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Assessing Assam's Fish Seed Production Gap and its Implications on Food Security and Sustainable Aquaculture

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ABSTRACT

The study highlights the critical role of the fisheries sector in Assam's economy and food security. Assam, a key hub for freshwater fish production in Northeast India, produced 4.43 lakh metric tonnes of fish in 2022-23, but the state continues to face a significant production-demand gap. Fish consumption in Assam averages 13.06 kg per capita annually, yet the state's internal production falls short of meeting this demand, leading to daily imports of 12 to 15 metric tonnes of fish. The paper focuses on the growing gap between fish seed production and demand, projecting an increasing deficit expected to reach 10.11 lakh metric tonnes by 2030 if no strategic interventions are made. Through projections using models such as ARIMA, the study emphasizes the need to scale up fish seed production and establish more hatcheries to bridge this gap. Currently, Assam has 431 hatcheries, and an additional 169 are required to achieve self-sufficiency by 2026. The findings stress the importance of sustainable aquaculture practices, infrastructure development, and government initiatives like the Pradhan Mantri Matsya Sampada Yojana (PMMSY) to ensure long-term food security and economic stability in Assam's fisheries sector.

Keywords : Fish seed production, demand-supply gap, sustainable aquaculture, food security

JEL codes : Q12, Q16, Q22, Q57

I

INTRODUCTION

Fisheries and aquaculture industries play a vital role in the global food production system, significantly contributing to agricultural exports, food security, and the livelihoods of millions of people worldwide. Freshwater fish farming has emerged as one of the fastest-growing food production sectors in recent years. The fishing industry, directly and indirectly, employs millions of people, emphasizing the importance of fisheries to the global economy. Currently, aquaculture produces more than 52 per cent of the world's fish food for human consumption (Naylor et al., 2021). In India, fisheries are particularly significant, employing over 14 million people (Department of Fisheries, 2020). India is the third-largest fish-producing nation and the second-largest in aquaculture (PIB, 2023). The fisheries sector is a key contributor to India's development programs, supporting employment, food security, and foreign exchange earnings. Each year, Indian fisheries contribute INR 1.75 lakh billion (1.03 per cent) to the country's gross value added (Rajeev & Bhandarkar, 2022). In 2019, India's estimated per capita fish consumption was about 7.8 kg (FAO, 2024). Export earnings from fish and fishery products totalled around USD 7.9 billion in 2022 (MPEDA, 2024).

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India possesses abundant freshwater resources that hold great potential for fish production. The country's freshwater resources include 195,210 km of rivers and canals, 2.9 million hectares of minor and major reservoirs, 2.4 million hectares of ponds and lakes, and about 0.8 million hectares of floodplain wetlands and other water bodies. India's extensive network of major and minor rivers, tributaries, creeks, streams, and canals has an estimated combined length of 45,000 km, with the total system reaching 0.17 million km (Economic Survey, 2023-24). Over the years, India's fish production has seen impressive growth, increasing from 24.42 lakh tonnes in 1980-81 to 175.45 lakh tonnes in 2022-23. Fish production's average annual growth rate is 7.98 per cent (Statistical Handbook Assam, 2023-24).

Assam, located in northeast India, stands out as a key contributor to the region's fish production, accounting for approximately 77 per cent of the total fish output in the northeastern region. The state's favorable climate and rich water resources have helped it become a major hub for fish seed production, supported by the establishment of numerous hatcheries. In 2022-23, Assam produced around 4.43 lakh tonnes of fish, contributing 85 per cent of the total fishery production in the northeastern states. The fisheries sector in Assam has immense potential due to the state's natural resources, which include ponds, derelict water bodies, and beels (floodplain wetlands) covering 2.59 lakh hectares. Assam's two major river systems, the Brahmaputra and Barak, and their tributaries extend across 11,304 km of riverine fishery. These water resources provide significant opportunities for boosting fish production, creating employment opportunities, and providing essential nutrition to the population. Assam's fish production level has steadily increased, reaching 4.43 lakh metric tonnes (MT) in 2022-23. The state's per capita fish consumption has also risen, from 12.18 kg in 2021-22 to 13.06 kg in 2022-23. With over 90 per cent of the state's population being fish consumers, there is a constant demand for fish throughout the year. Assam imports 12 to 15 MT of fish daily from other states to meet the growing consumption demand, reflecting a gap between local production and demand. Despite increased production, Assam remains dependent on fish imports to fulfill its population's needs.

To address this gap and achieve self-sufficiency in fish production by 2026, Assam's fisheries department has projected that an investment of ₹3,997 crore will be necessary. This investment would support various fish production supply chain areas, including infrastructure development, operational improvements, and hatchery establishment. Currently, Assam has 431 hatcheries, but an additional 169 hatcheries are required to meet the state's fish production targets. Hatcheries are essential for producing fish seeds, which are critical in increasing fish production. Assam's current fish seed production stands at 4,000 MT, but to achieve self-sufficiency, the state needs to increase fish seed production to 2.5 lakh MT.

This study analyzes the gap between the demand and supply of fish seeds in Assam. The study's objectives are twofold: (i) to estimate the projected production of fish seed in Assam, and (ii) to assess the demand-supply projections and conduct a gap analysis of fish and fish seed production in the state. Addressing these gaps through strategic planning and investment is crucial for ensuring long-term sustainability in Assam's fisheries sector and enhancing food security for the state's population.

II

METHODOLOGY

Secondary data regarding Assam fishery production and related variables was obtained from various published sources. Data from the 68th round of the National Sample Survey (NSS) was assembled to provide information on fish spending among rural and urban consumers. Population data for Assam from the 2001 and 2011 Censuses were obtained, and projections were estimated up to the year 2030

The expenditure elasticity for rural and urban areas was calculated separately, and then the final expenditure elasticity was calculated by proportionate addition of urban and rural elasticity. The elasticity obtained was used for demand projections.

$Q_i = ae_{it}^b$

$\ln Q_i = \ln a + b \ln e_{it}$

Q_i = quantity of commodity consumed by i^{th} household

e_{it} = total consumption expenditure of the i^{th} household at time t

a = intercept, and b = coefficient

The total per capita projected demand up to 2030 has been obtained using base period consumption and expenditure elasticity and growth rate of per capita NSDP. The aggregate demand of the state was estimated by multiplying the projected demand by the projected adult population of Assam up to 2030. The total fish production was projected up to 2030 as the projected supply.

Population and supply projection was made by using the following formula

$P_t = P_0 (1+ r)^t$

P_t = Population/ supply to be estimated

P_0 = Population /supply of the base year

r = Population growth rate/supply growth rate, t = Time period

Estimation of Demand

The following formula estimated the future demand for fish:

$Q_{it}= P_t\{q_{io}(1+g)^{ne_{it}}\}$

Q_{it}= Quantity demanded of the commodity

P = Projected adult population

Q_{io}= Base period consumption of the commodity

g= Growth rate of per capita NSDP

n= number of years

e_{it}= expenditure elasticity

Autoregressive Integrated Moving Average (ARIMA) Model

The model was first introduced by Box and Jenkins (1970) [15] to analyze and forecast univariate time series data. The ARIMA model is characterized by the notation ARIMA (p, d, q), where p, d, and q denote the orders of auto-regression, integration (differentiation), and moving average, respectively. The auto-regressive process of the order (p) is computed as:

$$Y_t = c + \varphi_1 Y_{(t-1)} + \varphi_2 Y_{(t-2)} + \ldots\ldots\ldots\ldots \varphi_p Y_{(t-p)} + \varepsilon_t$$

Moving average process of order (q) is computed as:

$$Y_t = \mu - \theta_1 \varepsilon_{(t-1)} + \theta_2 \varepsilon_{(t-2)} + \ldots\ldots\ldots\ldots \theta_q \varepsilon_{(t-q)} + \varepsilon_t$$

And the general form of ARIMA model of order (p, d, q) is:

$$Y_t = \mu + \varphi_1 Y_{(t-1)} + \varphi_2 Y_{(t-2)} + \ldots \Phi_p Y_{(t-p)} + \varepsilon_t - \theta_1 \varepsilon_{(t-1)} - \theta_2 \varepsilon_{(t-2)} - \ldots \theta_q \varepsilon_{(t-q)} + \varepsilon_t$$

Where Y_t = The value of the time series at time t; c = constant; $\varphi_1, \varphi_2, \ldots \varphi_p$ = Parameters of component; the Autoregressive; $\varepsilon_{t-1}, \varepsilon_{t-2} \ldots \varepsilon_{t-q}$ = Lagged forecast errors of the Moving Average component; $\theta_1, \theta_2, \ldots \theta q$ = Parameters of the Moving Average component; ε_t = White noise error term at time t. The whole methodology of the Box-Jenkins process, which involves parameter estimation, diagnostic checking, and forecasting, was done in R-studio v4.4.3 software using the required plug-ins.

Analysis of ACF & PACF Plots

Autocorrelation (ACF) and Partial Autocorrelation (PACF) plots are the graphical tools used in time series analysis. ACF shows the correlations between a time series and its lags, while PACF displays partial correlations for intermediate lags in the time series. Significant values at certain lags indicate patterns and dependencies in the dataset.

Stationarity Test

The statistical test known as the Augmented Dickey-Fuller (ADF) test is commonly used to determine stationarity in a time series dataset. The null hypothesis of the ADF test is that the time series possesses a unit root and is non-stationary. If the test statistic is significantly negative and falls below critical values from a table, the null hypothesis is rejected, suggesting that the time series is stationary. On the other hand, failure to reject the null hypothesis indicates that the time series is non-stationary.

Ljung-Box Test

It is a standard test used in time series and forecasting to identify significant autocorrelations in the residual of a fitted ARIMA model. The test helps ensure that the model adequately captures the data's autocorrelation structure and if any remaining systematic patterns in the residuals need to be addressed. The test checks the null hypothesis that no autocorrelation exists in the time series up to a specified lag. In our present analysis, a lag order of five was considered for validating the best-fitted ARIMA model.

III

RESULTS AND DISCUSSION

The yearly production of fish seeds in millions from 1986–1987 to 2022–2023 shows a noticeable increase tendency and considerable volatility over the years. Production levels have significantly varied, possibly caused by shifting environmental factors and changing aquaculture techniques. Production has been steadily increasing since the mid-2000s, and this trend continued until the most recent reported years, 2021–2022 and 2022–2023, when production peaked at 18,219 million and 20,843 million, respectively. This spike points to increased market demand for fish stocks, better management techniques, and technological developments in aquaculture. Sustainable practices and strategic planning are essential to satisfy future demands while maintaining environmental and economic sustainability. The data highlights the sector's resilience and growth potential.

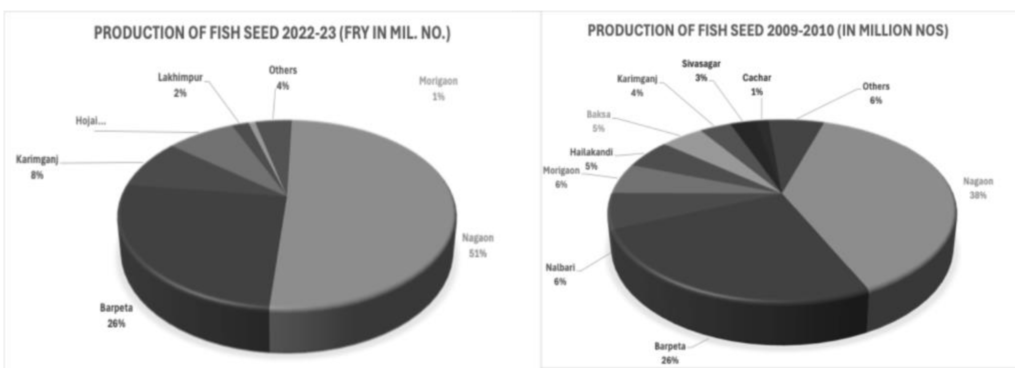

Figure 1: Production of Fish Seed during 2009-10 and 2022-23

When the output of fish seed is compared between 2009–2010 and 2022–2023, Assam's districts exhibit notable variations. Nagaon took the lead in 2009–2010 with 38 per cent, followed by Barpeta with 26 per cent, with 'Others' contributing 8 per cent and Cachar contributing 1 per cent, Nalbari, Morigaon, Baksa, Hailakandi, Karimganj, and Sivasagar contributed lesser portions. Nagaon's stake rose to 51 per cent by 2022–2023, while Barpeta's stayed at 26 per cent. Karimganj's share increased to 8 per cent, while Hojai—who was not

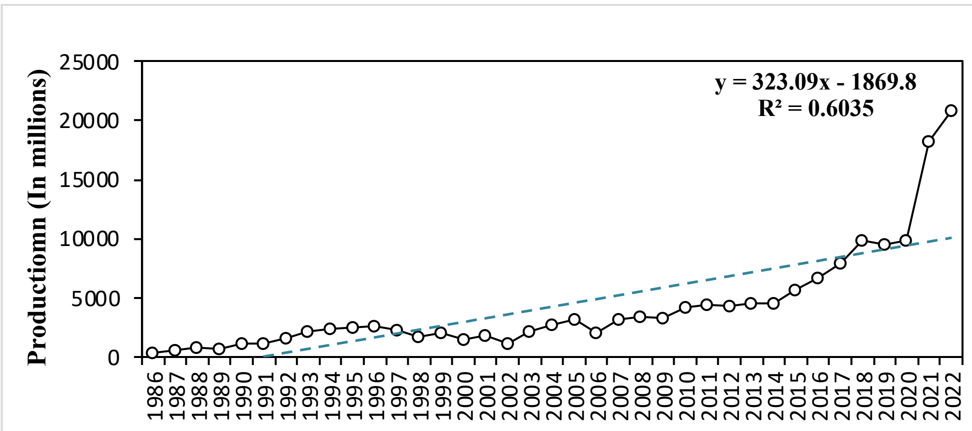

Figure 2: Trends in Fish Production (1986-2022)

previously identified—showed up with 6 per cent. Lakhimpur secured a 2 per cent percentage of the vote. The notable 2009–2010 contributions from Nalbari, Morigaon, and Baksa are no longer mentioned separately, suggesting a potential reduction or consolidation into the 'Others' category, which now stands at 4 per cent. Morigaon's percentage dropped sharply from 5 per cent to 1 per cent. These modifications imply that output is concentrated in fewer areas, with Nagaon and Barpeta as key hubs.

Table 1 presents the projected supply and demand trends in lakh tons from 2023 to 2030. The supply figures represent the anticipated availability of the product, while the demand figures denote the expected consumption. The gap between supply and demand widens yearly, indicating a growing deficit over time. By 2030, the supply is predicted to be 6.98 lakh tons, while the demand is forecasted to reach 17.09 lakh tons, resulting in a deficit of 10.11 lakh tons. These projections highlight the critical need for strategic planning to address the increasing supply-demand imbalance and ensure adequate product availability in the coming years.

TABLE 1: SUPPLY-DEMAND PROJECTION AND GAP ANALYSIS OF FISH IN ASSAM

Year	Supply (Lakh Tonnes)	Demand (Lakh Tonnes)	Gap (Lakh Tonnes)
(1)	(2)	(3)	(4)
2023	4.83	10.24	-5.41
2024	5.09	11.03	-5.94
2025	5.37	11.87	-6.50
2026	5.66	12.77	-7.11
2027	5.97	13.75	-7.78
2028	6.29	14.79	-8.5
2029	6.63	15.91	-9.28
2030	6.98	17.09	-10.11

Table 2 forecasts fish seed production from 2023-24 to 2030-31, showing estimates in millions for each year. It includes a range from lower to upper limits, considering factors like environment, technology, and economics. In 2023-24, production is expected to be around 23,486.47 million fish seeds, possibly ranging from 20,663.64 million to 26,309.29 million. In 2024-25, production is forecasted to increase to 26,129.93 million fish seeds, with a potential range of 21,576.63 million to 30,683.23 million. This upward trend continues each year, aiming to meet growing demands in aquaculture. These insights help policymakers and industry leaders plan for sustainable growth and secure a steady fish seed supply.

TABLE 2: FORECASTED FISH SEED PRODUCTION FOR NEXT 7 YEARS (2023 TO 2030)

Year (1)	Fish seed production (Nos. in million) (2)	Lower limit of forecasted production (3)	Higher limit of forecasted production (4)
2023-24	23486.47	20663.64	26309.29
2024-25	26129.93	21576.63	30683.23
2025-26	28773.40	22495.10	35051.70
2026-27	31416.86	23345.52	39488.20
2027-28	34060.33	24108.16	44012.49
2028-29	36703.79	24777.40	48630.19
2029-30	39347.26	25352.59	53341.93
2030-31	41990.72	25835.00	58146.41

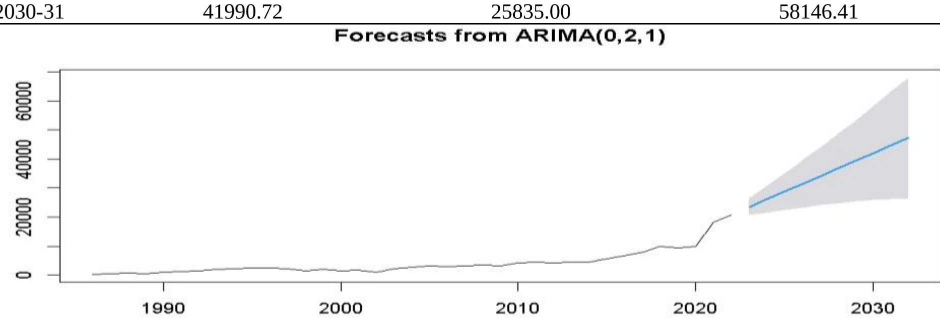

Figure 3: Production Forecasting using ARIMA (0,2,1) model

At the rate at which the fish seed production is increasing, it is estimated that this will reduce the gap and create a surplus of fish seed in the state. This may be attributed to the fact that there has been a rise in hatcheries in the state and other initiatives.

Supporting Fish Farmers and Conservation: The Fishery Department of Assam has actively supported farmers through various initiatives. One of the major efforts is the State Owned Priority Development (SOPD) schemes, focusing on enhancing fish and fish seed production. This includes expanding fish culture areas, providing essential inputs, and improving infrastructure to boost productivity. A notable project under SOPD is the Gene Bank Scientific Conservation Programme for Indigenous Fish (SCoPIF), which aims to safeguard the diversity of local fish species and develop new propagation technologies.

Infrastructure Development and Financial Support: Through the Rural Infrastructure Development Fund (RIDF), the department has implemented crucial projects such as refrigerated fish-carrying vehicles and mini fish feed plants. These initiatives aim to improve transportation and feed availability, vital for maintaining fish quality and supporting rural livelihoods.

Central Government Initiatives: Under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), there's a strong focus on modernizing fishery infrastructure and providing comprehensive support to fish farmers. This includes establishing hatcheries, constructing new ponds, and offering livelihood support programs. Additionally, the Group Accident Insurance Scheme (GAIS) ensures that fishermen and fish farmers are covered for accidents, providing a safety net for those involved in risky occupations.

Community Engagement and Future Plans: The Fishery Mission Society under CMSGUY is dedicated to doubling fish farmers' income through sustainable practices and creating new water bodies. Projects like APART enhance fish productivity through innovative farming techniques and support systems. Looking ahead to 2023-24, the department plans to expand infrastructure, continue conservation efforts, and introduce new technologies to further improve fish farming across the region.

IV

CONCLUSIONS

The study reveals a growing disparity in fish production within Assam. This gap highlights the need for strategic interventions to bridge the shortfall between fish supply and demand. The continuous increase in fish seed production is a key factor in addressing this challenge. Scaling up fish seed production, supported by government initiatives, has the potential to mitigate the widening gap in fish production. Government efforts aimed at enhancing fish seed production are crucial in this endeavour. These initiatives encompass various schemes and policies designed to boost the availability of high-quality fish seeds, which are essential for sustaining and expanding fish farming operations across Assam. As fish seed production rises, it is anticipated to play a pivotal role in narrowing the gap between fish production levels and the increasing demand within the state.

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