculture. Though it is far behind China still. India has made itself one of the largest shrimp exporters in the world but there is significant market space and potential to tap in other fisheries products. To understand how this potential can be tapped and what institutional settings are needed for this expansion to work for India's small and marginal farmers, it is important to decompose the drivers of this growth till date. The next section tries to study the drivers of fisheries growth in India from 1980s.

CHAPTER 3
BLUE REVOLUTION: DRIVERS OF GROWTH

The Blue Revolution, referred as the *Neel Kranti* Mission, was initiated in India during the 7th Five-Year Plan (1985-1990) under the leadership of Dr. Hiralal Chaudhari and Dr. Arun Krishnan, who are recognized as the "Fathers of the Blue Revolution." The main goal was to boost the production of fish and marine products. It focused on implementing technological advancements in fisheries and aquaculture to enhance profitability within the sector. **Figure 3-1** depicts a consistent upward trend in inland fisheries production, reflecting its growing importance within India's overall fish output. Over the years, inland fisheries have experienced significant expansion, with production rising from 0.82 MMTs in FY 1979 to 14.7 MMTs in FY 2025, while total fish production has increased from 2.31 MMTs to 19.5 MMTs. This shift indicates that aquaculture is becoming a dominant contributor, surpassing marine fisheries in growth rate.

Figure 3-1: Expansion of Inland Fisheries in India (FY 1979 - 2025)



Source: Handbook on Fisheries Statistics (2018 and 2023) and PIB Press Release 2025

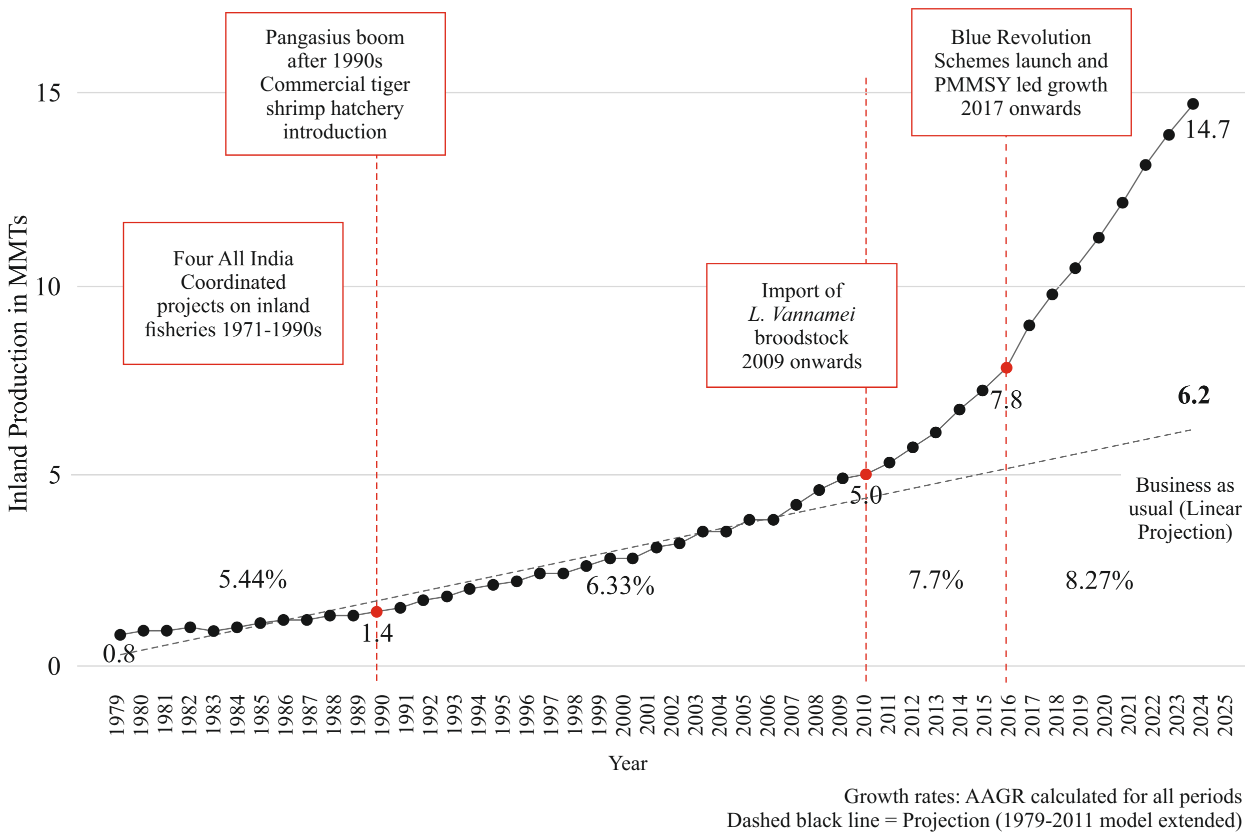
The early phase of this growth was gradual, but post-1990s, a noticeable acceleration took place, driven by technological advancements, increased private sector involvement, and policy initiatives supporting aquaculture development. Key factors contributing to this rise include the expansion of hatcheries, improvements in breeding techniques, adoption of better feed practices, and institutional support through credit and infrastructure development. The significant gap between inland and marine fisheries production in the recent period suggests a transition towards controlled aquaculture systems, which provide advantages such as higher productivity, better disease management, and year-round fish availability compared to traditional capture fisheries.

3.1 Structural Transformation of Inland Fisheries in India

We use the Bai-Perron (1998, 2003) multiple structural breaks model for detecting unknown breakpoints in a time series or regression model where the relationship between variables changes over time. In this model, the dependent variable is explained by the independent variable with different regression coefficients for distinct time periods. The structural breakpoints indicate the points at which these relationships shift, and the model estimates different regression equations for each segment while accounting for error terms.

India's inland fisheries sector has evolved through four major phases, transitioning from institutionally supported expansion (1979-1990) to technological maturation and commercial intensification (1991-2010), followed by a shrimp-driven boom (2011-2017) and finally, a policy-driven expansion under Blue Revolution and PMMSY schemes (2017-2025) (**Figure 3-2**).

Figure 3-2: Structural Breaks in Inland Fisheries Production (FY 1979 - 2025)



Source: Handbook on Fisheries Statistics (2023) and PIB press release August 2025 for production
Note: Structural breaks determined statistically using Bai-Perron (1998, 2003) Test

The structural evolution of inland fisheries can be categorized into four distinct phases, each marked by key drivers of growth, institutional developments, and technological breakthroughs.

The first phase, Take-off (1979-1990): India's inland fisheries sector has witnessed significant advancements through various All India Coordinated Research Projects (AICRPs), which laid the foundation for modern aquaculture practices. In 1971, four AICRPs were introduced to address various aspects of inland fisheries development. These included Composite Fish Culture, which focused on polyculture techniques for maximizing fish yield, Riverine Fish Seed Prospecting, aimed at enhancing seed availability from natural water bodies, Air-breathing Fish Culture[6], which explored the potential of species capable of surviving in low-oxygen environments, and Ecology and Fisheries Management of Reservoirs, which provided insights into sustainable fisheries practices in reservoirs (ICAR-CIFRI, 1980). Recognizing the synergies between projects, Composite Fish Culture and Fish Seed Production were merged in 1974, streamlining research and implementation efforts (MPEDA, 2023). Another significant initiative was the AICRP on Brackish Water Fish Farming launched in 1973, which contributed to the early development of coastal and estuarine aquaculture in India (ICAR-CIBA). One of the key initiatives was also the Inland Fisheries Project (1979), launched with World Bank assistance of USD 39.7 million (World Bank, 1979). This project played a crucial role in improving fish seed production by providing credit support for the establishment of modern hatcheries, leading to the development of 62 hatcheries across North India. The project not only enhanced fish seed availability but also contributed to the scientific expansion of inland fisheries.

Government hatcheries played a crucial role in improving seed availability, ensuring a steady supply of quality fish stock. Institutional lending from NABARD and public sector banks facilitated credit access, enabling infrastructure development. Extension services and training programs encouraged farmers to transition from traditional fishery practices to scientific aquaculture, leading to a substantial increase in inland fish farming.

The second phase, Maturation (1991-2010): Characterized by technological advancements and the emergence of private sector participation. The introduction of Pangasius (*Pangasius hypophthalmus*) in the 1990s marked a turning point as it became one of the most commercially viable species due to its high growth rate and adaptability. The boom in Pangasius farming led to an increase in the use of floating pelleted feeds, improving feed conversion ratios and overall productivity. Private hatcheries reduced dependence on government seed supply, allowing faster scaling up of production. Artificial breeding techniques, such as the expansion in use of Ovaprim (a synthetic hormone), improved spawning efficiency and fish seed quality further contributed to the scale up. Fish seed production increased from 490 million fish fry in 1973-74 to 22000 million in 2005-06. The introduction of high-density polyethylene (HDPE) water tanks significantly lowered transportation costs and reduced the mortality rate of carp fingerlings during transit. This phase saw commercial aquaculture take centre stage with higher productivity, better feed management, and advanced breeding techniques fuelling growth. The CAGR export growth was 6.1 percent during 1995-96 to 2010-11.

The third phase, Aquaculture Boom (2011-2017): The period between 2011 and 2017 marked a major structural shift in aquaculture, driven by the introduction and expansion of *Litopenaeus Vannamei (L. Vannamei)* shrimp farming. This phase, termed the "shrimp boom," was characterized by rapid production growth, increasing global market share, and the adoption of modern aquaculture practices. The foundation for India's shrimp revolution was laid with the import of specific pathogen-free (SPF) *L. Vannamei* brood stock from Taiwan in 2001[7]. However, commercial farming remained restricted until 2009, when the Coastal Aquaculture Authority (CAA) formally approved *L. Vannamei* cultivation for large-scale commercial production (CAA, 2023-24). This policy shift allowed Indian shrimp farmers to diversify from the native black tiger shrimp (*Penaeus monodon*), which was susceptible to disease outbreaks, towards a more disease-resistant and high-yielding species. Following the legalization of *L. Vannamei* farming in 2009, the sector witnessed exponential growth. The number of registered shrimp hatcheries surged from 24 in 2009-10 to 296

[6] Air-breathing fish farming is a cost-effective and high-yield aquaculture method, particularly suited for shallow water conditions. The system requires minimal inputs, with fingerlings and feed being the primary necessities, while water management becomes crucial in intensive operations. Successful breeding of *Magur (Clarias batrachus)* in paddy fields has enhanced fingerling production, integrating well with rice farming and expanding seed trade in West Bengal, Bihar, and Assam. In Bihar, the air-breathing fish farming was practiced with Makhana production (CIFRI, 1980).

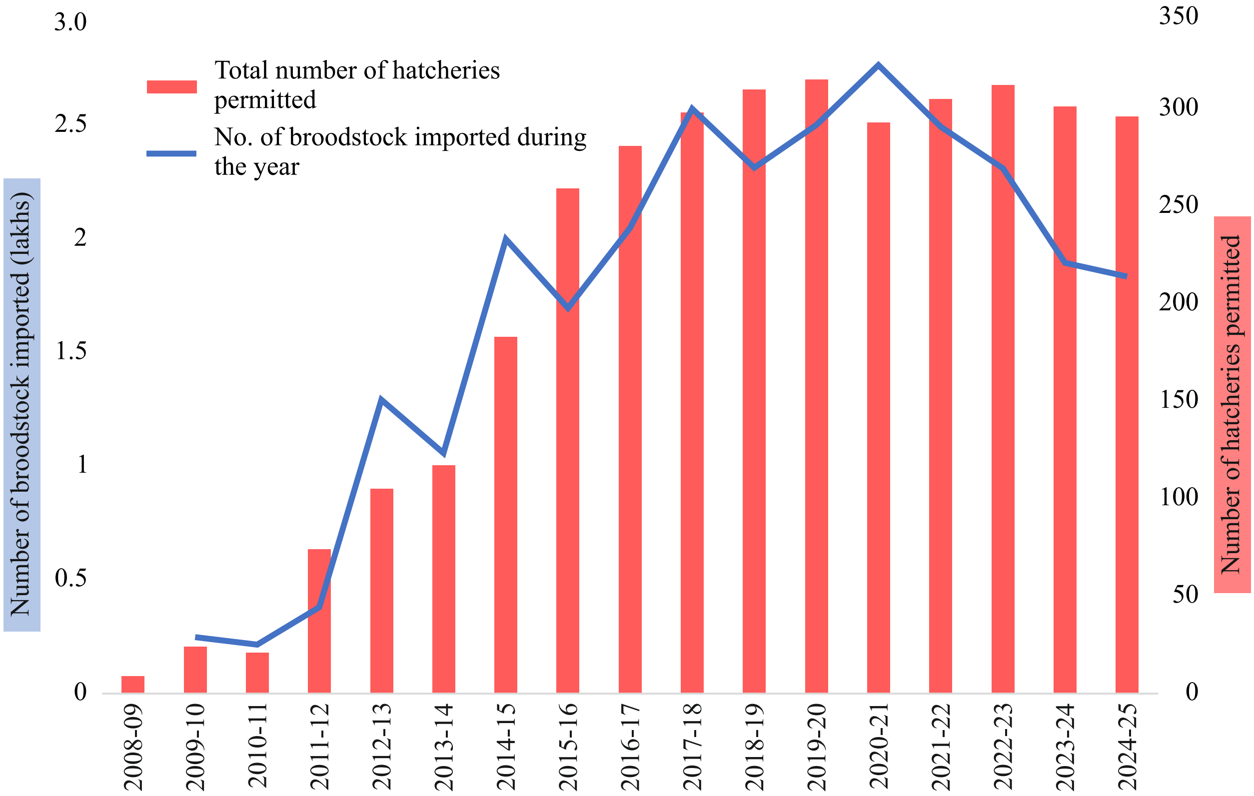
[7] Taiwan played a crucial role in the global expansion of *Litopenaeus Vannamei (L. Vannamei)* shrimp farming, particularly in South America and Southeast Asia, including India. The species was introduced to these regions as an alternative to traditional shrimp species, primarily due to its faster growth rate, higher stocking density tolerance, and disease resistance.

in 2024-25, with the production capacity increasing from 615 million post-larvae (PL) to 68180 million PL (CAA, 2024-25) (**Figure 3-3**). During this period total fish export growth (CAGR) was 8 percent, while frozen shrimp export witnessed a CAGR of 12 percent. Domestic Nauplii Rearing Hatcheries (NRHs) for *L. Vannamei* species have increased from just 5 in 2015-16 to 202 in 2024-25. There is a sharp decline in number of broodstock imported over the last 5 years, and seed production capacity has also stagnated.

This expansion was driven by:

- Higher Productivity and Profitability: *L. Vannamei* shrimp farming offers higher stocking densities, better feed conversion ratios (FCR), and lower production costs than traditional shrimp species, making it more profitable.
- Export-Led Growth: The rising global demand for Indian shrimp, particularly from the United States, European Union, and China, created strong market incentives for farmers to transition to *L. Vannamei*.
- Private Sector Investment: The high return on investment attracted significant participation from corporate aquaculture firms and independent farmers, leading to infrastructure development and value-chain integration.
- Advancements in Hatchery and Disease Management: Adoption of biosecurity protocols, improved disease surveillance, and water quality management helped mitigate the risks of viral outbreaks such as White Spot Syndrome Virus (WSSV) and Early Mortality Syndrome (EMS) (FAO, 2022).

Figure 3-3: Number of *L. Vannamei* Hatcheries Registered with CAA since Inception and Growth in Imports of Brood Stock (July 2009 to March 2025)



Source: Coastal Aquaculture Authority (CAA) 2024-25

The shrimp boom transformed India into the world's second-largest exporter of farmed shrimp (**Figure 3-4 and 3-5**). Between 2010 and 2020, India's shrimp exports grew at a CAGR of over 10 percent, surpassing traditional competitors like Thailand and Vietnam. The U.S. and EU markets became key importers, with India accounting for more than 40 percent of shrimp imports into the U.S. by 2022 (MPEDA, 2023).

The fourth phase, Blue Revolution Scheme and PMMSY-led Growth (2017-2025): This phase has been characterized by large-scale government interventions aimed at boosting productivity, enhancing infrastructure, and strengthening value chains. Under the Blue Revolution (2015-16 to 2019-20), the government allocated INR 3,000 crores to promote aquaculture, modernize infrastructure, and encourage technological innovations. *The Pradhan Mantri Matsya Sampada Yojana* (PMMSY) (2020-21 to 2025-26) earmarked INR 20,050 crores to further increase fish production, improve cold storage and processing facilities, and enhance market linkages. Policies promoting cluster-based aquaculture, digital traceability systems, and FFPOs have strengthened institutional frameworks and farmer participation. Genetic improvements, biotechnology applications, and climate-resilient aquaculture models have been integrated to ensure long-term sustainability. This phase is characterized by government-led investment, infrastructure upgrades, and policy reforms ensuring sustainable and inclusive growth in India's inland fisheries.

Figure 3-4: Shrimp Production in India (2008-09 to 2023-24)

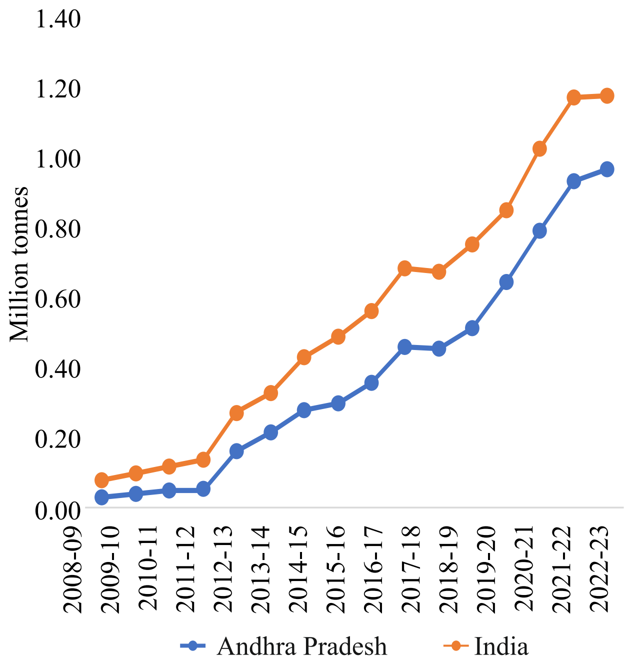
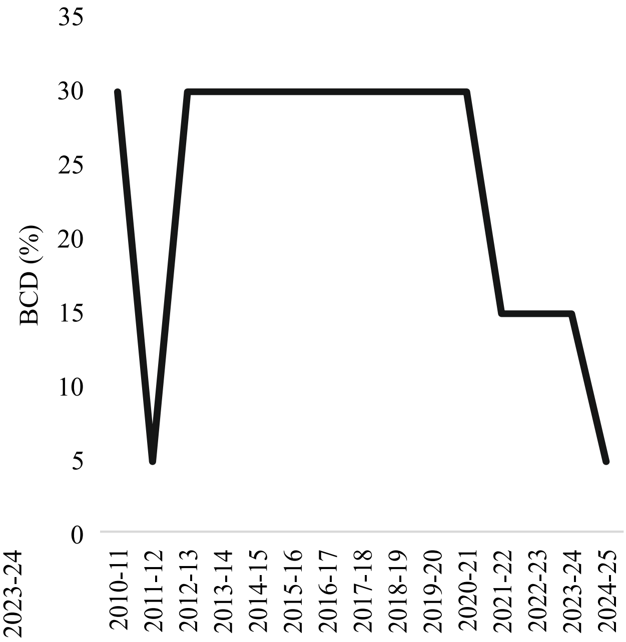


Figure 3-5: Basic Import Duty on Shrimp and Prawn Feed (2010-11 to 2024-25)



Note: Shrimp includes L.Vannamei and P.Mondon varieties. L. Vannamei makes up 93 percent share in total shrimps in 2023-24.
Source: MPEDA (2025) and Ministry of Trade and Commerce, GoI

3.2 Determinants of Growth

The ARDL regression model estimates the key drivers of the GVA in the fisheries sector, with the dependent variable being the log difference of GVA at constant 2011-12 prices for 1990-2022[8] (**Table 3-1**). The model identifies four key drivers showing a long-run relationship with GVA of fisheries. The first driver is GDP per capita, which has a coefficient of 0.33, significant at the 5 percent level. This suggests that a 1 percent increase in GDP per capita results in a 0.33 percent increase in the GVA of the fisheries sector in the long run holding

[8] Period used based on availability for data of all variables. ARDL model is used because variables are integrated of different orders..

other variables constant. Rising incomes and economic growth are important factors in driving the demand for fisheries products that can lead to greater investment and improved productivity in the sector. According to World fish India panel study, the proportion of fish consumers increased from 66 percent to 72.1 percent between 2005-06 and 2019-21. Among fish eaters per capita annual consumption rose from 7.4 kg to 12.3 kg (World Fish, 2023).

The second key driver is fish seed production, with a coefficient of 0.14, statistically significant at the 1 percent level. This implies that a 1 percent increase in fish seed production leads to a 0.14 percent increase in the GVA of the fisheries sector in the long run, holding other factors constant. Fish seed production plays a crucial role in enhancing sectoral productivity, highlighting the need for policies aimed at improving seed availability and quality to support sustainable growth. The growth of fish seed production plays a crucial role by driving the shift from traditional methods of trapping wild fish to modern practices such as hatchery stocking and mass-scale seed production. The fish seed production has increased from 6.32 billion fry in 1985-86 to 54.1 billion fry in 2020-21. In TE 2020-21, West Bengal is the largest fry producer producing 12.5 billion fry followed by Jharkhand with total fry production of 10.8 billion fry. Andhra Pradesh, which is the largest producer of fish and aquaculture ranks 7th in the list with a production 1.74 billion fry. Seed commercialization has allowed fish farming to move away from the unsustainable practice of relying on natural fish populations, enabling the controlled and large-scale production of high-quality fish seeds (fingerlings). This has improved the efficiency, reliability, and scalability of aquaculture operations. Hatchery-based seed production has revolutionized fish farming by ensuring a consistent supply of fish seed, enhancing stock management, and reducing pressure on wild fish populations. This has made aquaculture more commercially viable and sustainable.

Table 3-1: Drivers of Growth of Fisheries Sector in India (1990-2022)

ARDL (1,0,0,0,0) regression				
Sample: 1990-2022				
Number of observations = 32				
R-squared = 0.62				
Adj R-squared = 0.56				
Root MSE = 0.02				
First difference of ln GVA	Coefficient	Std. Err.	t	p value
ADJ				
Ln GVA of fisheries at 2011-12 constant prices				
Lag 1	-0.34***	0.07	-4.98	0.000
Long Run				
Ln GDP per capita	0.33**	0.15	2.08	0.047
Ln Fish seed production	0.14***	0.03	4.34	0.000
Blue Revolution and PMMSY dummy (No=0, Yes=1)	0.31***	0.05	5.72	0.000
Ln Export of shrimp	0.28***	0.09	2.85	0.008
Short Run				
Constant	1.38***	0.31	4.42	0.000
Pesaran, Shin and Smith bound test significant at 1% level				
Breusch-Godfrey LM test for autocorrelation p value = 0.89				
Portmanteau test for white noise statistic = 0.0168 p value = 0.89				

*Note: *** 1 percent significance level, **5 percent significance level*
Source: Handbook on Fisheries Statistics, GoI, 2022, MPEDA, MOSPI

The third identified driver is a dummy variable for when the government support significantly improved for the fisheries sector. This variable takes the value 1 for years 2016-22 and else 0. The positive coefficient on this variable is associated with a long-run shift in equilibrium of the GVA of fisheries. So, for these years for which dummy is 1, the GVA fisheries shows a 0.31 unit higher than previous years where the government support was lower. During these years the central government induced relatively massive budgetary support with the Blue Revolution scheme from 2015-16 to 2019-20, FIDF fund from 2018-19 and then PMMSY from 2020-21 to 2024-25. This support which includes income support, capital subsidies for various activities, and other infrastructural support to individuals as well as state agencies boosted GVA of this sector.

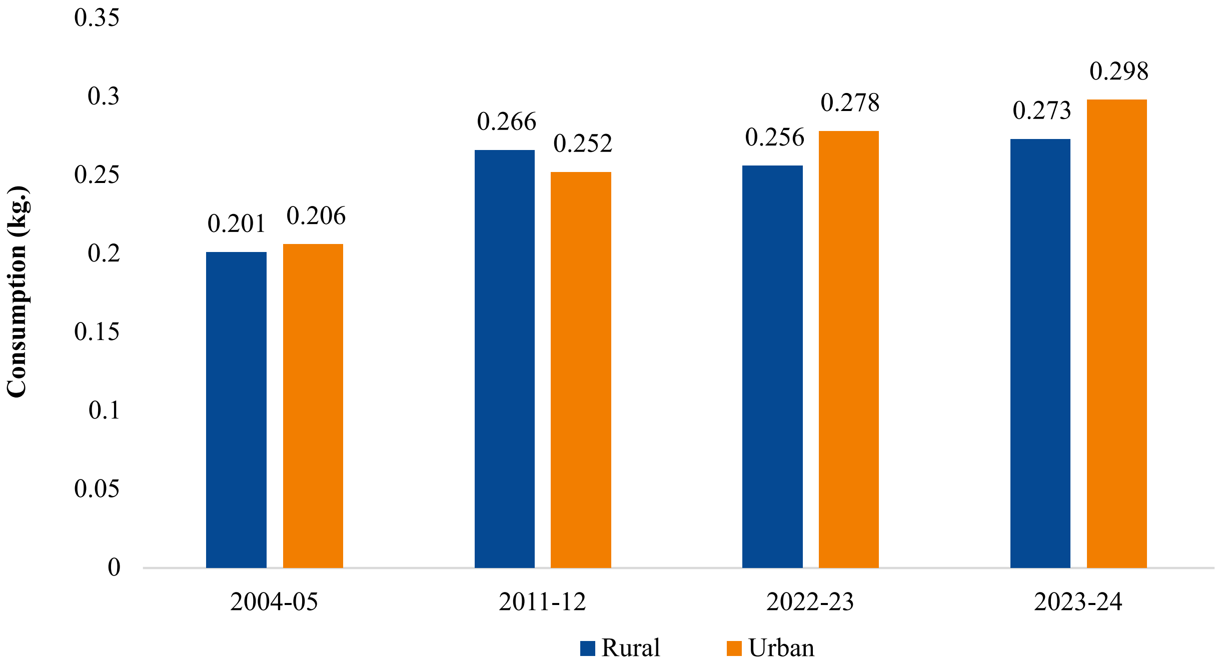
The fourth driver is the log of exports which has paced with the introduction of *L. Vannamei* shrimp culture in India. A one percent increase in exports increased GVA by 0.28 percent in the long run holding other factors constant. This indicates how the demand in export market and value chain strengthening can bring growth in the sector.

3.3 Demand Pattern of Fisheries

Fish production in India has shown a consistent upward trajectory, nearly doubling from 8.7 MMTs in 2011-12 to 19.5 MMTs in 2024-25. However, this surge in output has not translated into a commensurate rise in domestic consumption. According to Bennett's Law, as household incomes rise, the share of expenditure on high-value foods like meat, dairy, and fish typically increases. Yet, national consumption trends suggest a deviation from this pattern in the case of fish. Based on unit-level data from the Household Consumption Expenditure Survey (HCES), all-India per capita fish consumption marginally increased from 0.26 kg/month in 2011-12 to 0.28 kg/month in 2023-24.

In rural India, monthly per capital fish consumption rose from 0.201 kg in 2004-05 to 0.273 kg in 2023-24. In urban areas, fish consumption increased from 0.206 kg to 0.298 kg per capita per month in the same period (**Figure 3-6 and 3-7**), driven by factors such as rising incomes, urbanization, and greater access to diverse and processed fish products.

Figure 3-6: Monthly Per Capita Per Month of Fish Consumption (2004-05, 2011-12, 2022-23 and 2023-24)

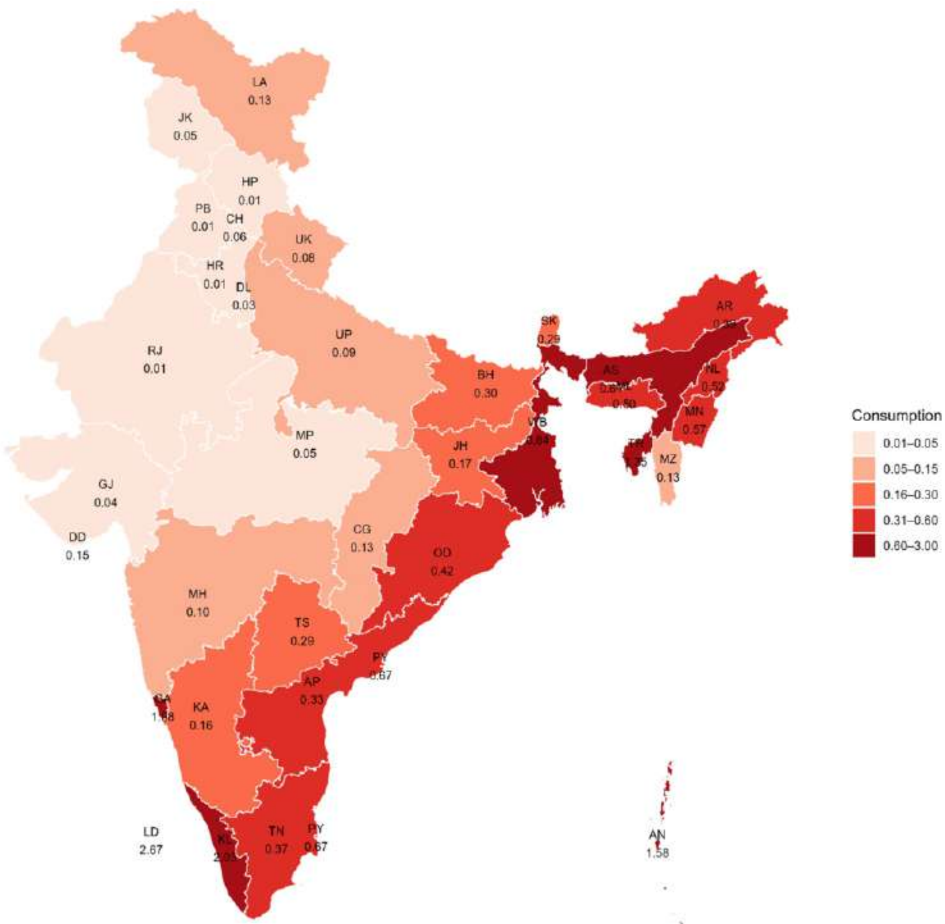


Source: Unit level HCES survey, National Sample Survey (NSS) Rounds, MoSPI, GoI

Regional dietary preferences continue to play a dominant role in shaping fish consumption patterns. As per HCES 2023-24, fish consumption remains concentrated in the eastern and southern states, where it forms an integral part of the local diet. Lakhshadweep leads with 2.67 kg per capita per month consumption, followed by Kerala (2.03 kg), Goa (1.98 kg), and Andaman and Nicobar Islands (1.58 kg). Among large states West Bengal has 0.84 kg per capita per month consumption followed by Assam (0.61 kg). These states have long-standing cultural and economic ties to fisheries, supporting sustained consumption. However, Andhra Pradesh—India's largest producer of fish—reports surprisingly low consumption at just 0.33 kg per capita per month, pointing to a disconnect between production and domestic demand. Other coastal states such as Tamil Nadu and Odisha also exhibit relatively high consumption levels, of around 0.37 kg supported by their proximity to fishing grounds and the presence of robust fisheries sectors. The north-eastern states, particularly Assam and Tripura, also show significant fish consumption, reflecting the dietary importance of fish in the region. In contrast, inland and northern states such as Rajasthan, Haryana, Punjab, and Himachal Pradesh have the lowest levels of fish consumption, with values between 0.01 to 0.05 kg per capita per month, likely due to lower availability, dietary habits favouring other protein sources, and limited local fish production.

To bridge this gap, especially in non-traditional fish-consuming states, there is a need for targeted awareness campaigns, nutritional branding, and integration of fish-based meals in government schemes such as the Mid-Day Meal Programmes. Enhancing domestic demand is essential not only for nutritional security but also to ensure stable market returns for millions engaged in the fisheries value chain.

Figure 3-7: Fish Consumption Across States in India (kg/capita/month) in 2023-24



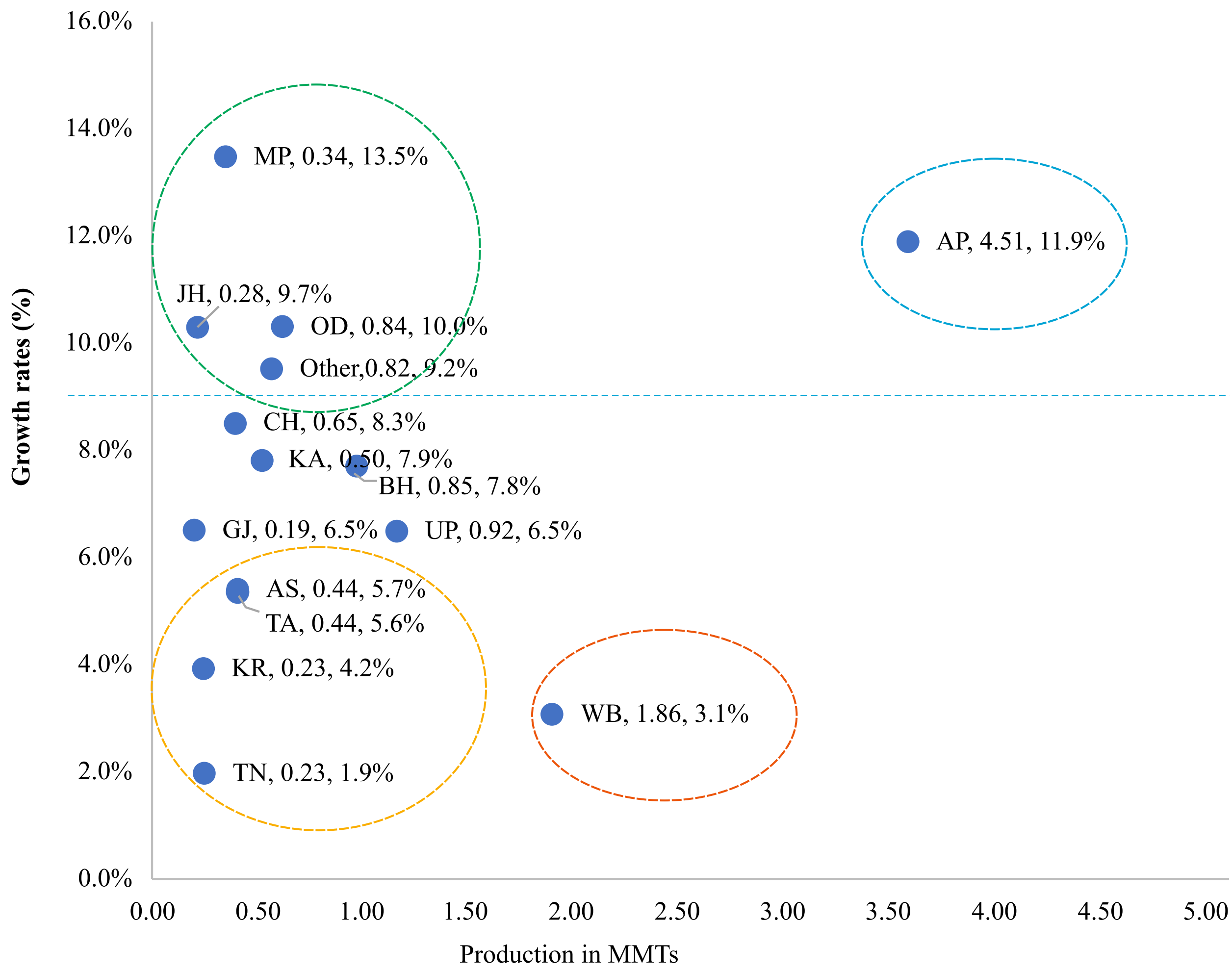
Source: Unit level HCES survey, National Sample Survey (NSS) Rounds, MoSPI, GoI

The previous chapter highlighted the overall fisheries growth pattern across states, and this section delves deeper into the driving factors of inland fisheries in India, analyzing regional variations and key determinants influencing sectoral performance across states.

3.4 State-wise Growth Patterns in Inland Fisheries in India

India's inland fisheries sector has exhibited diverse growth patterns, influenced by regional policies, resource availability, technological interventions, and market linkages. Based on production levels in 2022-23 and CAGR from 2011-12 to 2022-23, states are categorized into four distinct groups. States with production above 1 million tonnes are classified as high production states, while the national state average CAGR of 8.3 percent (2011-12 to 2022-23) serves as the benchmark for high-growth states (Figure 3.8).

Figure 3-8: Scatter Diagram Showing Inland Fisheries Production in 2022-23 and Growth Rate (2011-12 to 2022-23)



Source: Handbook on Fisheries Statistics, GoI (2023)

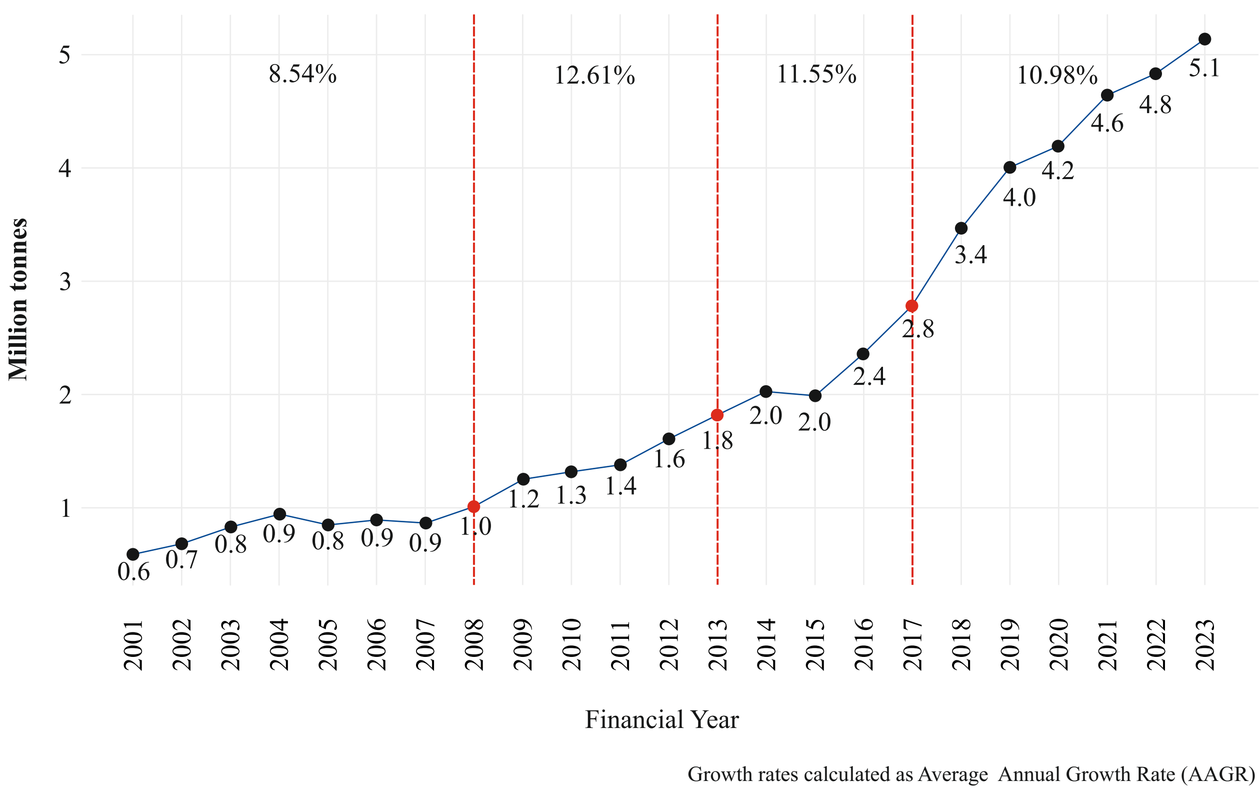
1. High Production - High Growth (Dominant Leaders in Expansion)

Andhra Pradesh is the only state that falls under this category, with both high production and high growth. Andhra Pradesh (4.51 million tonnes, 11.9 percent CAGR) continues to dominate India's inland fisheries sector, accounting for nearly 30 percent of national production. Its rapid expansion is attributed to intensive aquaculture practices through shrimp culture, large-scale private sector participation, well-established hatchery networks, and extensive government support through the Blue Revolution and PMMSY (MPEDA, 2023). Targeted interventions by the Andhra Pradesh Fisheries Department have played a significant role in supporting fish farmers. These include the provision of quality fish seed, financial assistance, infrastructure development, and capacity-building programs. Such initiatives have empowered farmers to adopt modern practices and improve productivity (Kumar & Ansari, 2023). The state has also integrated advanced technologies such as biofloc systems, aeration-based farming, and high-density stocking, leading to enhanced productivity.

3.4.1 The Success Story of Andhra Pradesh in Aquaculture Production

Andhra Pradesh's model for the development and growth of the fisheries sector need to be better understood and the state level driving factors need to be identified for policy lessons. For a comprehensive understanding of the factors responsible for this growth performance we need to understand the sector's development with a historical lens that enabled private investments in the sector early enough fostering an environment for the development of value chains and complemented the reforms in the sector in the recent years (**Figure 3-9**).

Figure 3-9: Inland Fish Production in Andhra Pradesh with Structural Breaks (FY 2001 to FY 2023)



Source: Handbook on Fisheries Statistics (2023) for production;
Note: Structural breaks determined statistically using Phillips-Perron Test

Belton et. al. (2017) maps the development of the aquaculture value chain in the state through late 1950s to 2014. Andhra Pradesh's aquaculture success is largely driven by shrimp culture in its brackishwater areas. Although brackishwater shrimp culture has traditional roots in states like Kerala and West Bengal, Andhra Pradesh emerged as a major producer only from the mid-1980s onwards. Demonstration of semi-intensive shrimp farming, coupled with institutional support such as the establishment of public seed production and research centres (e.g., Andhra Pradesh Shrimp Seed Production and Research Centre) and the subsequent growth of private hatcheries in the late 1980s and 1990s, helped lay the foundation for the state's rapid expansion in shrimp aquaculture. The government supported the farmers intensively with extension services till 1980s and later with the establishment of Fish Farmers Development Agencies (FFDAs) by the central government, the role of the state government in providing extension services reduced. Extension services are crucial in fisheries. The success of pilot projects in the state incentivized other farmers to participate in shrimp farming (Muralidharan, 2010). There is high risk of mortality in breeding and it is important to adopt management practices to reduce this risk for sustaining the enterprise. The support that the government provided to the farmers till 1980s helped in forming institutions for private investment to flow in the sector through establishment of private hatcheries, farmers converting their paddy fields to ponds with more capital investment, inter-state trade to kick off, etc. Post this period with private investment flowing in coupled with some key technological innovations in logistics and infrastructure, the coastal aquaculture took off particularly with pangasius seed variety.

The import of seeds from West Bengal in early 1980s, introduction of better carp breeding techniques like Ovaprim in early 1990s, investments in hatcheries, innovations in the logistics part of the value chain like the HDPE tanks and thermocol boxes for efficient transport in mid 1990s, the nursing of stunted fingerlings in the late 1990s that cut down the crop cycle by two months, mechanization of pond construction from late 1990s, innovation and adoption of floating feeds, improved road network for trade from early 2000s and the introduction of specific pathogen free shrimp species like *L. Vannamei* among other factors contributed to the development of the aquaculture value chain in the state.

The government introduced new fisheries policy in 2015 for the years 2015 to 2020 identifying the sector as a growth engine for social and economic development of the state. The state brought in a number of support measures for the pond culture farmers such as providing financial assistance for mechanization for prawn and shrimp farms as capital subsidy and power subsidy for farmers. These measures were successful in increasing production. Andhra Pradesh's inland fisheries production increased from 1.83 MMTs in 2015-16 to 4.07 MMTs in 2020-21, an AAGR of 18.3 percent. Fiscal incentives like capital subsidy on cold storages, subsidy on fish processing/filleting units, interest subvention on loans, stamp duty exemption in land registration and power subsidy were also introduced for processing units during the same time period.

The government support to the sector along with good returns in the initial years helped in knowledge creation and information dissemination among the capital holding farmers which was later carried forward by the farmers themselves through innovations at farm level infrastructure and practices. The farmer entrepreneurship grew and even post Kolleru Lake restoration[9] when inland aquaculture production fell by 24 percent, the private investment in aquaculture flowed in the following two years. For 2007-09, inland fisheries production in the state grew by 56 percent. Out of 46326 farms registered under CAA from 2006-07 to 2023-24 in India, 22634 farms (49%) were registered in Andhra Pradesh in which 96 percent of the farms were small up to 2 hectares. Similarly, 231 of 330 hatcheries are registered in Andhra Pradesh.

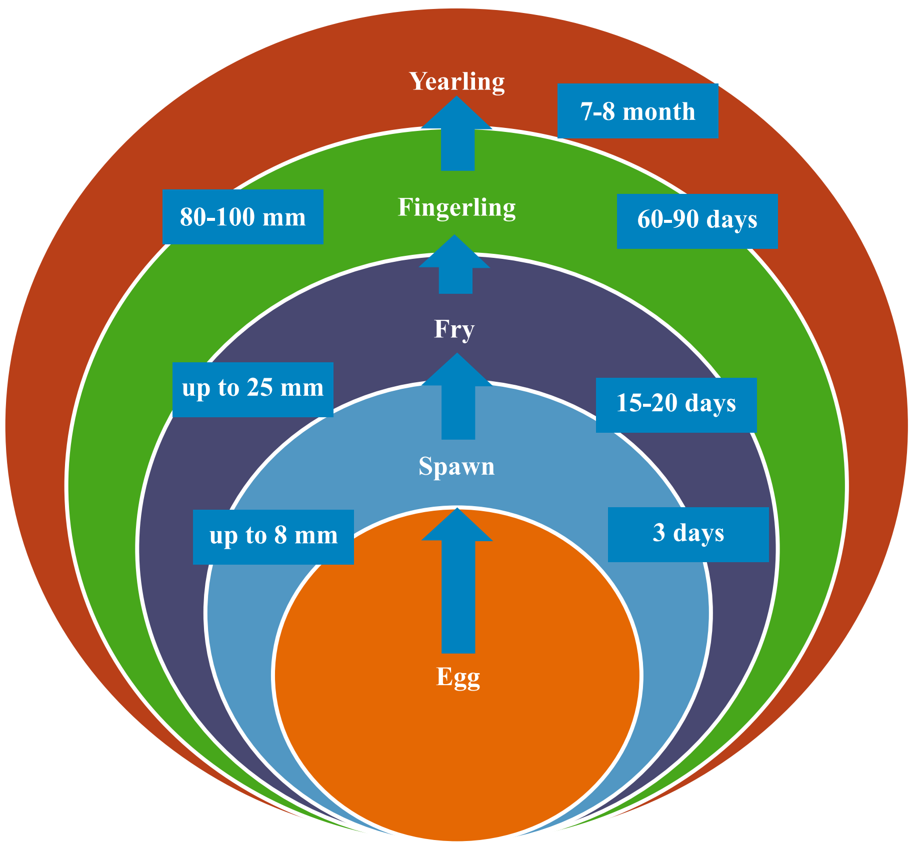
[9] In 2006, Supreme Court appointed Central Empowered Committee (CEC) directed the state government to remove all the encroachments from the Kolleru Lake for preservation. Around 31,000 acres of fish ponds were removed.

Post 2010-11 the government increased its expenditure budget for fisheries. The state expenditure on fisheries in 2012-13 was Rs. 196 crores which increased to Rs. 336 crores in 2023-24. The government has eased doing business for farmers and firms through digitizing the process for applications under various schemes. Broadly, the growth story can be understood through the seed trade from West Bengal in the initial years, establishment of private hatcheries in the state boosting domestic seed production and availability, introduction and import of new and suitable species for breeding, technological innovations in spawning and in logistics, government support in developing value chains through physical infrastructure and extension services, farmer entrepreneurship and innovation over many years and the development of export value chain for shrimps.

2. Low Production - High Growth (Emerging Players in Fisheries Expansion)

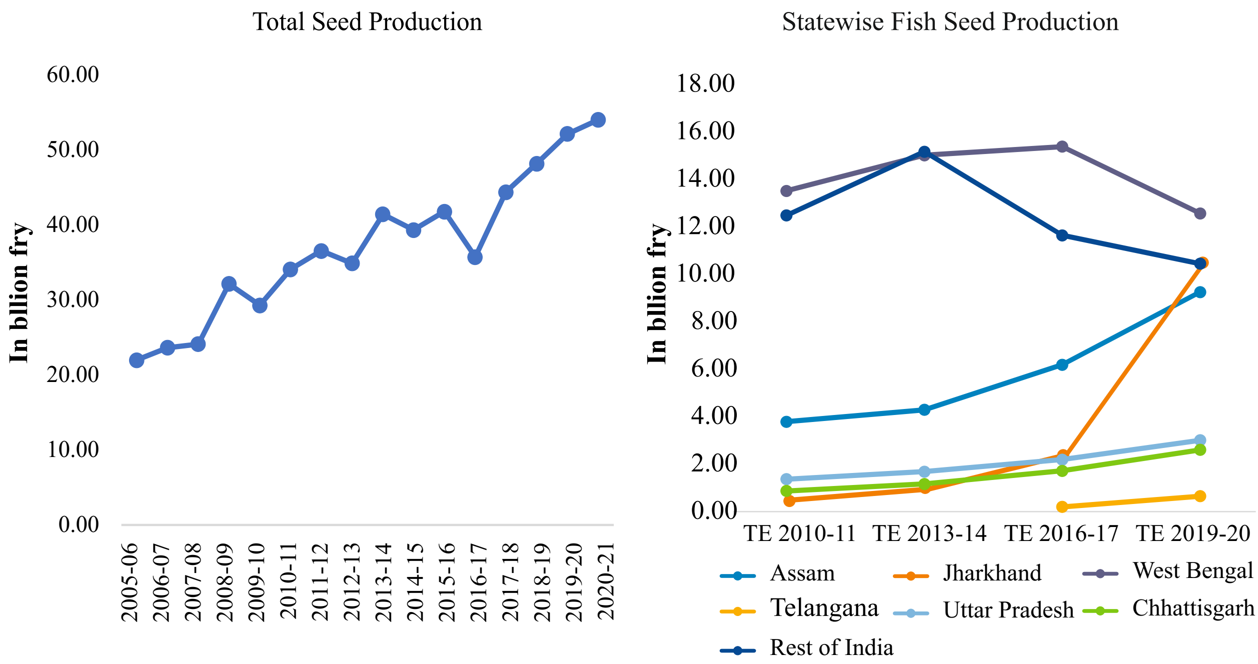
These states currently produce less than 1 million tonnes, but their CAGR is above the national average of 8.3 percent, indicating strong potential for expansion. Odisha (0.84 million tonnes, 10.0 percent CAGR), Chhattisgarh (0.65 million tonnes, 8.3 percent CAGR), Madhya Pradesh (0.34 million tonnes, 13.5 percent CAGR), and Jharkhand (0.28 million tonnes, 9.7 percent CAGR) have emerged as fast-growing contributors to inland fisheries. Chhattisgarh and Madhya Pradesh have capitalized on increasing fish seed production, expanding aquaculture clusters, and incentivizing small-scale farmers through state policies. Jharkhand's growth is fuelled by government funded fish farming clusters, improved market access, and increasing investment in scientific fish seed production (MPEDA, 2023). The fish seed production increased multi-fold in Jharkhand in the last five years (**Figure 3-11**) (See **Figure 3-10** for phases of fish seed development).

Figure 3-10: Phases of Fish Seed Development (for carps)



Source: Action plan for Blue Revolution 2020

Figure 3-11: Total Domestic Seed Production (LHS) and State-wise Seed Production (RHS)



Source: Handbook on Fisheries Statistics, GoI (2023)

Odisha's rapid growth is driven by reservoir fisheries expansion, investment in cage culture, and state-backed aquaculture promotion programs (ICAR-CIFRI, 2022). The production increased from 0.27 MMTs in 2011-12 to 0.84 MMTs in 2022-23 (**Figure 3-12**).

Figure 3-12: Fisheries Production in Odisha (1999-00 to 2022-23)

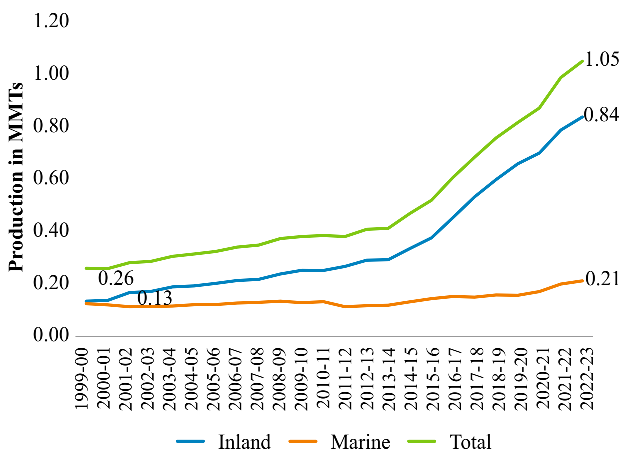
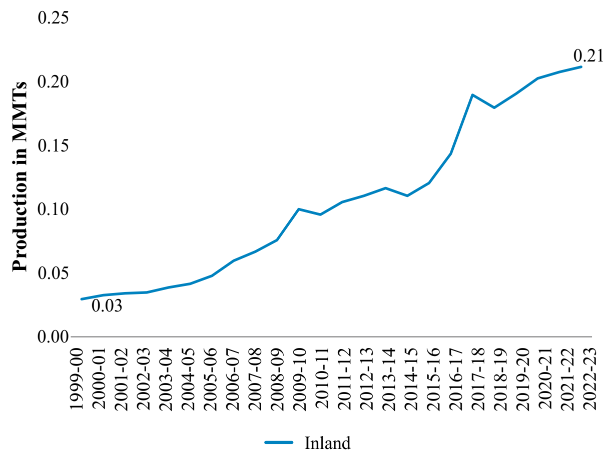


Figure 3-13: Fisheries Production in Haryana (1999-00 to 2022-23)



Source: Handbook on Fisheries Statistics, GoI (2023)

Haryana has promoted inland saline aquaculture, incentivizing farmers to cultivate shrimp and freshwater fish in non-traditional farming areas diversifying production. The production doubled from 0.11 MMTs in 2011-12 to 0.21 MMTs in 2022-23, increasing by 91 percent (**Figure 3-13**).

Figure 3-14: Fisheries Production in Karnataka (1999-00 to 2022-23)

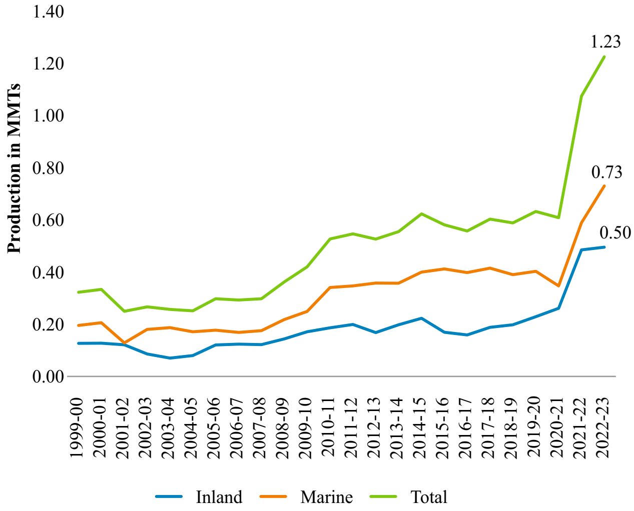
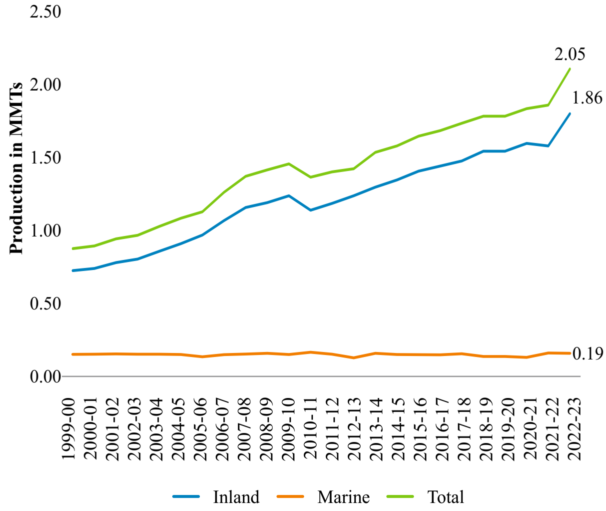


Figure 3-15: Fisheries Production in West Bengal (1999-00 to 2022-23)



Source: Handbook on Fisheries Statistics, GoI (2023)

3. High Production - Low Growth (Mature States Facing Slow Expansion)

West Bengal (1.86 million tonnes, 3.1 percent CAGR) remains a major inland fisheries producer, yet its growth rate has slowed significantly. The state's stagnation is due to market saturation, dependence on traditional aquaculture practices, and constraints in hatchery and cold storage infrastructure (ICAR-CIFRI). Despite having an extensive network of water bodies, West Bengal's reliance on low-intensity fish farming and limited adoption of high-density aquaculture techniques has hindered expansion. The state requires technological modernization, improved seed quality, and enhanced market linkages to regain its growth momentum (**Figure 3-15**).

4. Low Production - Low Growth (Lagging States in Aquaculture Development)

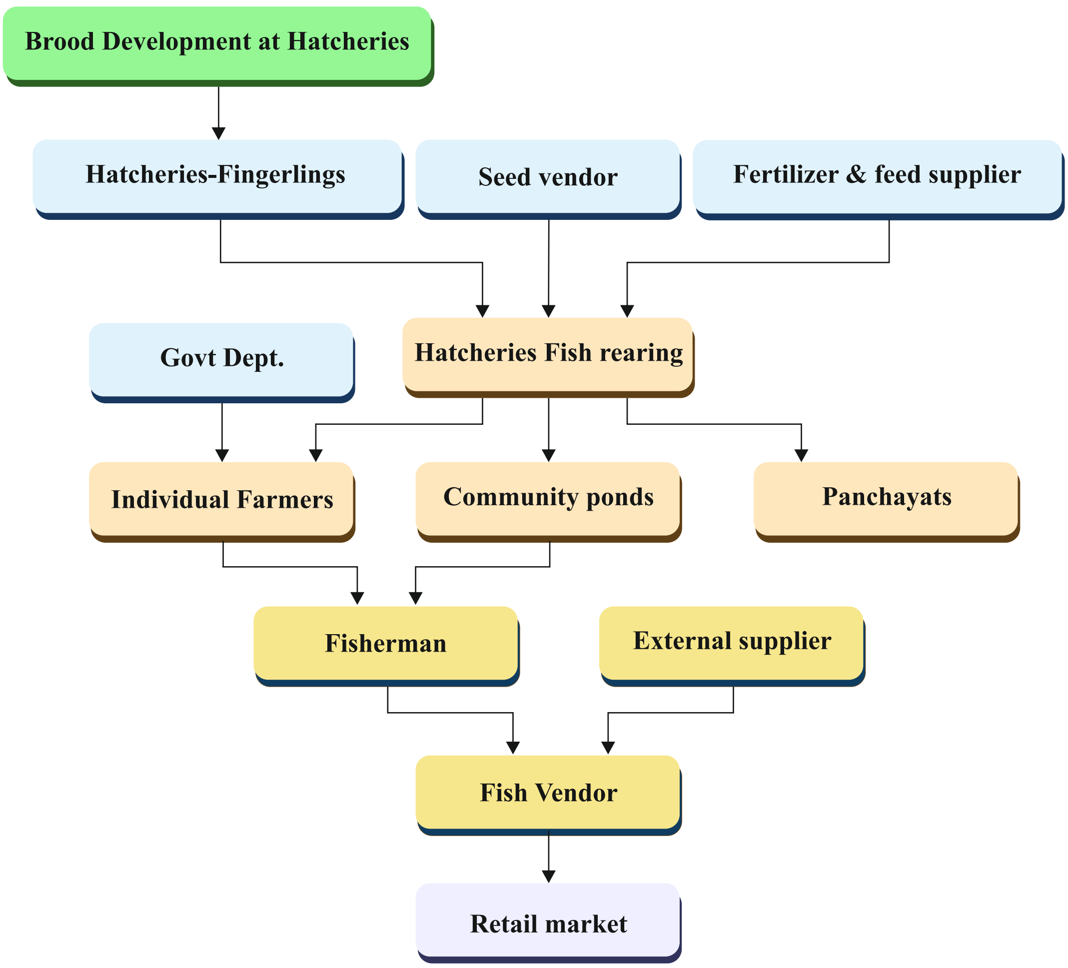
These states have less production and low growth (below national average of 8.3 percent CAGR), indicating structural challenges, policy bottlenecks, and limited investment. The states are ranked in descending order based on production levels. Uttar Pradesh (0.92 million tonnes, 6.5 percent CAGR) has one of the largest inland water resources in India, yet its fisheries sector remains underdeveloped. The slow growth is linked to limited private sector involvement, weak seed supply chains, and slow adoption of intensive aquaculture practices (FAO, 2023). Bihar (0.85 million tonnes, 7.8 percent CAGR) has shown some improvement, particularly in pond-based aquaculture, but continues to face infrastructure constraints and inconsistent production cycles (MPEDA, 2023). Assam (0.44 million tonnes, 5.7 percent CAGR) has struggled with limited availability of quality fish seed, poor post-harvest facilities, and vulnerability to seasonal floods, which disrupt fisheries activities. Karnataka (0.23 million tonnes, 4.2 percent CAGR) (**Figure 3-14**) and Tamil Nadu (0.23 million tonnes, 1.9 percent CAGR) have both lagged due to a greater emphasis on marine fisheries rather than inland aquaculture, along with insufficient policy incentives for freshwater fish production (FAO, 2023). Gujarat (0.19 million tonnes, 6.5 percent CAGR) has remained more focused on marine capture fisheries, leading to slower growth in inland aquaculture. The lack of investment in freshwater hatchery infrastructure techniques has further hindered Gujarat's inland fisheries expansion.

The growth in fisheries production in India is driven by the expansion of inland fisheries, particularly inland aquaculture. In this section we identified the structural breaks in inland fisheries in India and analysed the role of the policy and technological interventions around these breaks. The major drivers of fisheries sector growth can be identified as increasing consumption demand, robust private sector participation, technological imports and research for seed production, and farmer entrepreneurship in the initial phase and the recent phase saw increased government support, infrastructure development and large private investments driving export growth. The previous section also analyzed the state-wise growth in fisheries over two decades and highlight the states which are lagging and which are growing. For policy, the lessons from fast growing states are relevant for lagging states with potential. The next section traces the value chain developed over these phases and identifies the value-chain gaps which can be streamlined to make it more efficient, sustainable, and inclusive.

CHAPTER 4
AQUACULTURE VALUE CHAIN IN INDIA

This chapter analyses the aquaculture value-chain in India. The domestic value chain of inland fisheries in India, particularly for wet markets, remains highly fragmented with multiple layers of intermediaries, leading to inefficiencies and lower price realization for producers. The aquaculture value chain consists of several interconnected stages, from input supply and production to processing, distribution, and export marketing. Indian aquaculture value chain include several interdependent segments, each contributing to production, distribution, and value addition (**Figure 4-1**).

Figure 4-1: Value Chain in India (for carps)



Source: Prepared by author from MANAGE, 2022 report

The upstream value-chain in fisheries refers to the initial stages of production, including broodstock development, hatcheries, seed supply, feed production, and nursery rearing involving both government and private players.

1. Farmers: Fish farmers either own the pond or tank or the water resource and engage in aquaculture, or they lease in individually or through panchayat or cooperatives.
2. Intermediaries (Wholesalers and Commission Agents): These stakeholders facilitate aggregation, price discovery, and transportation but often reduce farmer earnings due to commission structures.
3. Processors and Exporters: Engage in value addition through freezing, packaging, and compliance with global trade standards.
4. Retailers and Consumers: The final stage of the chain where fish is sold in domestic markets or exported.

The CISS-F framework-Competitiveness, Inclusivity, Sustainability, Scalability, and Finance-serves as a structured approach for analysing the value chain of inland fisheries.

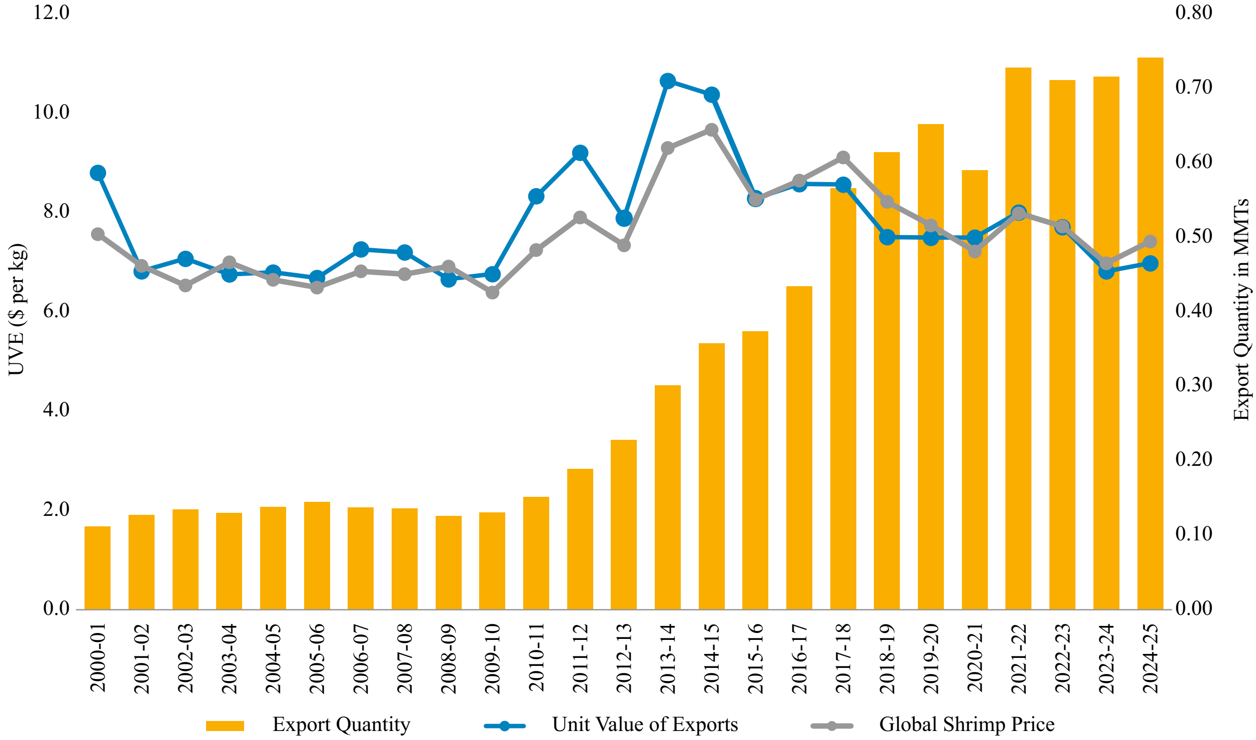
4.1 Competitiveness

We calculate the unit value of exported shrimps (UVE) from India from 1995-96 to 2024-25 and compare it with the global prices of shrimps to assess the competitiveness of Indian shrimps in the global export market. The Pearson correlation coefficient for these time series is 0.86 suggesting strong co-movement. The UVE and global shrimp price show similar trends, indicating that Indian shrimp export prices are influenced by global market movements. The UVE and global prices have stayed in the range of USD 6-9 per kg in this time period with the exception of 2013-15 when UVE was above USD 10 per kg. Indian shrimps have stayed competitive over time (**Figure 4-2**). Following the outbreak of Early Mortality Syndrome (EMS) in major shrimp-producing countries like China, Vietnam, Thailand, and Indonesia around 2013-14, global buyers shifted their sourcing, leading to a significant rise in export demand for Indian shrimp. The increase of UVE of shrimp from India and global shrimp prices suggests strong demand for Indian shrimp exports, with the expansion of *L. Vannamei* farming. However, post-2018, UVE declined despite rising export volumes, suggesting increased global competition, higher supply from other shrimp-producing nations (e.g., Ecuador and Vietnam). However, change in trade policies impact the aquaculture export and the competitiveness of India in this market. The effective duty on Indian shrimp exports to the United States have increased from 7.7 percent to 17.7 percent, including a countervailing duty (CVD) of 5.8 percent and anti-dumping duty of 1.8 percent[10].

With Indian exporters operating on thin margins of around 4 percent as mentioned by Kumar, president of the Seafood Exporters Association of India (Deccan Herald, 2025) this tariff escalation is likely to transmit directly into reduced farm-gate prices and shrinking incomes for producers. Exporters need to diversify both, the export markets and exported products for stability from such shocks (Das, Gupta and Gulati, 2025).

[10] The U.S. imposed an anti-dumping duty on Indian frozen shrimp in 2004, following the International Trade Commission's finding that imports were harming the US shrimp industry. This duty has undergone periodic reviews and currently stands at 1.8 percent. In October 2024, a CVD of 5.8 percent was added by the US on grounds of export subsidies by India, which is 3.57 percent for Ecuador (ITA, 2025). Unlike India, Ecuador does not import SPF brood stock giving them advantage in export market.

Figure 4-2: India's Shrimp Exports in Quantity and Unit Value of Exports (UVE)

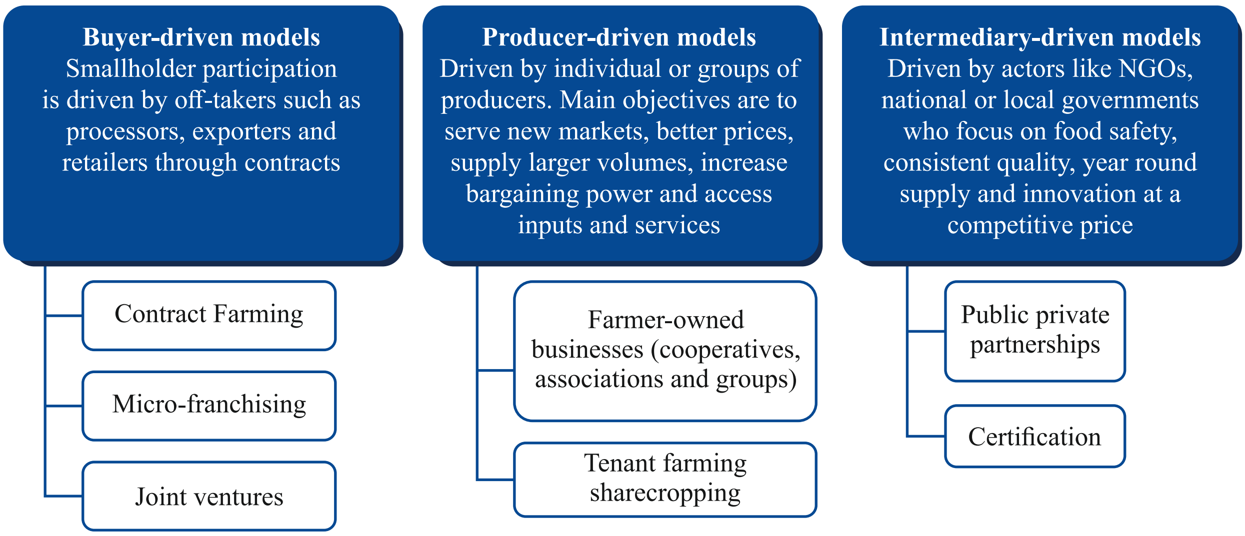


Source: MPEDA for export quantity; Authors' calculations for UVE; FRED Economic Data for global shrimp prices

4.2 Inclusivity

A significant portion of India's aquaculture sector is dominated by small and medium-scale farmers, many of whom lack direct access to high-value markets. However, the aquaculture value chain in India is fragmented, multi-tiered, and often inefficient, leading to price distortions and income disparities among stakeholders. Understanding the structural dynamics of the value chain is crucial for designing policy interventions that enhance market efficiency, improve farmer incomes, and promote sustainability.

Figure 4-3: Types of Inclusive Business Models (IBMs) in Aquaculture



Source: A review of inclusive business models and their application in aquaculture development, Kaminski et al. 2020

Small, medium, and large-scale farmers involved in freshwater fish culture *(carp, catla, rohu)* or shrimp aquaculture in inland fishing in their own property or in community ponds. With increasing inland aquaculture, the community ponds access has become more competitive. In inland aquaculture, the most relevant type is 'polyculture' of major carps, composite carp culture, and shrimp culture. The inland culture fishery sector in India has witnessed significant growth over the past few decades, transitioning from capture fisheries in open water bodies to intensive aquaculture in village tanks and ponds (Ghosh & Indu, 2005). However, this expansion has not been inclusive, as the shift in property regimes and the rising cost of entry have systematically excluded traditional fishing communities. For instance, village ponds play a critical role in enhancing small-scale inland fisheries, serving as a vital source of livelihood for rural communities. These water bodies are leased to fish farmers through an auction process, ensuring a structured approach to fisheries management. The auction-based leasing system allows fish farmers to gain temporary rights to fish cultivation, enabling organized and sustainable aquaculture in rural areas. While the sector holds the potential to contribute to rural livelihoods and food security, the uneven distribution of access and benefits raises critical concerns about equity and social justice. The need for higher investments, social capital, and the ability to enforce fishing rights has led to the dominance of affluent entrepreneurs in the sector. The study by Ghosh and Indu (2005) highlights that in states like Andhra Pradesh and Haryana, influential upper-caste individuals have taken over village ponds, relegating traditional fisherfolk to wage labour. Similarly, in Bihar and Kashmir, traditional fishing communities such as the *Mallahs* and *Hajis* have lost control over water bodies, with powerful individuals securing leases through political connections. In output market, smallholders rely on local intermediaries, which can lead to inefficiencies and lower farm-gate prices.

The cooperative movement in India's fisheries sector dates back to 1913, when the first Fishermen's Cooperative Society, "Karla Machhimar Cooperative Society Ltd.", was established in Ratnagiri District, Maharashtra. Initially, these cooperative societies operated in isolation, lacking a unified structure to collectively address their concerns or advocate for their interests at a national level. Over time, efforts were made to organize fisheries cooperatives at a broader scale. Local fishery cooperatives were gradually brought together at the district level, followed by the formation of state-level federations. However, there was no national-level organization to represent the collective interests of fishery cooperatives at the central level. Recognizing this gap, the All-India Federation of Fishermen Cooperatives was established in 1980 as the national apex body for fisheries cooperatives. To strengthen its role in supporting cooperative fisheries, the federation was later renamed as the National Federation of Fishers Cooperatives Ltd. (FISHCOPFED). Today, FISHCOPFED plays a vital role in promoting, organizing, and advocating for fisher cooperatives across India, ensuring that small-scale fishers have access to resources, markets, and financial support to sustain their livelihoods. Through its network, FISHCOPFED helps in policy advocacy, training, and capacity building for fishery cooperatives, contributing to the overall growth of the inland and marine fisheries sectors in India.

Box 4-1: Success Story of Telangana's Fishermen Cooperative Model

Telangana has emerged as a leader in cooperative-based aquaculture, significantly improving the livelihoods of inland fishers. With 4,634 fishermen cooperative societies covering over 3.36 lakh active fishers, the state has successfully integrated small-scale fishers into a structured value chain. A key initiative driving this success is the 100 percent subsidized fish seed and prawn juvenile stocking program, which has enhanced fish availability and productivity across the state's vast 7.75 lakh hectares of water spread area.

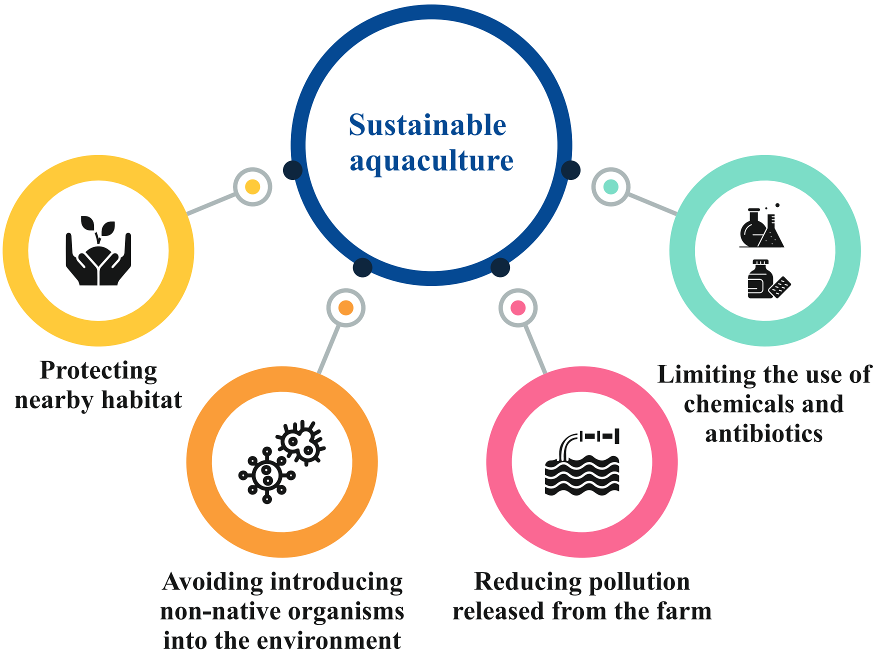
The Telangana government has played a proactive role in fisheries development by bringing all minor irrigation (MI) tanks under the Fisheries Department, ensuring systematic fish seed stocking and production growth. Investment of Rs. 296.52 crores in fish seed stocking and Rs. 42.76 crores in prawn juvenile supply have led to a 30 percent increase in fish production, rising from 2.68 lakh tonnes in 2014-15 to 3.48 lakh tonnes in 2020-21. To enhance fish marketing, the government introduced Mobile Fish Retail Outlets, empowering women from backward communities to engage in direct fish sales improving income distribution in the sector.

Strengthening cooperative fisheries, Telangana implemented *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) and Integrated Fisheries Development Scheme (IFDS), allocating Rs. 1,000 crores for infrastructure, hatcheries, biofloc units, cage culture, and market facilities. This model has significantly improved fishers' livelihoods while ensuring sustainability. Recognized as the Best Performing Inland Fisheries State on World Fisheries Day 2021, Telangana's success story highlights how cooperative-based approaches, state intervention, and infrastructure development can transform aquaculture into a sustainable and profitable sector.

4.3 Sustainability

Aquaculture offers significant environmental sustainability advantages compared to other forms of animal husbandry. According to the Blue Food Assessment (Gephart, et al., 2021) the carbon footprint of aquaculture is substantially lower, generating 5.1 kg of carbon equivalent per kg of edible fish product, compared to 8.4 kg for poultry, 12.2 kg for pork, and 39.0 kg for beef. Hence, fish farming is one of the most climate-friendly protein sources. Moreover, aquaculture emits considerably fewer greenhouse gases compared to traditional rice cultivation, known to produce significant quantities of methane and nitrous oxide, estimated at 5 tonnes CO_2 equivalent per hectare per year (Robb et al. 2017) (Gulati & Singh, 2023). Despite its environmental advantages, intensive aquaculture practices can have negative impacts on ecosystems, particularly when not managed sustainably (Yuan, et al., 2019). The environmental impact varies depending on the farming techniques employed (Desilva & Soto, 2009). Robb et al. (2017) found that Indian pond aquaculture produces 2.12 kg of CO_2 equivalent per kilogram of carp live weight annually, resulting in about 3.1 tonnes of CO_2 equivalent per hectare per year-still lower than that of rice paddy fields. Sustainable practices, such as integrating rice and fish cultivation, can maximize land and water resource use while minimizing ecological damage, offering a viable solution for environmentally sustainable food production (Ahmed & Turchini, 2021).

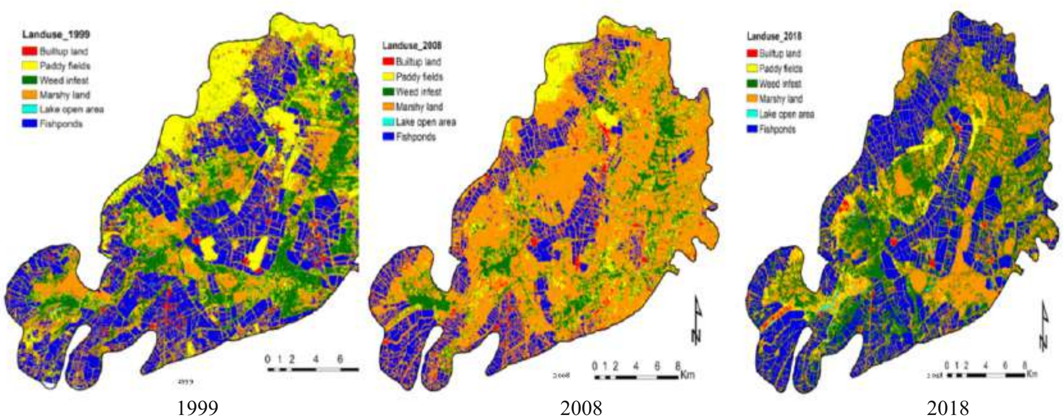
Figure 4-4: Components of a Sustainable Aquaculture Model



Yet, poorly managed intensification—through nutrient loading, antibiotic misuse, or saline water seepage—can impact the environmental sustainability.

For instance, in Andhra Pradesh's Kolleru Lake region, where the rapid expansion of fish farming—driven by higher profitability—led to saline water seepage into adjacent agricultural fields, rendering soil unsuitable for crop cultivation. Satellite analysis by Rao et al. (2004) found that by 2001, 42 percent of Kolleru Lake's 245 km² area had been converted to aquaculture, while only 8.5 percent remained under agriculture. Alongside effluent discharge and unchecked encroachments, these practices triggered ecosystem degradation, prompting judicial intervention and a rollback of shrimp ponds. However, the high economic incentives have led to the resurgence of saline water aquaculture in the region (**Figure 4-5**). As the Government scales up investments under schemes like the PMMSY, ecological safeguards must be institutionalized. This includes enforcing water treatment standards, zoning aquaculture activity, aquifer mapping, monitoring salinity impacts, and integrating environmental assessment into subsidy-linked production incentives.

Figure 4-5: Land-use Map of Kolleru Lake Wetland (1999, 2008 and 2018)



Source: Kolli et al. (2020)
Note: Blue area is fish ponds

4.4 Scalability

Inland aquaculture in India has significant potential for expansion, driven by its vast water resources, growing demand for fish protein, and government initiatives supporting blue economy development. However, scalability varies across states due to differences in water availability, infrastructure, and technological adoption. However, India's inland fisheries sector exhibits a significant regional concentration, despite the presence of vast water resources across various states.

The scalability of aquaculture is primarily influenced by three interrelated factors: natural resource endowment, infrastructure readiness, and institutional support systems. States like Andhra Pradesh, West Bengal, and Odisha have leveraged their natural advantage in water availability alongside proactive government policies and private sector engagement to scale up aquaculture activities. In contrast, states such as Bihar, Chhattisgarh, and parts of Uttar Pradesh, despite having inland hydrological potential, lag behind due to fragmented land holdings, limited access to quality seed and feed, inadequate post-harvest infrastructure, and access to markets.

Even among the major inland aquaculture-producing states, Andhra Pradesh stands out as an outlier. The state benefits from a highly developed and vertically integrated ecosystem—comprising a dense network of hatcheries, seed and feed suppliers, cold chains, processing units, and export logistics—that has enabled it to dominate both domestic production and export markets. This convergence of infrastructure, policy facilitation, and market connectivity has allowed Andhra Pradesh to dominate national aquaculture production, particularly in shrimp farming, and tap into rising demand in export markets. Andhra Pradesh leads in inland fish production with 11514 km of rivers, 1.31 lakh ha of reservoirs, and 3.48 ha of tanks and ponds. Andhra Pradesh stands out as an exceptional case in inland aquaculture, contributing disproportionately to national production, contributing to 36 percent of fisheries and aquaculture production in TE 2022-23. With abundant water resources, advanced farming techniques, and a highly developed hatchery network and processing in value chains, the state benefits from economies of scale (**Figure 4-6** and **Figure 4-7**).

Figure 4-6: Hatcheries Concentration in India (2023-2024)

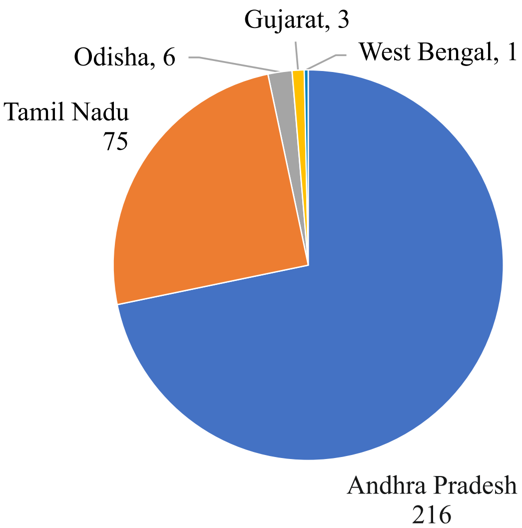
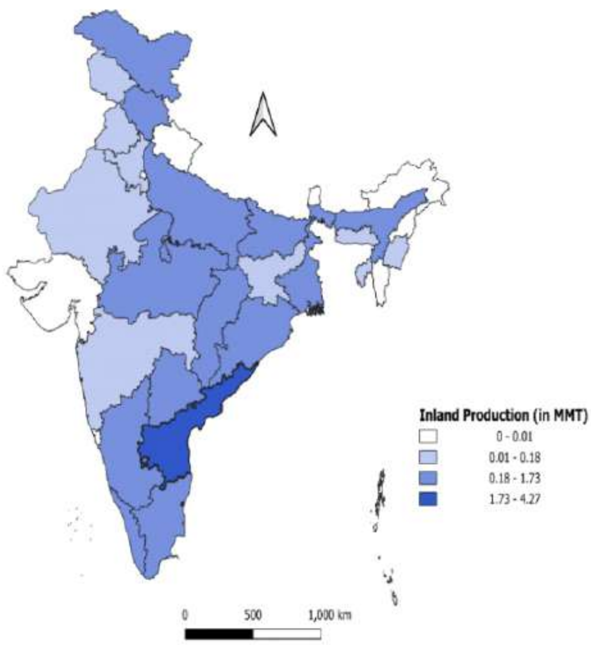


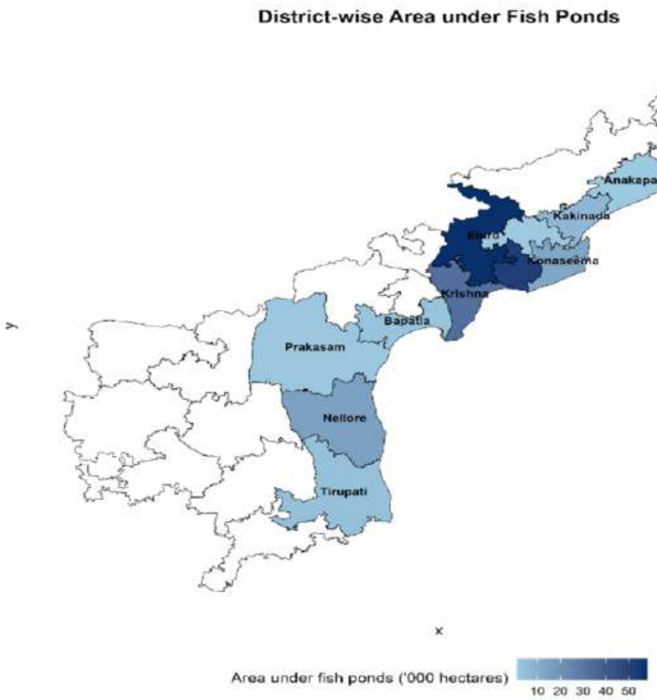
Figure 4-7: India's Inland Fisheries Production(2023-2024)



Source: Handbook on Fisheries Statistics, GoI (2023) and CAA Annual Report 2023-24

Even within the state, Eluru, West Godavari and Krishna districts comprise 75 percent area of aquaculture of the state. (AP Aquaculture Information System) (**Figure 4-8**).

Figure 4-8: District-wise Area Under Fish Ponds in 2023-24 in Andhra Pradesh



Source: AP Aquaculture GIS, Govt. of Andhra Pradesh Note: Only 12 of 26 districts in Andhra Pradesh have area under fish culture. All 12 districts are coastal.

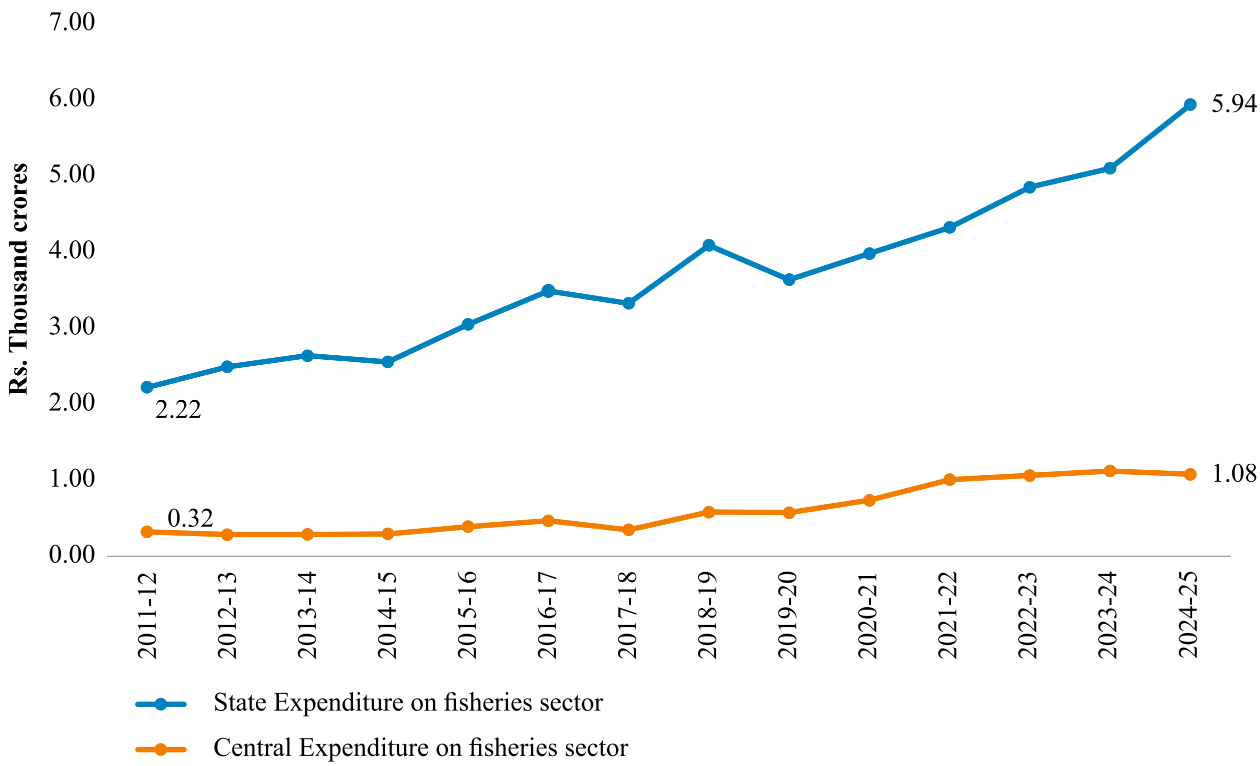
States with limited water resources, such as Punjab and Haryana face challenges face challenges in scalability due to lack of reservoirs and fresh water availability. Punjab, with only 868 km of rivers and 687 ha of reservoirs, has minimal scope for expansion. Haryana, similarly constrained by water availability, requires alternative models like saline water shrimp farming. The state has witnessed growth in aquaculture and fisheries production in canal water, production rose by 90 percent between 2011-12 to 2022-23. The state has 1.45 lakh hectares of saline/water logged area, and area under saline aquaculture is 655 hectares. Out of total 6.74 Mha. SAS, 1.20 Mha. is in the north-western India which is Inland Saline Water (ISW): Punjab (1.51 lakh ha., Haryana 2.32 lakh ha., Rajasthan 3.75 lakh ha., Bihar 1.53 lakh ha., Uttar Pradesh 1.37 kah ha., and MP 1.39 lakh ha.). According to CSSRI, Karnal study, Salinity Affected Subsoils (SAS) in India is expected to increase from, 6.74 mha. To 16.25 mha. These saline-affected lands, often unsuitable for traditional agriculture, hold immense potential to be transformed from wastelands to wealth lands. Hence, there is an ample opportunity to expand the production in this state. To scale inland aquaculture effectively, states must optimize water resource utilization by Recirculating Aquaculture Systems (RAS) and biofloc technology which can enhance productivity, particularly in states with water scarcity and for sustainable aquaculture.

4.5 Finance

In the last decade the expenditure in the fisheries sector has escalated which reflects on the growth of the sector. **Figure 4-9** shows that Central government expenditure on fisheries have increased from an annual expenditure of Rs. 320 crores in 2011-12 to Rs. 1080 crores in 2024-25 (RE) in real terms at 2011-12 constant prices. The Union budget 2025-26 has allotted a budgeted expenditure of Rs. 2704 crores for fisheries, 2 percent of total agriculture budget. Public expenditure on fisheries from 2011-12 to 2024-25 has registered a CAGR of 9 percent. State governments' expenditures on fisheries have also increased from an annual expenditure of Rs. 2220 crores in 2011-12 to Rs. 5940 crores in 2024-25 with a CAGR of 7.3 percent in real terms.

The public expenditure, at both central and state level has increased in real terms. At the centre, there has been shift in the schemes and policies from 2020-21 onwards with the launch of an umbrella scheme PMMSY with an outlay of Rs. 20050 crores over a period of five years. State governments have their own welfare and development schemes for the fish farmers including assistance in their capital requirements. Earlier in 2015-16, the central government had launched the 'Blue Revolution' scheme and later in 2018-19 set up the Fisheries and Aquaculture Infrastructure Development Fund (FIDF).

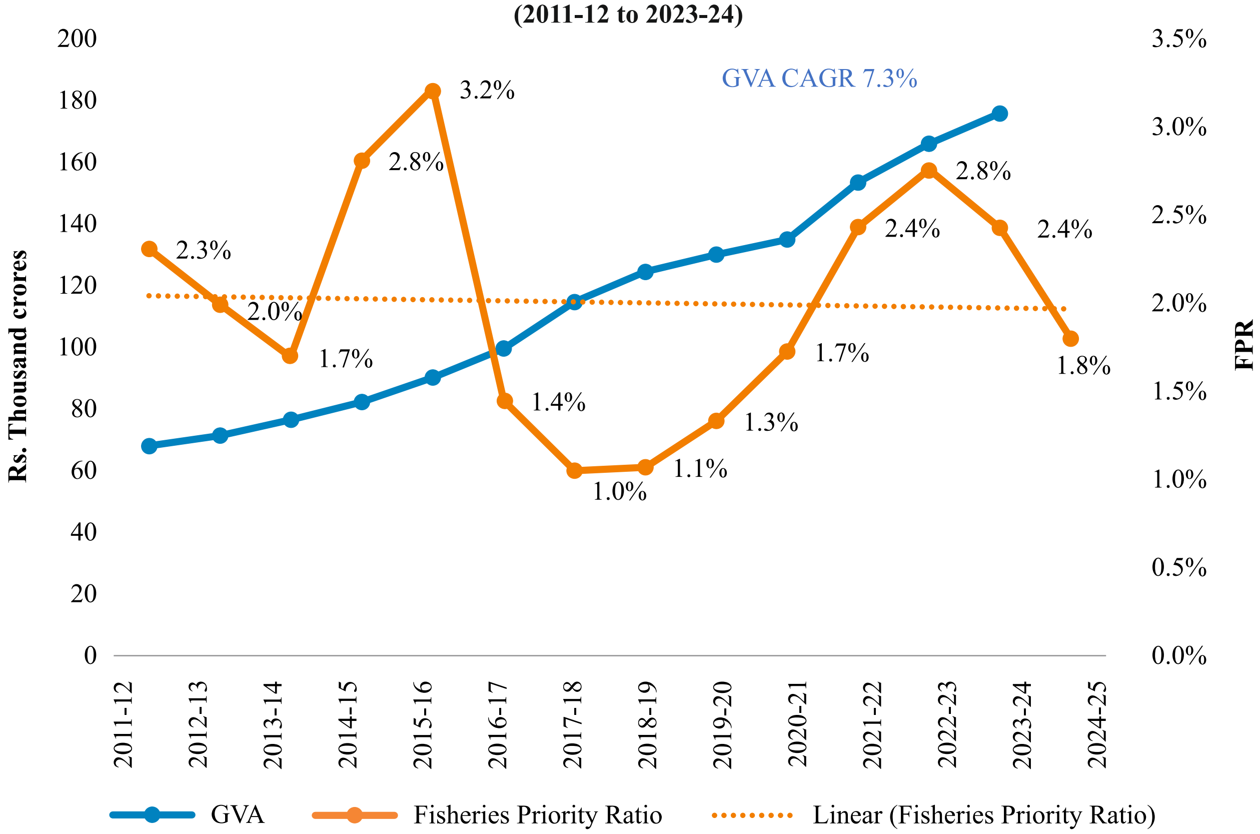
Figure 4-9: Central and State Expenditures on Fisheries Sector (2011-12 to 2024-25) at Constant Prices of 2011-12



Source: RBI State Finances; Union Budget Document

We calculate the ratio of real expenditure on fisheries as a percentage of real budget expenditure in agriculture and allied sectors to assess the expenditure priorities for fisheries in the central and state budgets from 2011-12 to 2022-23 by Fisheries Priority Ratios (FPRs). We find variations in the ratios over time for both central and state government expenditure. Linear trends of these time series show a stagnant priority for fisheries sector development in the central government expenditure. This is reflected on the sustained growth of Gross Value Added (GVA) for fisheries at the national level. The national aggregate GVA for fisheries has increased at a CAGR of 7.6 percent for the period 2011-12 to 2023-24 at 2011-12 constant prices (**Figure 4-10**).

Figure 4.10: Union Govt. Fisheries Priority Ratios and GVA Fisheries (2011-12 to 2023-24)

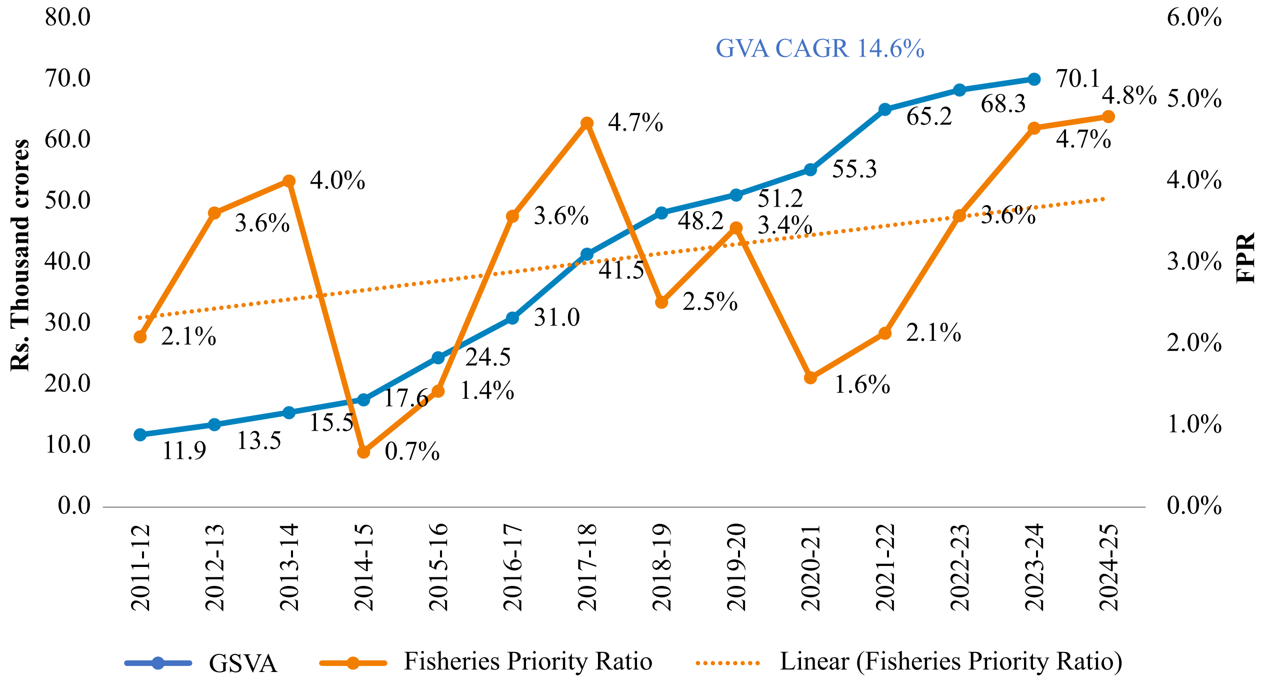


Source: RBI State Finances and Authors' calculations
Note: Budget expenditures at constant prices of 2011-12. For a consistent comparison over time, we have excluded expenditure on PM-KISAN from 2018-19 onwards and Interest Subsidy Scheme from 2016-17 onwards from Agri and allied sectors expenditure when the latter was moved from MoF to MoAFW budget

We investigate public expenditure on fisheries for four states: Andhra Pradesh, West Bengal, Odisha and Haryana. Andhra Pradesh has the largest increase in share of domestic production over the last two decades. We compare the trends in FPR with the GSVA. We find among the four states only West Bengal has a downward trendline, i.e., a decreasing priority of expenditure on fisheries as compared to total agriculture expenditure. This downward trend is accompanied by a low growth rate of GSVA at just 3.1 percent. While Andhra Pradesh, Odisha and Haryana show high growth rates of GSVA at 14.6, 9.1 and 7.7 percent respectively accompanied by an increasing trendline of FPR. So, we find a positive correlation between higher priority for expenditure on fisheries over time and the GSVA for fisheries over the same period. (**Figure 4-11** to **4-14**)

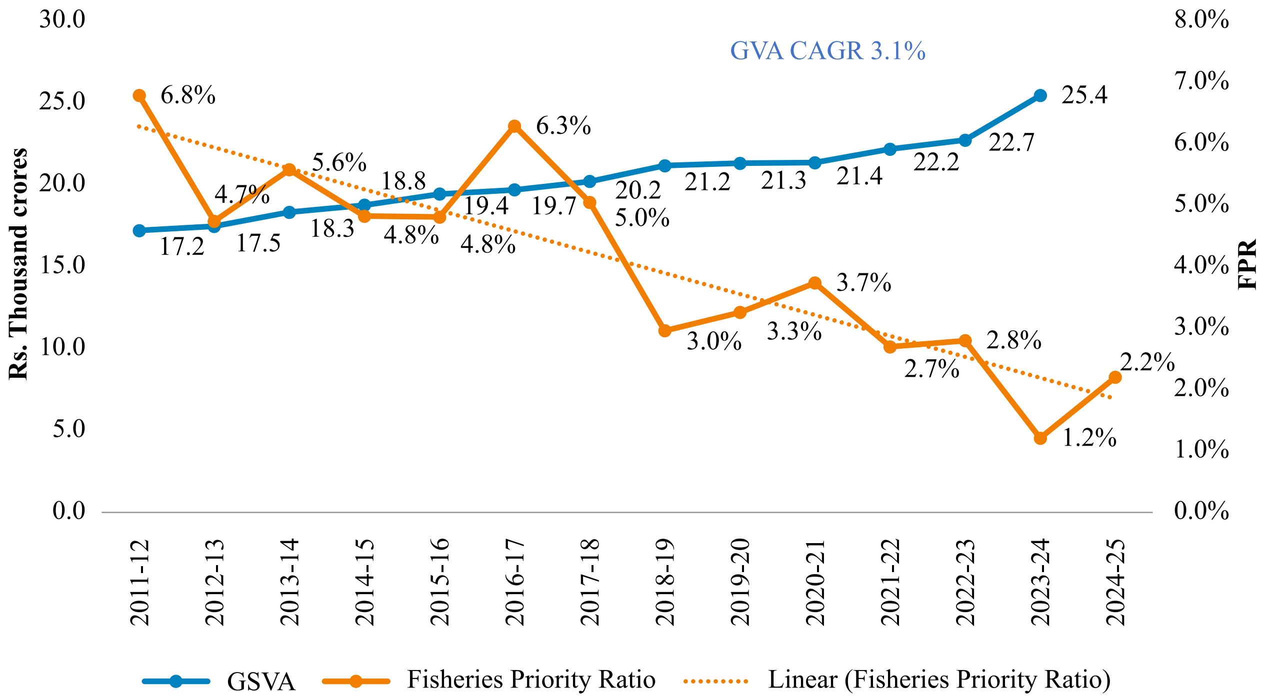
There is a research gap in understanding state-wise the differential growth patterns and their drivers. Though the real expenditure has been increasing for fisheries in all four states, West Bengal, the growth in expenditure is modest than the other three states which explains their slow growth rates. The FPR declined from 6.8 percent in 2011-12 to 2.2 percent in 2024-25 in West Bengal. Total expenditure in value-chain support in Andhra Pradesh was Rs. 121 crores in (RE) 2023-24, in contrast to a meagre 49 crores in West Bengal. In Odisha as well the total expenditure in value-chain development in state budget Rs. 105 crores in (RE) 2022-23. About 50 percent of that expenditure goes to development of shrimp exports and promotion of intensive aquaculture and biofloc technology. Haryana state has also increased expenditure in value-chain development from Rs. 26 crores in 2020-21 to Rs. 182 crores in (RE) 2022-23, comprising 73 percent of their total state expenditure. This share is 32 percent in West Bengal, and 17 percent in Odisha.

Figure 4-11: Andhra Pradesh Govt. Fisheries Priority Ratios and GSVA Fisheries (2011-12 to 2024-25)



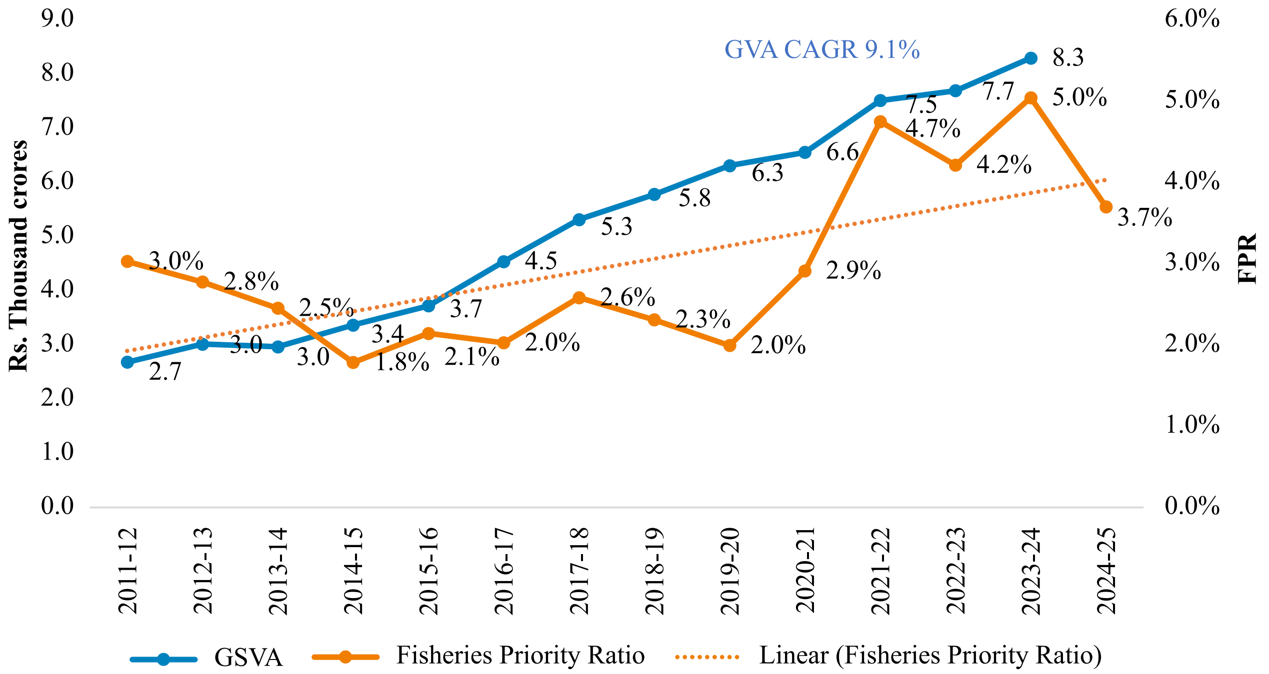
Source: RBI State Finances and Authors' calculations. GSVA fisheries data available till 2023-24.

Figure 4-12: West Bengal Govt. Fisheries Priority Ratios and GSVA Fisheries (2011-12 to 2024-25)



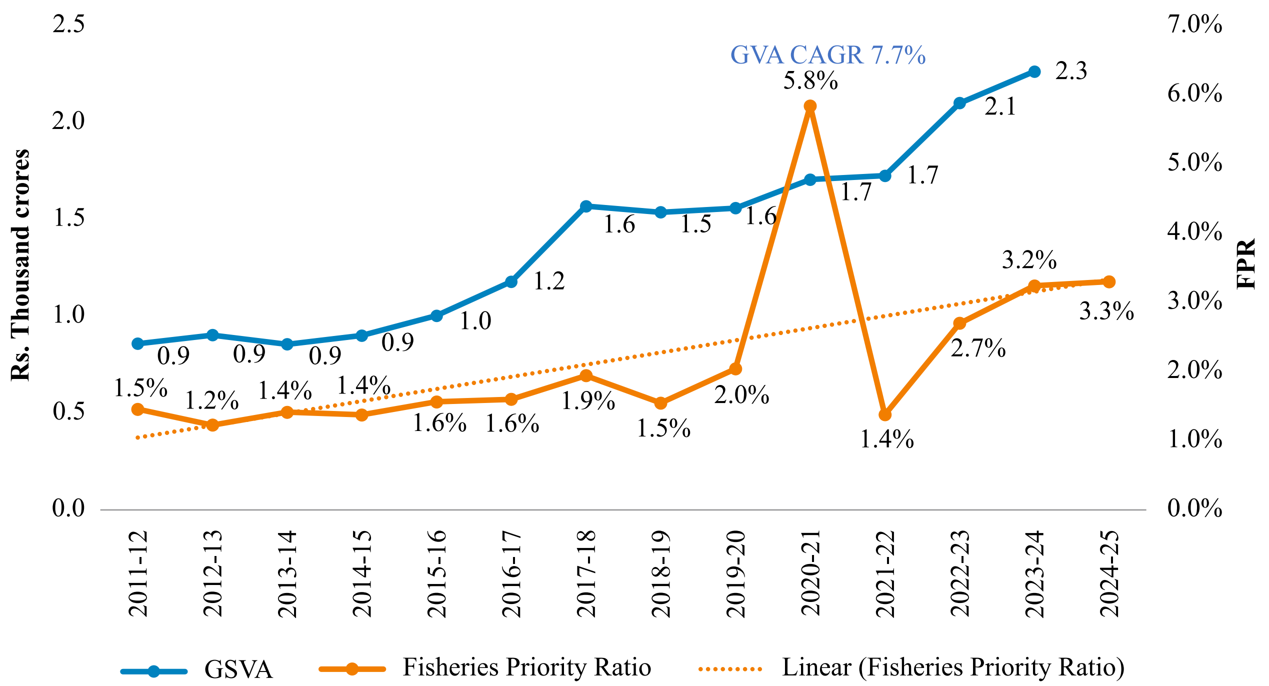
Source: RBI State Finances and Authors' calculations

Figure 4-13: Odisha Govt. Fisheries Priority Ratios and GSVA Fisheries (2011-12 to 2024-25)



Source: RBI State Finances and Authors' calculations

Figure 4-14: Haryana Govt. Fisheries Priority Ratios and GSVA Fisheries (2011-12 to 2024-25)



Source: RBI State Finances and Authors' calculations

Commercial aquaculture growth is also driven by the private aquaculture feed industry expansion in Asia since 1990s where China, Vietnam, Thailand, Taiwan and India are the major players. Of all the private players in India this section highlights the major companies operating in the aquaculture and fisheries sector. At the private level, there are multiple business models in the aquaculture and inland fisheries sector both in the input and output markets. Within aquaculture, shrimp industry is more organized. They are operating with a vertically integrated model, which provides feed, farm management, processing, and export following BAPs. As of 2024, the revenue of the Avanti Feeds was Rs. 5505 crores, controls around 50 percent of shrimp feed market share. Avanti Feeds Limited exports more than 22 countries including USA, Japan, with more than 16000 farmers' network (Avanti Feeds Ltd., 2024). **Table 4-1** gives a snippet of some of the key private players in this sector.

Table 4-1: Key Private Players in Sea Food Value Chains in India

Company	Description	Major Location
Avanti Feeds Limited	Established in 1993, Avanti Feeds has grown into one of India's largest shrimp feeds producing company in aquaculture space, with a sale of more than 400k MT in 2022-23. Committed to promoting sustainability and reliability within the aquaculture industry, Avanti Feeds strives to enhance the sector's long-te m viability.	Telangana
Sandhya Aqua	Sandhya Aqua Exports Pvt. Ltd. Is one of the largest exporter and processor of shrimp in India (more than 15,000 MT), operating since 2005. With over 1,000 acres of aquaculture farms and BAP-certified hatchery operations, the company ensures quality control from broodstock to harvest.	Andhra Pradesh
Devi Seafoods	Devi Sea Foods has established in 1992 and currently function as a comprehensive, vertically integrated shrimp value chain that spans from hatchery to export, ensuring quality and traceability at every stage. It's under very large** category in processing producing 52000 MT shrimp per year, 2022-23.	Andhra Pradesh
Apex Frozen Food	It is one of the integrated producer and exporter of shelf stable quality aquaculture products since 1995. It supplies ready-to-cook products to a diversified customer base consisting of food companies, retail chains, restaurants, club stores and distributors spread across the developed markets of USA, UK and various European countries. It's output majorly comprises of variants of processed *Vannamei* shrimp (Whiteleg shrimp) and are sold under the brands owned by our customers and also through our brands namely Bay fresh, Bay Harvest and Bay Premium. Shrimp production is under large category, more than 34,240 MT per year, 2022-23.	Andhra Pradesh
Waterbase Ltd.	The Waterbase Ltd., established in 1993, is a leading manufacturer and exporter of prawn feed (medium), shrimp, and crab & fish processing machinery. Waterbase exports shrimps in different forms to quality conscious markets of Japan, USA and Europe - IQF, Block Frozen and Cooked. The company's processing plant is FDA listed, EU approved and processing is as per HACCP guidelines.	Andhra Pradesh

Company	Description	Major Location
Zeal Aqua	Zeal Aqua operates as an aquaculture company, focusing on shrimp farming and satellite farming activities. They offer shrimp feeds, shrimp seeds, probiotics, and other aquaculture-related products. The company follows a farm-to-fork model, integrating aquaculture farms and processing plants.	Gujarat

*Source: Inventiva, industry sources, Shrimp Insights (2024). Feed manufacturing scale: * Very large = > 400k MT, large = 200-400k MT, medium = 100-200k MT, small = 50-100k MT, very small = < 50k MT. While exact sales figures are not publicly disclosed, available secondary information categorizes the scale of operations—**for production of shrimp categories are: small = < 10,000 MT, medium = 10,000-20,000 MT, large = 20,000-50,000 MT, very large = > 50,000 MT. The list is not exhaustive, but it suggests that some firms operate integrated value chains spanning from feed production to processing, while others remain specialized in specific segments. Notably, these companies are predominantly concentrated in Andhra Pradesh, reflecting the regional clustering of India's aquaculture industry.*

Key challenges and risks in adoption of aquaculture and its scalability

This section provides a general overview on the challenges and risks in scaling up aquaculture practice in the country. Some issues are specific to the sector and some are structural issues.

- **Access to Finance**

  The key challenge for a farmer in adopting aquaculture is capital requirement. Several studies have surveyed or estimated the costs of cultivation in terms of paid-out costs for aquaculture practice for carps and shrimps. These variable costs are themselves high when compared to paddy or other crop cultivation but the fixed capital requirements in aquaculture for pond construction, implements, etc. are also sufficiently large. Access to credit for Indian farmers has been a long-standing stubborn problem which even after improvements remains an anchor holding back farm productivity in India. Small land holding sizes, high risk in production and marketing and low uncertain returns from farming disincentivizes formal lenders to provide loans to farmers. According to AIDIS 2019, access to formal credit has increased from 56 percent to 66 percent in rural India, however 34 percent is yet from non-institutional sources in rural India (AIDIS, 2019). This is a structural issue that needs to be addressed for scaling up aquaculture practices in the country. A better targeted approach can be developed where the value chains allow for stability in income from aquaculture and consequently access to credit can be facilitated for those value chain integrated farmers.

- **Technical knowledge**

  Diversification from crop cultivation to aquaculture demands the technical knowledge set for competitive and remunerative yields. This is where the government needs to step up in providing extension services through either public institutions and demonstration centres or through incentivizing private players or both by extending their expertise to new farmers for better value chain integration and market efficiency. For example, shrimp exporters have interest in ensuring the quality of their produce for meeting high quality requirements and stable supply. This can be best met only through new farmers learning better management practices and techniques from established market players. A specific example can be taken from Haryana where feed suppliers from Andhra Pradesh and Tamil Nadu provide feed for shrimp farming in the state along with technical expertise on how to feed the fish at every stage of growth for efficient utilization and maximum yield. There also exists a risk factor here if technical knowledge with the farmer is insufficient. Mismanagement increases disease risk in the farms. Biosecurity risks and mortality from diseases in aquaculture practice is very high even when compared to climate risks with crop cultivation. These risks can be minimized with better management and farmers may not be able to afford to learn these practices through errors.

- **Poor infrastructure and inefficient value chains**

  This is a structural as well as sector specific challenge. The infrastructure required for sectoral development of inland aquaculture includes seed hatcheries, brood stock facilities, cold storages and cold chain logistics, feed mills and distribution networks, processing facilities, research centres for species diversification, etc. Inland fisheries production in India is concentrated in the coastal region specifically Andhra Pradesh, West Bengal and Odisha constituting 55 percent of all inland fisheries production in the country in 2022-23. And so is the required infrastructure. But the infrastructure is now developing through initiatives under Blue Revolution and PMMSY. From 2015-16 to 2019-20, 30 new fish feed mills were established out of which 23 were in land locked states. From 2020-21 to 2022-23, another 151 medium and large feed mills were established with 99 in land locked states. This states the development of aquaculture in inland states. However, we don't know how much market do these new mills are serving at present. There still are considerable infrastructure challenges to be resolved for efficient functioning of value chains. Processing plants being just one of many. The economies of scale are required for full utilization of a processing plant which is currently lacking in inland states.

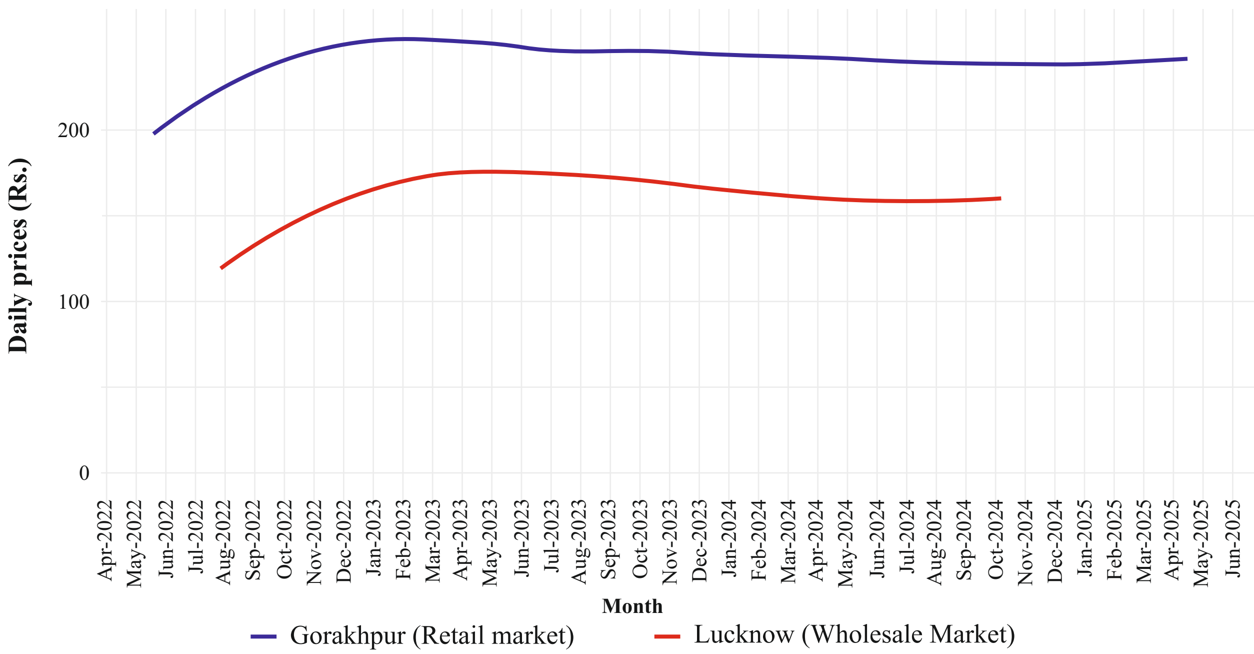
- **Transaction costs, coordination problems and information asymmetry**

  Availing government subsidies, accessing formal credit, integration into established value chains, leasing land or overcoming social and cultural barriers to start aquaculture practice involves some transaction costs. Access to government schemes and resources such as community ponds, which are generally managed at the local level, may vary among different categories of farmers. Although subsidies and support programs are intended to be universally accessible, their uptake often remains uneven due to limited awareness, lack of working capital especially among small and marginal farmers. Furthermore, asymmetries in access to market information, including prevailing input and output prices, may constrain the ability of farmers with fewer informational resources to make effective production and marketing decisions. These can be addressed through forming collectives like FFPOs which brings down some of these transaction costs. Moreover, scaling up aquaculture through export-oriented channels requires greater adoption of BAPs to ensure compliance with international quality, traceability, and sustainability standards. Expanding awareness and institutional support for BAPs certification is essential to enhance market access and competitiveness of aquaculture producers in global value chains.

- **Risk perception of farmers**

  Fisheries sector is characterized by a high degree of uncertainty, making them risk-intensive economic activities. Producers in this sector commonly face two primary forms of risk: production risk, which stems from environmental fluctuations, disease outbreaks, and input quality variability; and price risk, which arises from volatile market conditions, export dependencies, and limited price discovery mechanisms (Dahl & Oglend, 2014). The unpredictability of weather, water quality, or pathogen incidence can cause significant yield fluctuations, especially for small and medium producers operating without technical support or insurance coverage. At the same time, price instability-often due to oversupply, export restrictions, change in trade policies or shifts in international demand-reduces income reliability, particularly for shrimp and inland fish farmers whose products are relatively undifferentiated in the global market. Also, in terms of wholesale price share as retail price is substantially low for fish value-chain due to high storage loss at retail level, 22 percent of total loss percent of 4.85 percent is at storage level for inland fisheries (NABCONS, 2022). The monthly average prices in the retail market at Gorakhpur is Rs. 242 per kg for *rohu* from 2022-25. For the same period, the prices were Rs. 161 per kg in the wholesale market. Farmers get price of carp on an average Rs. 100 (Market intel), which indicates farmers' share in consumer rupee to be about 41 percent. We notice a 50 percent markup from wholesale to retail markets. Hence, value-chain efficiency is required through stronger domestic market integration, diversified export value-chains to augment farmers' income.

Figure 4-15: Daily Trend of Prices of Rohu (Indian Major Carps) April 2022 to June 2025



Source: FMPIS, GoI

- **Biological and climatic constraints**

  Some challenges exist due geographical factors like climate or biological reasons. For instance, in North Indian states, the colder climate during the winter months-from December to February-renders shrimp farming unsuitable, effectively limiting farmers to only one or, at most, two crop cycles per year. This is not the case in South Indian states where the weather is suitable year-round for up to 3 crop cycles in the case of shrimps. This constraint leaves farmers in the northern states in India less competitive and with lower return on equity when compared to their southern counterparts.

The chapter finds that inland fisheries value chains, particularly for wet markets, remain highly fragmented, with multiple intermediaries reducing efficiency, high quantity and quality loss at post-harvest stages, and lower farmer price realisation. Limited processing capacity has constrained value addition, reflected in the negligible share of frozen fillet exports from India, despite strong global demand for species such as carps, tilapia, and pangasius. In contrast, the export-oriented shrimp value chain is relatively more organised, with stronger traceability and compliance with international standards. On competitiveness, the analysis of unit values of shrimp exports since the mid-1990s shows that Indian shrimp remains globally competitive. However, competition has intensified sharply, particularly from Ecuador, whose share in global shrimp exports rose from 7 percent in 2013 to 27 percent in 2024, compared to India's increase from 14 percent to 19 percent. This pressure is further exacerbated by recent trade policy shocks, notably the sharp escalation of US punitive tariffs on Indian shrimp, which has significantly raised the effective tariff burden and might be transmitted downward pressure on farm-gate prices if export is not diversified. From an inclusivity perspective, the report highlights persistent barriers faced by small and medium farmers, including limited access to water resources, informal land leasing, and inadequate access to finance. Cooperative models and FFPOs emerge as critical institutional mechanisms to improve resource access, reduce transaction costs, and enhance farmer bargaining power. In terms of scalability, aquaculture growth remains regionally concentrated in coastal states such as Andhra Pradesh, Odisha, West Bengal yet significant expansion potential exists in inland and salinity-affected regions. With salinity-affected subsoils projected to increase substantially by 2030, inland saline water areas offer a viable pathway for transforming ecologically stressed land into productive aquaculture zones, particularly when supported by water-efficient technologies such as Recirculating Aquaculture Systems and biofloc. On finance, the report finds a strong positive relationship between public expenditure priorities and fisheries sector growth. States with rising Fisheries Priority Ratios such as Andhra Pradesh, Odisha, and Haryana-have experienced significantly higher growth in fisheries GSVA, while declining budgetary priority in West Bengal has coincided with slower sectoral growth in the state.

CHAPTER 5
ROLE OF AQUACULTURE TO AUGMENT FARMERS' INCOME

Small and medium scale aquaculture has direct and indirect impact on rural growth than traditional crop agriculture for augmenting income of farmers and job creation (Ahmed, Belton, & Murshed-e-Jahan, 2015). Kassam & Dorward, 2017 analysed the role of aquaculture to increase income of rural population in low-income countries with a focus on Ghana. The study shows the positive role of pond aquaculture to alleviate poverty in the region. Aquaculture practices like polyculture improves economic profitability with high cost-benefit ratio (Purcell, Patrois, & Fraisse, 2006). There are several case studies in India which highlight the direct and indirect impact of aquaculture to augment income of farmers through diversification of rice-fish integrated system (Samaddar et al., 2024), or through moving from traditional crop to aquaculture particularly in salinity affected regions. The transition from rice to aquaculture in Andhra Pradesh showed a promising opportunity for augmenting farmer incomes. The profitability of shrimp farming far exceeds that of traditional crops such as paddy and coconut cultivation, making it a highly attractive alternative for farmers in East Godavari district, Andhra Pradesh (Kumaran et al., 2003).

In the coastal region of Andhra Pradesh, the practice of fish culture can yield higher incomes up to 3 or 5 times the incomes from traditional crop cultivation. Two crops of paddy (kharif and rabi) can provide a farmer Rs. 83 thousand of income per hectare while shrimp cultivation in just one cycle can raise his income up to Rs. 6-7 lakhs per hectare. Income can go further up if farmer successfully practices two crop cycles of shrimp in a year. Similarly, carp culture is also highly profitable, up to 3 times as compared to traditional paddy cultivation. The profitability from fish culture is not independent of any challenges. Higher profits come with specific production and price risks and higher capital and labour requirements.

This chapter highlights the role of inland fisheries in augmenting farmers' income based on the latest SAS data. The regression uses several key factors influencing farmers' total monthly income, with the dependent variable being the natural logarithm of income[11] **(Table 5-1).** One of the most important findings is that participation in inland fisheries impacts farmers' income. With a beta coefficient of 0.472, significant at the 1 percent level, participation in inland fisheries is associated with a 47.2 percent increase in total monthly income for farmers in comparison to non-participating farmers. This demonstrates that inland fisheries are a key income-augmenting activity, offering income diversification streams, especially in regions where traditional crop-based incomes are vulnerable to market or climatic fluctuations. The strong positive effect suggests that promoting inland fisheries can boost farm incomes.

Other significant factors are operated land area, irrigation intensity, measured as the percentage of irrigated land to gross cropped area, selling to procurement agencies positively influence farmers' income, with a significant at the 1 percent level. Access to secondary or higher education is another crucial determinant that shows that educated farmers (head of the family secondary or above) earn 44.2 percent more than those with lower education levels. This suggests that education enhances the ability of farmers to access information,

[11] The adjusted R^2 of 0.23 indicates that 23 percent of the variation in farmers' income is explained by the independent variables. The Breusch-Pagan test for heteroskedasticity is significant, suggesting variance inconsistency in the residuals, though the model remains useful for interpretation.

adopt new technologies, and navigate markets effectively, leading to better income. Farming experience captured through the head of the household's age, has a positive impact on income, with a coefficient of 0.045. This means that experienced farmers are better equipped to manage resources and adapt to market conditions, resulting in higher incomes.

Access to Kisan Credit Cards (KCC) contributes positively to income, with a coefficient of 0.057, significant at the 10 percent level. Access to formal credit helps farmers invest in productive inputs and technology, enhancing their overall income. The result shows that participation in inland fisheries is a significant income augmenting activity for farmers, alongside factors like land size, irrigation, education, and access to formal markets and credit. Promoting inland fisheries plays a vital role in enhancing farmers' incomes and reducing rural poverty.

Table 5-1: Regression Results on Role of Fisheries and Aquaculture in Augmenting Farmers' Income

Variables	Beta coefficients	Standard error
Y= Ln farmer total income monthly		
Ln operated area in ha.	0.178***	.001
Participation in inland fisheries and aquaculture (No=0, Yes=1)	0.472***	0.049
Irrigation intensity in percent (Area irrigated to GCA)	0.003***	0.0003
Access to secondary or above education (No=0, Yes=1)	0.442***	0.010
Ln experience of HOD (age)	0.045***	0.009
Access to KCC (No=0, Yes=1)	0.057*	0.013
N	44,882	
Adjusted R2	0.23	
Breusch-Pagan test of heteroskedasticity	61.49***	

Source: Unit level data, SAS, NSS
*Note: *, ** and *** represent significance at 10, 5 and 1 percent respectively*

Box 5-1: Case Study Analysis of Technology Adoption in Aquaculture

Nalekta Chowhai, a farmer from Changlang district, Arunachal Pradesh, with a high school education established his farm in 2019. His income from paddy cultivation amounted to Rs. 70,000/ha. However, he has diversified into aquaculture, cultivating Indian Major Carp and Exotic Carps through intensive fish culture in grow-out ponds, comprising seven units with a total production capacity of 3.5 tonnes. His total income from aquaculture reached Rs. 21 lakhs/ha, surpassing his paddy income. Nalekta received financial assistance of Rs. 12.60 lakhs from the *Mukhya Mantri Neel Kranthi Abhiyan,* with a total investment of Rs. 7.50 lakhs in aquaculture, highlighting the potential for higher earnings through fish farming. Avtar Singh Subhan from Punjab operates on saline-affected land and has adopted shrimp culture as an alternative to paddy cultivation. While specific income figures from paddy cultivation are not available, Avtar reported an annual production of five tonnes of shrimp from 3.1 acres of land, with total income from aquaculture reaching Rs. 33 lakhs. He received financial assistance of Rs. 10 lakhs under PMMSY to support his shrimp farming initiatives, that proved to be a lucrative venture compared to traditional paddy farming.

Source: Collated from success stories NFDB

Box 5-2: Modern Aquaculture Success in Bareilly: A Case Study

Sh. Vedpal, a progressive fish farmer from Bareilly, Uttar Pradesh, transitioned from traditional agriculture to aquaculture, leveraging government schemes to build a successful fish farming enterprise. In 2017-18, he received support under the Blue Revolution Scheme to establish a 0.5-hectare fish rearing unit for cultivating Indian major carps (*Catla, Rohu,* and *Mrigal*). Encouraged by the initial success, he expanded his operations by leasing a 1.0-hectare *Gram Sabha* Pond for grow-out fish farming, investing Rs. 4 lakhs in production and infrastructure.

With his son joining the business, Sh. Vedpal was able to recover his investment within 18 months, earning a profit of Rs. 3 lakhs. His dedication, combined with the guidance of the Department of Fisheries, Government of India, helped him establish himself as a successful aquaculturist. In 2020-21, he further advanced his venture by applying for a medium-scale Recirculatory Aquaculture System (RAS) project under the PMMSY scheme, with a total cost of Rs. 25 lakhs, of which Rs. 15 lakhs were his own investment. The project was successfully completed, and he is now cultivating pangasius fish. His farm has become a learning hub for local farmers, inspiring others to adopt modern aquaculture techniques and establish profitable fish farming ventures.

Source: Collated from success stories on RAS, NFDB[12]

Box 5-3: Biofloc Technology for Tilapia Farming Haryana

Biofloc Technology (BFT) is an innovative approach to aquaculture that leverages the natural ability of microbial communities to convert waste into feed. By promoting beneficial microbial activity, biofloc systems enhance water quality and provide an additional protein-rich food source for aquatic species. This significantly reduces the need for frequent water exchanges and chemical inputs, making the method both economically viable and environmentally sustainable. Originating in Israel in the early 2000s and later adopted in countries like Brazil and Indonesia, BFT is now gaining traction in India, especially among small and medium-scale farmers aiming to boost productivity with limited resources. Its potential to reduce input costs and improve biosecurity makes it a viable option for the future of sustainable aquaculture in India. Currently, the scale is low, about 4205 biofloc units are there in India (PMMSY, 2024).

[12] Re-circulatory Aquaculture Systems (RAS) are advanced closed-loop systems that continuously treat and reuse water within the aquaculture unit. By recycling up to 90 percent of water, RAS drastically reduces freshwater consumption and minimizes discharge into the environment. These systems are particularly advantageous for high-density fish or shrimp farming, offering better control over water quality, disease management, and biosecurity. As such, RAS represents a sustainable solution for intensifying aquaculture production while addressing ecological concerns. Currently at all India, level 12,081 RAS units are there in India (PMMSY, 2024).

Box 5-4: Cage Culture of Indian Major Carps (IMC), Odisha

India has 3.15 million hectares of reservoirs and more than 3.5 lakh ha of floodplain wetlands (*beels, jheels, mauns, pats,* etc.) spread across the river basins in the country. Cage Culture is an emerging technology for intensive production of fish and is considered to have huge potential for increasing the fish production of the country. It is often considered as the future of Indian Fisheries. In recent years, efforts being made to promote cage culture in the inland open water bodies like reservoirs and floodplain wetlands in the country. Estimated project cost 7.85 crores for 100 cages in integrated approach. Currently, 52,058 cages are operational in inland fisheries and aquaculture.

5.1 Comparison of Profitability of Crop Agriculture vs. Aquaculture

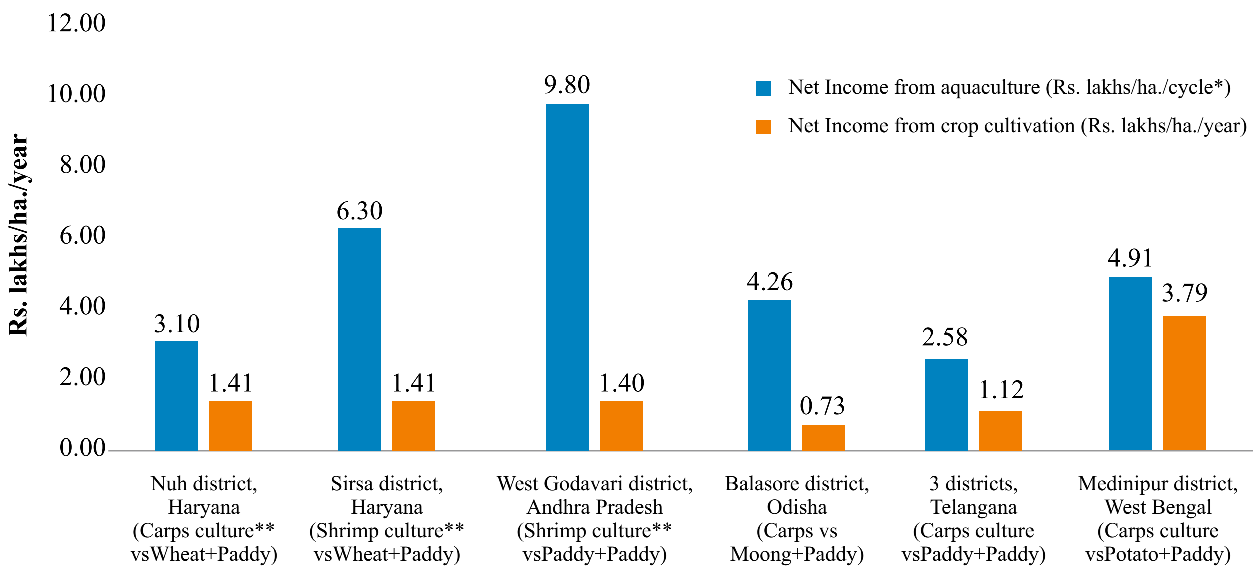
This section compares the cost of cultivation and returns from aquaculture farming vis-à-vis traditional paddy cultivation. Aquaculture presents higher profitability compared to traditional paddy farming due to various factors:

1. **Higher Revenue Potential:** Aquaculture, particularly shrimp and fish farming, generates higher returns per hectare compared to paddy cultivation. For example, shrimp and fish can be harvested more frequently than paddy, allowing multiple production cycles in a year or harvesting throughout the year in case of come carps, whereas paddy is grown in two cycles (Kharif and Rabi seasons). The increased frequency of harvest translates to higher annual revenue from aquaculture and provides livelihood resilience for marginal and small farmers.
2. **Efficient Use of Inputs:** Aquaculture requires a different set of inputs-such as feed, fingerlings, and infrastructure-compared to the labour and water-intensive requirements of paddy. Aquaculture has higher variable cost in terms of feed and infrastructural development and management but these are often outweighed by the higher returns from the sale of fish or shrimp. Paddy farming is constrained by low market prices and price fluctuations, reducing its profitability particularly in states where public procurement is low.
3. **Lower Vulnerability to Climate Risks like erratic weather:** Paddy cultivation is highly dependent on water availability, from monsoons or irrigation systems. Droughts or erratic rainfall severely affects paddy yields. In contrast, aquaculture-especially with the adoption of controlled systems like RAS, biofloc technology are less vulnerable to climate risks and thrive in different water conditions, ensuring consistent production. Climate change impacts the yield of crops whereas aquaculture offers a controlled environment that is a more reliable source of livelihood, especially for marginal and small farmers.

4. **Market Demand:** The demand for fish and shrimp domestically and internationally, has been growing steadily, supported by rising incomes, urbanisation and health-conscious dietary preferences. For those who consume fish, the per capita annual intake increased from 7.43 kg to 12.33 kg, an increase of 4.9 kg or 66 percent between 2005-06 to 2019-20 (Padiyar, et al., 2024). Among lower-middle-income countries (LMICs), classified by the World Bank, India demonstrated a notable rise in per capita fish consumption at 60 percent, compared to the group's average of 45 percent. Hence, expansion of production of fisheries through inland fishing and aquaculture can cater to the growing demand.

5. **Profitability per hectare:** If we assess annual profitability of crop agriculture vis-à-vis. aquaculture the data clearly demonstrates that aquaculture-whether carp or shrimp farming-offers significantly higher returns per hectare per cycle compared to traditional crop cultivation. In Haryana, carp-based aquaculture yields Rs. 3.1 lakh/ha, compared to just Rs. 1.41 lakh/ha from paddy and wheat, while shrimp farming pushes income further to Rs. 6.3 lakh/ha, four times the combined returns from wheat and paddy (Figure 4). Similar patterns are observed in Odisha, Telangana, West Bengal, where aquaculture returns range between Rs. 2.58 lakh/ha. to Rs. 4.91 lakh/ha. per year, higher than the crop income. Andhra Pradesh, leveraging shrimp farming, records the highest profitability at Rs. 9.8 lakh/crop/ha. which extends to Rs. 14.5 lakh/ha/year with two cycles underscoring the economic incentives of transitioning from paddy to high-value aquaculture. The farmers in the state generally practice two cycles with stocking at February-March and stocking at September-October with a culture period 90-120 days (Srinivas & Venkatrayulu, 2019). This shift is prominent in the coastal districts, where saline or waterlogged soils limit the productivity of paddy farming, making shrimp culture more viable. These trends make a compelling case for scaling up aquaculture as a key strategy for enhancing farm incomes and rural livelihoods even in salinity affected areas in inland states. As in Haryana, shrimp aquaculture has expanded due to high profitability compared to traditional paddy-wheat agriculture. However, profitability in aquaculture varies across states based on biological cycle of the crops, types of aquaculture crop, cropping practices, market structure and access to working capital.

Figure 5-1: Profitability in Crop vis-à-vis Aquaculture



*There can be more than one cycle of aquaculture per year. In Haryana however, farmers practice single cycle a year. In Andhra Pradesh, for example, two cycles a year is the norm for shrimp culture with some progressive farmers achieveing three cycles a year as well. **Data collected and calculated by authors during their field visits to respective districts in February, May and November 2025. Calculations verified from multiple stakeholders during consultations. For carps culture in other districts, data sourced and returns recalculated from Das et al. (2024), Sindhu et al. (2023) and Beg at al. (2024). The costs andvalue of output adjusted through Wholesale Price Index of Inland Fish to 2024-25.

*Note: For crops which have MSP, we have used projected costs of cultivation for KMS 2025-26 and RMS 2024-25 for comparisons from CACP reports. Gross returns calculated as MSP*Yield for same years. For potato, the cost of cultivation has been imputed forward using the index of farm inputs and gross returns have been imputed forward through WPI of Potato till 2024-25.*

Aquaculture in Andhra Pradesh, Odisha, West Bengal, and Haryana involves significant cost components, with feed costs dominating the variable expenses. On an average, feed accounts for 43 percent of the total variable costs. The cost of fingerlings follows at 13 percent while labour accounts for 8 percent, and manure constitutes 10 percent. The remaining variable costs include electricity and other operational expenses, which vary based on farm size, production intensity, and location.

Beyond variable costs, fixed expenses present substantial financial challenges, particularly for new entrants and small-scale farmers. Pond preparation alone requires Rs. 163924/ha., representing 56.7 percent of total fixed costs. Additionally, lease rent amounts to Rs. 93835/ha., making up 32.5 percent of fixed costs for carps. The impact of high lease rents is particularly higher for small farmers (with ponds less than 2 acres), as competition for limited water bodies drives lease prices further up reducing their profitability (Gothwal, 2024).

A regularized lease market and FPO business models could play a transformative role in reducing financial risks and facilitating shared investments in pond infrastructure. By integrating FPOs and cooperatives, small-scale farmers could gain better security over water resources, making long-term investments in productivity-enhancing technologies more viable. However, acquiring ponds on lease remains complex due to local political economy factors, including land conflicts, informal market practices, and regulatory hurdles that constrain smallholder participation.

Adopting alternative aquaculture technologies like bio-floc can help mitigate these challenges. Biofloc systems, by enabling high-density fish production in controlled environments, can reduce reliance on large pond leases, thereby lowering fixed costs and improving production efficiency. Moreover, bio-floc enhances water resource utilization, minimizing pond preparation cost while maintaining a sustainable and controlled farming environment.

To ensure scalability and long-term viability of aquaculture in these states, policymakers must focus on lease market reforms, cooperative investment models, and the adoption of cost-efficient technologies. Addressing these structural bottlenecks will not only enhance profitability for farmers but also promote inclusive and sustainable aquaculture growth in India.

Overall, aquaculture as an income augmentation economic activity still has large potential for India's small and marginal farmers. Policy focus is needed to enable and support these farmers to take some risk and take up aquaculture. Government support in terms of extension services, training, workshops and infrastructure delivery are essential for further transformation.

CHAPTER 6
POLICY SUGGESTIONS FOR AQUACULTURE DEVELOPMENT

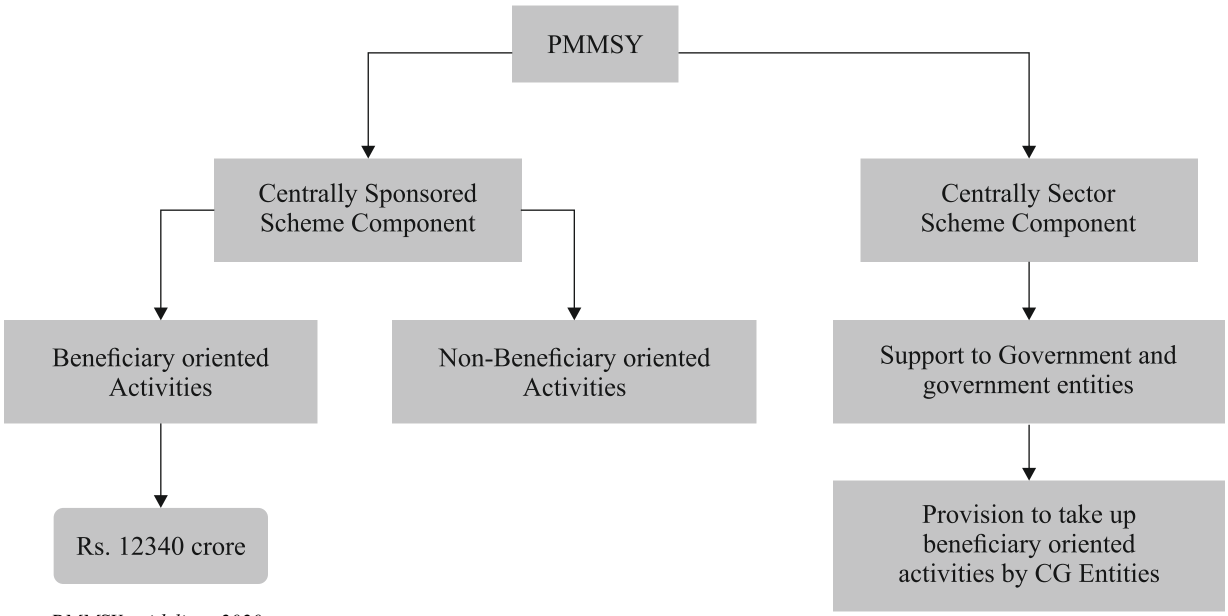
Aquaculture presents an opportunity to augment farmers' income by offering higher profitability, efficient resource utilization, and market-driven growth compared to traditional farming. The blue economy in India has immense opportunity to scale up from the regional concentration of production given the large potential of water resources. The report shows how the infrastructural development and investment in the sector have shaped the growth of the sector. Long-term sustainability and scaling up of the sector requires investment in infrastructure, access to quality inputs, disease management, financial support, and market integration. With the right policy interventions, technological advancements, and institutional support, aquaculture can play a pivotal role in enhancing rural livelihoods, improving food security.

1. A decade of intense focus on fisheries sector: Policy evaluation

The fisheries sector in India has witnessed significant policy-driven investment over the past decade, aimed at enhancing productivity, infrastructure, and sustainability. The 'Blue Revolution' scheme (2015-16 to 2019-20) marked the beginning of this focused intervention, with a corpus of Rs. 3,000 crores to expand both inland and marine fisheries. This initiative facilitated the construction of 19,264 hectares of new ponds and tanks, development of 1,638 hectares of brackish water aquaculture, and establishment of 15 hatcheries and 71 nurseries. As a result, inland fisheries production increased by 46 percent during this period.

In 2020-21, the central government introduced an umbrella scheme PMMSY with even bigger corpus of Rs. 20050 crores for five years from 2020-21 to 2024-25. The eligible beneficiaries can be individuals (farmers, entrepreneurs, etc.), fishery development corporations, self-help groups, fisheries federations, FFPOs, state governments, state fisheries development boards as well. The scheme has been divided into two main components: Central Sector Schemes (CS) and Centrally Sponsored Schemes (CSS) (Figure 6.1). The CS component is 100 percent funded by the central government with sub-components such as Genetic improvement programmes and Nucleus Breeding Centres, start-ups, incubators and pilot projects, training and capacity building, aquatic quarantine facilities, etc. Within CSS there are non-beneficiary oriented and beneficiary oriented sub-components with different funding pattern and group of activities under each. For non-beneficiary oriented sub-components within broad heads of enhancement of fish production and productivity, infrastructure and post-harvest management, markets and marketing infrastructure, development of deep-sea fishing, etc., the project cost is divided in the ratio of 90:10 (centre: state) for north-eastern and hilly states and 60:40 for other states. For beneficiary oriented sub-components like capital subsidy for establishments of various units, jetties, ponds, etc., the cost is divided in the same way. For the beneficiary under this component the government financial assistance of both centre and state governments together will be limited to 40 percent of the project/unit for General category applicants and 60 percent for SC/ST/Women applicants.

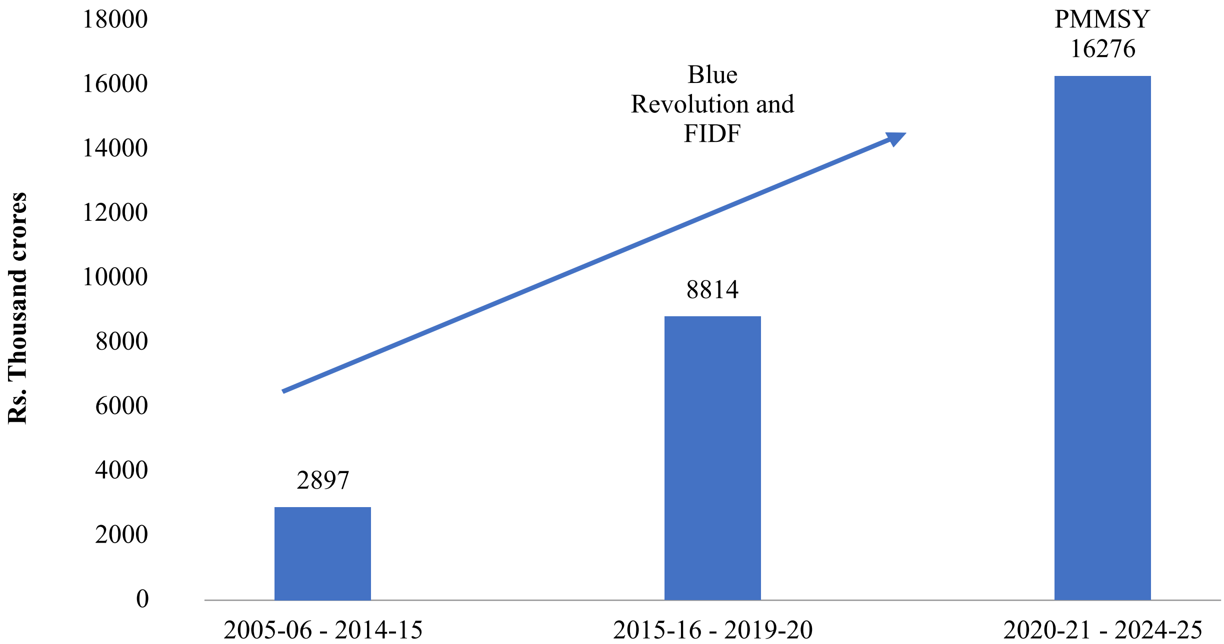
Figure 6-1: Structure of Pradhan Mantri Matsya Sampada Yojana (PMMSY) (2020-21 to 2024-25)



Source:PMMSY guidelines 2020

The **Figure 6-2** below provides a broad picture of the magnitude of government support over the years. This shows the priority the government has given to the fisheries sector in recent years. The result is evident. More than half of the production of all fisheries in the country has been in the last 10 years.

Figure 6-2: Union Government Expenditure on Fisheries Sector Over Last Two Decades (at 2011-12 constant prices for comparison)

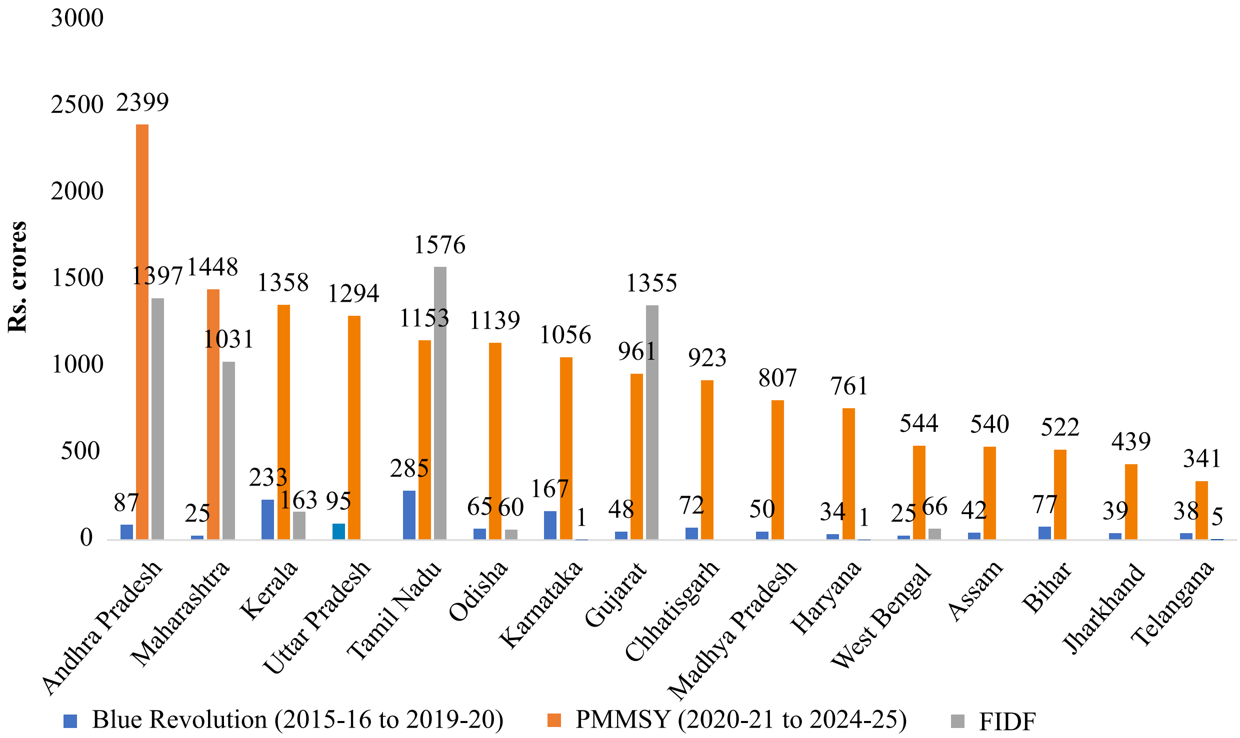


Source: PMMSY reform booklet, Union budget documents
Note: The expenditures have been rebased to constant prices of 2011-12 for comparison purposes using annual WPI

The components of the PMMSY scheme entails transfers to states as under Blue Revolution. As the figure below shows these transfers have increased multiple folds for each state under PMMSY even after accounting for the FIDF fund transfers. The government has significantly increased focus on the fisheries sector in the recent years. Overall, under these schemes plus the FIDF fund, out of a total corpus of Rs. 26174 crores, the largest beneficiary has been Andhra Pradesh with Rs. 3883 crores (15 percent) (transfers and total cost of project proposals approved) followed by Tamil Nadu with Rs. 3014 crores (12 percent), Maharashtra with Rs. 2504 crores (10 percent), Gujarat with Rs. 2364 crores (9 percent) and Kerala with Rs. 1754 crores (7 percent). All states have registered growth in central transfers for the fisheries development (**Figure 6-3**).

The structuring of the schemes may have changed but components and sub-components of the scheme remain more or less similar. The difference is the magnitude of support in terms of amount and permitted activities. For example, increasing the unit cost of the construction of new inland ponds/tanks for providing support, increasing input cost of finfish and freshwater culture from Rs. 1.5 lakhs/ha and Rs. 2.5 lakhs/ha to Rs. 4 lakhs/ha, providing income support in the fish ban/lean periods, increasing support to establishment of various capital-intensive units like hatcheries, nurseries, rearing units, etc.

Figure 6-3: Transfers to States under Blue Revolution and Total Cost of Projects Sanctioned under PMMSY and FIDF



Source:Handbook on Fisheries Statistics 2023 for Blue Revolution; PIB Press Release for PMMSY

India's aquaculture and fisheries sector has experienced significant growth over the past decade due to targeted policy interventions, infrastructural investments, and financial support. However, to enhance value-chain efficiency, ensure sectoral growth, and expand regional participation, there is a need for well-defined policies that augment farmers' income and sustain fisheries development. This policy evaluation focuses on key areas such as regional expansion, diversification, sustainable practices, financial accessibility, and market linkages to ensure a more robust and inclusive aquaculture sector.

Expanding Aquaculture Beyond Andhra Pradesh: The Need for Regional Replication

As our study shows Andhra Pradesh has emerged as an outlier in the fisheries sector both in terms of production and growth rate, largely due to substantial state expenditure and private investment. The state has recorded the largest increase in its share of domestic production over the past two decades, demonstrating a strong correlation between government prioritization of fisheries and sectoral growth. A comparative analysis of the Fisheries Priority Ratios (FPR) with the GSVAs in fisheries reveals that Andhra Pradesh, Odisha, and Haryana exhibit high GSVA growth rates of 15.7 percent, 9.2 percent, and 7.7 percent, respectively. These states have also shown an increasing trendline in FPR, reflecting growth potential in these states.

In contrast, West Bengal presents a declining trend in FPR, indicating reduced government prioritization of fisheries within the agricultural budget. This is coupled with a low GSVA growth rate of only 2.3 percent, significantly below the national average. The findings suggest that states prioritizing fisheries within their agricultural budgets tend to achieve higher sectoral growth. Replicating Andhra Pradesh's policy model, which integrates public and private investment in aquaculture infrastructure, credit accessibility, and market linkages, could help unlock fisheries potential.

Transitioning from Traditional Paddy Cultivation to Aquaculture: A Pathway for Livelihood Diversification

Aquaculture provides higher profitability compared to paddy farming, particularly for small and marginal farmers. Data from various states indicate that the profitability per hectare from aquaculture is significantly higher than from paddy cultivation or other traditional crop systems. In Andhra Pradesh, where the per hectare income from shrimp aquaculture much higher than paddy farming, INR 7.82 lakhs per hectare per crop vis-à-vis INR 41,428 per hectare per crop in 2021-22. However, fixed cost is very high in aquaculture, for instance shrimp aquaculture requires a capital investment of 15-17 lakh for a hectare of pond. However, PMMSY provide up to 40 to 60 percent subsidy in capital investment.

Land Lease Policies: Addressing Structural Barriers to Fisheries Expansion

Land leasing remains a major constraint in expanding aquaculture, particularly for small-scale farmers. Village ponds play a critical role in inland fisheries, serving as an important source of livelihood for rural communities. Also, the report shows lease rent is a major share of variable cost varying across regions. Even the access to leasing in land is a constraint. The lease rent for community ponds is lower than the individual owned land. Community ponds are typically leased out to farmers through an auction process, but access to water bodies remains uneven due to a lack of transparency in the lease market and dependent on regional political influences. As discussed in Chapter 4, studies highlight those influential individuals have dominated village pond leases, side-lining marginal sections. To address these challenges, a national-level land lease policy for fisheries should be implemented, focusing on transparent leasing mechanisms, digitization of land records, and cooperative ownership models. Encouraging FFPOs and fisheries cooperatives to invest in pond infrastructure would enable greater participation of small-scale farmers, ensuring more equitable access to water resources, lease security, and access to market.

Enhancing Market Efficiency: Strengthening Domestic and Export Channels

The fisheries sector is heavily reliant on traditional marketing structures, often dominated by *arahtiyas* (middlemen), fragmented trade networks, and complex distribution channels. Small-scale fish farmers remain highly dependent on local intermediaries for market access for both input and output, leading to inefficiencies and lower farm-gate prices. This limits direct access to high-value markets, particularly in urban consumption centres and export segments. Strengthening domestic and export market linkages through digital trade platforms, direct marketing channels, and FFPOs-led organized sales can significantly improve price realization for fish farmers. Additionally, India's frozen fish exports, particularly tilapia and carp, have not grown at the same rate as frozen shrimp exports. Frozen fish exports have just grown 0.5 percent from 2011-12 to 2022-23 by value. Expanding domestic consumption and export diversification is essential to reduce dependency on shrimp exports and create a more resilient and stable aquaculture sector. India can replicate Indonesia's aquaculture model, which integrates aquatic plant farming like seaweed with fish production, providing alternative income sources for small-scale farmers. Traditionally there have been instances of integrated rice-fish cultivation system, makhana-air-breathing fish culture, which can be scaled up for higher profitability.

Sustainable Aquaculture Practices: The Role of Technology and Community-Led Initiatives

Our study shows that one of the major challenges in aquaculture expansion is the high fixed capital cost associated with pond preparation across states. As the report shows seed production technology has major impetus in growth of aquaculture sector in India. China's aquaculture industry's major strengths have been well established seed production technology, research and development infrastructure, transformation of extension services in the country, and strong domestic and international demand for fisheries. India needs to expand the seed production and adopt innovative technologies such as Biofloc Technology and Recirculating Aquaculture Systems (RAS) can enhance water efficiency, reduce feed costs, and minimize environmental impact. These controlled aquaculture systems allow for intensive fish farming with lower land and water requirements, making them particularly suitable for regions facing land constraints. Integrating crop and fish farming through mixed agricultural systems can further enhance farm diversification and resilience. By adopting integrated farming models, farmers can utilize agricultural waste as feed inputs for fish production, reducing operational costs while improving overall farm productivity.

Infrastructure Investment and Technology Development: Strengthening the Fisheries Value Chain

Under Blue Revolution 2.0, expanding hatchery infrastructure, fish seed production facilities, and cold storage networks will be essential to increase domestic fish output and export competitiveness. Strengthening the cold storage and processing infrastructure across states can help replicate Andhra Pradesh's success and ensure better price realization, reduced post-harvest losses, and improved supply chain efficiency. Additionally, import duty reductions on aquaculture inputs can lower production costs and make fish farming more competitive. The Basic Customs Duty (BCD) on essential inputs such as shrimp brood stock, polychaete worms, and feed has been reduced, but ensuring a stable 0-5 percent duty on key inputs would bring further cost stability and long-term viability for small-scale farmers.

Conclusion: Ensuring Long-Term Growth, Sustainability, and Inclusion

A holistic approach to policy reform, technological adoption, and market integration is necessary to enhance value-chain efficiency, sustain sectoral growth, and promote regional expansion in fisheries. Strengthening fisheries value chains, eliminating structural barriers, and fostering innovation in sustainable aquaculture practices will be key to maximizing farmer incomes and establishing India as a global leader in fisheries and the blue economy. With consistent policy support, private sector collaboration, and inclusive financial mechanisms, aquaculture can transform into a high-growth, sustainable, and income-generating sector for millions of Indian farmers.

2. Transitioning to Aquaculture: Diversification through Fisheries

While crop diversification is critical, aquaculture offers a significant opportunity for farmers to diversify into high-profit, low-land-use agricultural activities. States like Andhra Pradesh have demonstrated the substantial income potential of shrimp farming and inland fisheries, particularly in saline or waterlogged areas, where traditional crop farming is less viable. The secondary review of case studies across different states indicated higher profitability of aquaculture over paddy cultivation, however aquaculture is capital intensive and require credit subsidies for working capital. However, small producers in aquaculture sector as well often face challenges related to scale, capital access, input procurement, and market linkages. Recognizing the success of the NDDB-led dairy cooperative model, the GoI is now seeking to replicate similar frameworks in the fisheries and aquaculture sectors, through expansion of Primary Agricultural Credit Societies (PACS). Currently, there are 25,660 Fisheries Cooperatives operating across India. Notably, Andhra Pradesh and Telangana together account for 27 percent of these cooperatives. This regional concentration underscores the importance of fisheries cooperatives in facilitating input access, credit support, and market linkages for the aquaculture development in these states.

Benefits of Aquaculture:

- **Higher Profitability:** Aquaculture, particularly shrimp farming, provides much higher profitability compared to traditional paddy farming. Aquaculture can raise farm incomes by 2 to 10 times depending upon culture.
- **Livelihood Diversification:** Aquaculture offers smallholder farmers an alternative income source without needing extensive landholdings, especially in saline or water-scarce regions.
- **Sustainability:** Biofloc Technology and Recirculating Aquaculture Systems (RAS) can reduce operational costs and environmental impact, making aquaculture a sustainable farming option for areas facing land and water constraints. RAS and automation ensure high-density, year-round farming with IOT (Internet of Things) monitoring the water quality and feed efficiency.

Policy Solutions for Aquaculture Development:

- **Financial Support:** To strengthen the fisheries sector and improve its value-chain efficiency, the Government of India has introduced targeted working capital and infrastructure support through flagship schemes. As discussed, the PMMSY launched in 2020-21 for a five-year period supports a wide range of activities, including the development of aquaculture infrastructure such as freshwater, saline, and brackish water ponds, hatcheries, brood banks, rearing units, and quality seed production facilities, along with promoting high-density systems like RAS, Biofloc, and cage culture. It also includes input support and skill development training to build capacity among fishers and fish farmers. Complementing PMMSY, the government has recently approved a sub-scheme, the Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana (PM-MKSSY), to be implemented from FY 2023-24 to 2026-27. This scheme specifically aims at supporting fisheries and aquaculture-based microenterprises by offering performance-based grants, thereby addressing the critical need for working capital and enterprise development support. However, the uptake of these schemes faces challenges at the grassroots level. Limited access to formal credit, lack of awareness among small-scale farmers, inadequate last-mile delivery of services, and regional disparities in infrastructure and institutional readiness often constrain the effective implementation of working capital support and enterprise financing. Moreover, many small and marginal fish farmers continue to rely on informal sources of finance, which limits their ability to invest in high-return aquaculture technologies.

Despite these challenges, the future potential of these initiatives is immense. If implemented effectively and scaled through robust institutional mechanisms such as cooperatives, FPOs, and self-help groups, these schemes can unlock a new wave of entrepreneurship in rural aquaculture, enhance financial inclusion, and generate stable livelihoods.

- **Replicating Andhra Pradesh's Success and scaling up:** The growth of inland fisheries is regionally concentrated in India and the catching up process of other states are slow. Public expenditure trends in fisheries across Andhra Pradesh, Odisha, Haryana, and West Bengal highlight a positive correlation between prioritized spending and fisheries GSVA growth. Andhra Pradesh, Odisha, and Haryana's increasing investment drives robust sectoral output, while West Bengal's decline in fisheries priority ratio that is share of expenditure in fisheries as percent to total agriculture and allied reflects on their slow growth rates. Scaling up aquaculture in India, particularly in inland regions also presents a complex interplay of sector-specific and structural challenges that must be addressed to unlock its transformative potential. High capital requirements, limited access to formal credit, and inadequate infrastructure-such as hatcheries and processing units-constrain the sector's growth, particularly for smallholder farmers transitioning from traditional agriculture. Compounding these are production and price risks, driven by environmental uncertainties and volatile global markets, which deter investment and adoption. To overcome these barriers, a multi-faceted approach is essential, encompassing enhanced credit access through value chain integration, investment in localized infrastructure, promotion of collectives like FFPOs, and adoption of Best Aquaculture Practices for global compliance. By addressing these challenges systematically, India can strengthen its aquaculture sector, ensuring sustainable growth, improved livelihoods for farmers.

3. Strengthening Domestic and Export Market Channels

The aquaculture sector's growth is heavily reliant on traditional marketing structures, which often limit direct market access for farmers. Strengthening market linkages, particularly through digital platforms and FFPOs-led sales networks, can enable farmers to bypass intermediaries and achieve better price realizations.

Policy Solutions for Market Linkages:

- **Digital Platforms and Market Access:** Expansion of digital trade platforms that connect farmers directly to consumers can augment farmers' price realisation. For instance, in China Platforms like Taobao, JD.com, and Hema Fresh (Alibaba's grocery chain) have become key distribution channels and there is transition from traditional wet market to e-commerce platforms, live streaming sales. However, in India the penetration of e-commerce platforms for aquaculture produces like Fresh to home, Licious, Bigbasket is very meagre and limited to metropolitan cities. Expansion of direct selling will reduce the role of middlemen and increase profit margins for farmers.

- **Export Diversification:** While shrimp exports have been dominant, diversifying into other fish species such as tilapia and carp will reduce dependency on a single export commodity. India should expand frozen fish exports and focus on developing new markets, both domestically and internationally.

4. Enhancing Infrastructure for Sustainable Growth

Infrastructure remains a critical bottleneck for both crop diversification and aquaculture development. Cold storage, processing plants, and hatchery infrastructure are needed to increase productivity and reduce post-harvest losses.

Policy Solutions for Infrastructure Development:

- **Cold Storage and Processing Facilities:** Expand cold storage and processing infrastructure for both high-value crops and aquaculture. This will help farmers achieve higher price realization and reduce wastage.
- **Integrated Farming Models:** Explore integrated farming systems, such as rice-fish systems, aquatic plant farming, and agroforestry, to diversify aquaculture production and create multiple income streams for farmers. This can enhance profitability, sustainability, and resilience.

5. Addressing Informal Land Lease for Aquaculture and Crop Diversification

Informal land leasing leads to a major challenge for aquaculture expansion. Lack of access to land and water resources limits the ability of small-scale farmers to invest in aquaculture practices due to lack of working capital.

Policy Solutions for Land Lease and Credit Accessibility:

- **Land Lease Records:** Develop a national database of leasable land for aquaculture, integrating geospatial data and ownership details. The community ponds and lease record data base can also play key role to trace the management practices. This would streamline leasing processes, minimize disputes, and enable farmers to identify and access suitable ponds efficiently. These reforms would significantly enhance the participation of small-scale farmers in aquaculture. Transparent leasing, digitized records and formation of FFPOs would increase access to community ponds. Cooperative models, backed by PMMSY subsidies, would lower financial barriers, enabling farmers to invest in high-value species like *L. Vannamei* in Haryana.
- **Financial Accessibility:** As analysed in the report, both aquaculture and high-value crop cultivation demand significant investments compared to traditional crops like paddy or wheat. Existing credit schemes, such as the KCC caters to the variable cost but fall short for capital-intensive cropping practices. Moreover, loan tenures (1-3 years) do not align with the 5-7-year payback periods needed for infrastructure investments, increasing financial strain. Financial support for capital investment in aquaculture and allied sectors is expanding, as seen in Haryana, where the cost of establishing a polyhouse with drip irrigation is around Rs. 28 lakh per acre, and the state government provides a 50 percent subsidy. Similarly, the PMMSY offers capital subsidies ranging from 40 to 60 percent for aquaculture infrastructure. However, even after availing the subsidy, farmers are still required to contribute a substantial amount that remains a major constraint for small farmers. Group-based lending through FPOs would empower farmers and who lack collateral, to access credit and market.

REFERENCES

Ahmed, M., & Lorica, M. H. (2002). Improving developing country food security through aquaculture development - lessons from Asia. *Food Policy*, 27, 125-141.

Ahmed, N., & Turchini, G. M. (2021). The evolution of the blue-green revolution of rice-fish cultivation for sustainable food production. *Sustainability Science*, 16(2), 1-16.

Ahmed, N., Belton, B., & Murshed-e-Jahan, K. (2015). *Aquaculture, employment, poverty, food security, and well-being in Bangladesh* : a comparative study. Washington DC: World Bank Group.

Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica*, 47-78.

Bai, J., & Perron, P. (2003). Computation and analysis of multiple structural change models. *Journal of Applied Econometrics*, 1-22.

Bank, W. (1979). *IDA Assists Inland Fisheries Project in India.* Retrieved from World Bank.

Beg, M. M., Roy, S. M., Moulick, S., Mandal, B., Kim, T., & Mal, B. C. (2024). Economic feasibility study of organic and conventional fish farming systems of Indian major carps. *Scientific Reports*, 14. doi:https://doi.org/10.1038/s41598-024-56432-4

Belton, B. (2014). Small-scale aquaculture, development and poverty: a reassessment. In M. Bondad-Reantaso, & R. Subhasinghe, *Enhancing the contribution of smallscale aquaculture to food security, poverty alleviation and socio-economic development*. FAO.

Belton, B., Bush, S. R., & Little, D. C. (2018). Not just for the wealthy: Rethinking farmed fish consumption in the Global South. *Global Food Security*, 16, 85-92.

Belton, B., Karim, M., Thilsted, S. H., Murshed-e-Jahan, K., Collis, W., & Phillips, M. (2011). Review of Aquaculture and Fish Consumption in Bangladesh.

Belton, B., Padiyar, A., Ravibabu G, & Gopal Rao K. (2017). Boom and bust in Andhra Pradesh: Development and transformation in India's domestic aquaculture value chain. *Aquaculture, 470*, 196-206.

Béné, C., Arthur, R., Norbury, H., Allison, E. H., Beveridge, M., Bush, S., . . . Williams, M. (2016, March). Contribution of Fisheries and Aquaculture to Food Security and Poverty Reduction: Assessing the Current Evidence. *World Development, 79,* 177-196.

Brummett, R. E., Lozard, J., & Moehl, J. (2008, October). African aquaculture: Realizing the potential. *Food Policy, 33*(5), 371-385.

Brummett, R., & Williams, M. (2000). The evolution of aquaculture in African rural and economic development. *Ecological Economics,* 193-203.

Bunting, S. W., Mishra, R., Smith, K. G., & Ray, D. (2014). Evaluating sustainable intensification and diversification options for agriculture-based livelihoods within an aquatic biodiversity conservation context in Buxa, West Bengal, India. *International Journal of Agricultural Sustainability,* 275-293. doi:https://doi.org/10.1080/14735903.2014.966530

CAA. (2023-24). *Annual Report*. Coastal Aquaculture Authority. Retrieved from https://caa.gov.in/annual_report.html

CIFRI. (1980). *Annual Report, Central Inland Fisheries Research Institute*. Barrackpore, West Bengal: ICAR.

Dahl, R. E., & Oglend, A. (2014). Fish Price Volatility. *Marine Resource Economics, 29*(4). doi:https://doi.org/10.1086/678925

Das, R; Gupta, S; Gulati, A (2025). From Adversity to Opportunity: Inland Shrimp Farming in India. Policy Brief No. 59. ICRIER, New Delhi

Das, A., Singh, K., Ahmad, N., Kumari, T., & Sinha, D. (2024). Economics of Fresh Water Cultured Fish Production in Odisha and Bihar, India: A Comparative Analysis. *Journal of Scientific Research and Reports,* 119-130.

Deccan Herald. (2025, April 14). Indian shrimp industry sails in troubled waters after Trump tariffs. Retrieved from https://www.deccanherald.com/business/indian-shrimp-industry-sails-in-troubled-waters-after-trump-tariffs-2-3492553

Desilva, S., & Soto, D. (2009). *Climate change and aquaculture: potential impacts, adaptation and mitigation.*

Dhande, K. K., Sharma, R., Kumar, R. S., & Prasad, G. S. (2024). Inland low saline shrimp culture in Andhra Pradesh: profitability and resource use efficiency. *Aquaculture International,* 6597-6610.

Duarah, J. P., & Mall, M. (2020). Diversified fish farming for sustainable livelihood: A case-based study on small and marginal fish farmers in Cachar district of Assam, India. *Aquaculture, 529*. doi:https://doi.org/10.1016/j.aquaculture.2020.735569

Ellis, F. (2008, November). The Determinants of Rural Livelihood Diversification in Developing Countries. *Journal of AGricultural Economics, 51*(2), 289-302.

FAO. (2024). *The State of World Fisheries and Aquaculture 2024*. Rome: FAO.

FAO. (2025). *FIshStatJ.* Retrieved from Food and Agricultural Organisation: https://www.fao.org/fishery/en/statistics/software/fishstatj

FAO, F. a. (2020). *The State of World Fisheries and Aquaculture.* Rome, Italy: FAO.

FAO, F. a. (2022). *The State of World Fisheries and Aquaculture.* Rome. Italy: FAO.

Gephart, J. A., Henriksson, P. J., Parker, R. W., Shepon, A., Gorospe, K. D., Bergman, K., . . . Troell, M. (2021). *Environmental Performance of blue foods.* Nature.

Ghosh, S., & Indu, R. (2005). *Inland Culture Fisheries in Village Tanks and Ponds: A Multi-location Study in India.* IWMI.

Ghoshal, T., De, D., Kumar, P., & Vijayan, K. (n.d.). *Brackishwater Aquaculture: Opportunities and Challenges for Meeting Livelihood Demand in Indian Sundarbans.* ICAR-CIBA.

GoI. (2022). *Handbook on Fisheries Statistics.* GoI. Retrieved from Department of Fisheries: https://dof.gov.in/fisheries-statistics

GoI. (2023). *Handbook on Fisheries Statistics*. Retrieved from Department of Fisheries: https://dof.gov.in/fisheries-statistics

Gulati, A., & Singh, R. (2023, August 28). How to help Haryana and Punjab move away from paddy to less water guzzling crops. *The Indian Express.* Retrieved from https://indianexpress.com/article/opinion/columns/ashok-gulati-and-reena-singh-write-how-to-help-haryana-and-punjab-move-away-from-paddy-to-less-water-guzzling-crops-9545179/

Hernandez, R., Belton, B., Reardon, T., Hu, C., Zhang, X., & Ahmed, A. (2018). The "quiet revolution" in the aquaculture value chain in Bangladesh. *Aquaculture,* 493, 456-468. doi:https://doi.org/10.1016/j.aquaculture.2017.06.006

Hossain, M., Khan, M., Saha, S. M., & Dey, M. M. (2022). Economic assessment of freshwater carp polyculture in Bangladesh: Profit sensitivity, economies of scale and liquidity. *Aquaculture, 548*(1). doi:https://doi.org/10.1016/j.aquaculture.2021.737552

Hu, F., Zhong, H., Wu, C., & et al. (2021). Development of fisheries in China. *Reproduction and Breeding,* 1(1), 64-79. doi:https://doi.org/10.1016/j.repbre.2021.03.003

ICAR. (n.d.). *Advances in Air Breathing Fish Culture in India.* Barrackpore, India: Central Inland Fisheries Research Institute.

ICAR-CIFRI. (2022). *Annual Report.* Barrackpore, Kolkata: Central Inland Fisheries Research Institute.

Kaminski, A. M., & et al. (2020). A review of inclusive business models and their application in aquaculture development. *Reviews in Aquaculture, 12*(3). doi:https://doi.org/10.1111/raq.12415

Kassam, L., & Dorward, A. (2017). A comparative assessment of the poverty impacts of pond and cage aquaculture in Ghana. *Aquaculture, 470,* 110-122.

Kawarazuka, N., & Béné, C. (2010, October). Linking small-scale fisheries and aquaculture to household nutritional security: an overview. *Food Security,* 343-357.

Kolli, M., Opp, C., Karthe, D., & Groll, M. (2020). Mapping of Major Land-Use Changes in the Kolleru Lake Freshwater Ecosystem by Using Landsat Satellite Images in Google Earth Engine. *Water, 12,* 2493. doi:https://doi.org/10.3390/w12092493

Kumar, K. N., & Ansari, M. (2023). Documenting and Analyzing Targeted Interventions of State Fishery Department of Andhra Pradesh, India. *Asian Journal of Agricultural Extension, Economics and Sociology, 41*(10), 666-675.

Kumaran, M., Ravichandran, P., Gupta, B., & Nagavel, A. (2003). Shrimp farming practices and its socio-economic consequences in East Godavari district, Andhra Pradesh, India-A case study. *Aquaculture Asia,* 48-52.

MPEDA. (2023). *Marine Products Exports Development Authority.* Retrieved from https://mpeda.gov.in/

MPEDA. (2025). *Marine Products Exports Development Authority.* Retrieved from https://mpeda.gov.in/

Muralidharan, C. (2010). Need for Ecosystem Approach to Brackishwater Shrimp Farming - A case from Andhra Pradesh, India. *World Brackishwater Aquaculture Conference (BRAQCON 2019),* (pp. 49-52). Chennai.

NABCONS. (2022). *Study to Determine Post-Harvest Losses of Agri Produces in India.* NABARD Consultancy Services. Retrieved from https://www.mofpi.gov.in/sites/default/files/study_report_of_post_harvest_losses.pdf

Nageswara, K. R., Murali, G. K., & Hema, B. M. (2004). Kolleru lake is vanishing - a revelation through digital processing of IRS-1D LISS-III sensor data. *Current Science,* 86(9), 1312-1316.

Naylor, R., Goldburg, R., Primavera , J., Kautsky, N., Beveridge, M., Clay, J., . . . Troell, M. (2000). Effect of aquaculture on world fish supplies. *Nature, 405,* 1017-1024.

Oboh, A. (2022). Diversification of farmed fish species: A means to increase aquaculture production in Nigeria. *Reviews in Aquaculture, 14*(4), 2089-2098. doi:https://doi.org/10.1111/raq.12690

Padiyar, P., Dubey, S., Bayan, B., Mohan, C., Belton, B., Jena, J., . . . Murthy, C. (2024). *Fish Consumption in India: Patterns and Trends.* World Fish.

Parrao, C. G., Shisler, S., Moratti, M., Yavuz, C., Acharya, A., Eyers, J., & Snilstveit, B. (2021). Aquaculture for improving productivity, income, nutrition and women's empowerment in low- and middle-income countries: A systematic review and meta-analysis. *Campbell Systematic Reviews.*

Primavera, J. (2006). Overcoming the impacts of aquaculture on the coastal zone. *Ocean and Coastal Management, 49*(9-10), 531-545.

Purcell, S. W., Patrois, J., & Fraisse, N. (2006). Experimental evaluation of co-culture of juvenile sea cucumbers, Holothuria scabra (Jaeger), with juvenile blue shrimp, Litopenaeus stylirostris (Stimpson). *Aquaculture Research.*

Robb, D. H., MacLeod, M., Hasan, M. R., & Soto, D. (2017). *Greenhouse gas emissions from aquaculture A life cycle assessment of three Asian systems.* Rome: FAO.

Rodrigues, A. R., Abdallah, P. R., & Gasalla , A. M. (2019). Cost structure and financial performance of marine commercial fisheries in the South Brazil Bight. *Fisheries Research, 210,* 162-174.

Samaddar, A., Panemangalore, A., Maliappan, S., Borah, G., Sikka, A., & Kumar, G. (2024). *Integrated agroecological rice fish farming in Andhra Pradesh, India: A case study.* Agroecology Initiative Technical Report.

Santosh, Gothwal, P., & Singh, A. (2024). An Economic Analysis of Cost and Returns of Fish Farming in Sirsa District of Haryana, India. *International Journal of Education and Management Studies,* 71-74.

Sindhu, M., Sravanthi, K., Alibaba, M., & Suhasini, K. (2023). An Economic Analysis of Semi-Intensive Pond Aquaculture in Southern Telangana *Zone. Indian Journal of Agricultural Economics.*

Srinivas, D., & Venkatrayulu, C. (2019). Sustainability of exotic shrimp Litopenaeus vannamei (Boone, 1931) farming in coastal Andhra Pradesh, India: Problems and Issues. *European Journal of Experimental Biology, 6*(3), 80-85. Retrieved from https://www.researchgate.net/publication/335001597_Sustainability_of_exotic_shrimp_Litopenaeus_vannamei_Boone_1931_farming_in_coastal_Andhra_Pradesh_India_Problems_and_Issues

Tacon, G. A. (2020). Trends in Global Aquaculture and Aquafeed Production: 2000-2017. *Reviews in Fisheries Science and Aquaculture, 28*(1), 43-56.

Wang, P., Ji, J., & Zhang, Y. (2020). Aquaculture extension system in China: Development, challenges, and prospects. *Aquaculture Reports, 17*. doi:https://doi.org/10.1016/j.aqrep.2020.100339

Wang, Q., Cheng, L., Li, Z., Xie, S., & De Silva, S. (2014). Freshwater aquaculture in PR China: trends and prospects. *Reviews in Aquaculture.*

WorldFish. (2023). *Annual Report.* Penang, Malaysia: World Fish. Retrieved from https://hdl.handle.net/20.500.12348/5575

Yuan, J., Xiang, J., Liu, D., He, T., Kim, S., Lin, Y., . . . Ding, W. (2019). Rapid growth in greenhouse gas emissions from the adoption of industrial-scale aquaculture. *Nature Climate Change, 9*(4), 318-322.

ANNEXURE

Annex 1: Change in Composition of Fisheries Sector in Major Producing Countries 1980-2022

		China	India	Indonesia	Norway	Peru	Philippines	Viet Nam
1980	Marine Capture	2.8 (44)	1.6 (63)	1.4 (74)	2.6 (100)	2.7 (99)	1.1 (66)	0.4 (70)
	Marine Aquaculture	2.2 (35)	0 (0)	0.1 (7)	0 (0)	0 (0)	0.3 (18)	0 (1)
	Inland Aquaculture	0.9 (14)	0.4 (15)	0.1 (5)	0 (0)	0 (0)	0 (2)	0.1 (16)
	Inland Capture	0.4 (6)	0.5 (22)	0.3 (14)	0 (0)	0 (0)	0.2 (14)	0.1 (12)
Total Production 1980		6.3 (100)	2.5 (100)	1.9 (100)	2.6 (100)	2.7 (100)	1.6 (100)	0.6 (100)
2000	Marine Capture	12.9 (29)	2.8 (50)	3.8 (74)	2.6 (61)	10.6 (100)	1.8 (59)	3.4 (39)
	Marine Aquaculture	16.5 (37)	0.1 (2)	0.6 (12)	0.5 (14)	0 (0)	1 (33)	0.1 (7)
	Inland Aquaculture	13.2 (30)	1.8 (33)	0.4 (7)	0 (0)	0 (0)	0.1 (4)	0.4 (17)
	Inland Capture	2 (4)	0.9 (16)	0.3 (6)	0 (0)	0 (0)	0.2 (5)	0.2 (10)
Total Production 2000		44.6 (100)	5.6 (100)	5.1 (100)	3.4 (100)	10.6 (100)	3.1 (100)	2.1 (100)
2022	Marine Capture	12 (14)	3.6 (23)	6.9 (31)	2.6 (61)	5.3 (97)	1.6 (39)	3.4 (39)
	Marine Aquaculture	42.4 (48)	1.2 (8)	11 (50)	1.6 (39)	0.1 (1)	2.1 (51)	1.9 (22)
	Inland Aquaculture	33 (37)	9 (57)	3.7 (17)	0 (0)	0.1 (1)	0.3 (6)	3.2 (37)
	Inland Capture	1.2 (1)	1.9 (12)	0.5 (2)	0 (0)	0 (1)	0.2 (4)	0.2 (2)
Total Production 2022		88.6 (100)	15.7 (100)	22.1 (100)	4.2 (100)	5.5 (100)	4.2 (100)	8.7 (100)

Source: FAO

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