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# AQUACULTURE ASIA

## Promoting farmed shrimp consumption

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## Freshwater snails

Catfish seed production

# AQUACULTURE ASIA

**Aquaculture Asia**

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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**NACA**

An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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## Various

I'll forgo the usual banging of the drum on development issues to provide a few updates and foreshadow some forthcoming events.

Firstly, NACA and FUTUREFISH will convene **Aqua-Innovate**, a 5-day workshop for aquaculture innovators to be held from May 12–16 in Bangkok, Thailand.

This event will bring together startups, researchers, solution providers, seafood producers, and investors to identify commercially viable and scalable nature-based solutions to the challenges facing aquaculture. Our goal is to transform the aquaculture industry through innovations, and nature-based solutions practices.

Selected participants will receive targeted mentoring and support to refine their ideas and explore real-world applications and partnerships. If you're developing a product, service, or approach that supports sustainable seafood production, I encourage you to apply. Applications close on **31 March 2025**, please visit the link below for further details and to access the application form:

https://enaca.org/?id=1391

Next, the NACA website has undergone a renovation, please do drop by and check it out at https://enaca.org. Going forward there will be increased focus on audio and video-based content. While you are there, I would like to encourage you to scroll down and sign up for the Email Newsletter, which will be published whenever there is sufficient content to justify an issue, but no more than once a month.

The website will carry a new video-based podcast, beginning in April. I will leave the title as a mystery for the moment, but it will feature long-form interviews with pioneers, entrepreneurs, innovators, scientists and industry legends, that you can watch or listen to at your leisure.

We are also working on a 100% free series of video-based aquaculture training courses, which will provide tuition in core aquaculture skills such as water quality, nutrition and health management. This will be available for both casual learning via YouTube, and formal courses on an e-learning platform where you can earn certificates, so long as you pass the required assessments. The idea here is to make core vocational-level aquaculture training available to everyone, everywhere, and for free.

Over time, we hope to open the platform for participation by partner institutions in the development of more specialised training courses in line with their own areas of expertise. For far too long, aquaculture training has been accessible only to a privileged few. We want to make it the norm, rather than the exception.

Lastly, for those few of you that manage your own websites, Tuskfish CMS 2.1 has been released, and yeah, that's free too. This version adds an extensible block management system with spotlight, recent content and custom HTML block types available by default. Block display is regulated by route (URL path), customisable block positions, and various configuration options. Get it from Github at:

https://github.com/crushdepth/tuskfish2/releases/tag/2.1

AQUACULTURE ASIA



# Promoting farmed shrimp consumption in India's domestic market: A step towards sustainability

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*Marketable-sized Penaeus vannamei in a farm in Purba Medinipur.*

## Economic importance of farmed shrimp

The brackishwater aquaculture industry plays a significant role in India's economy. Shrimp farming dominates this sector due to its high profitability. Initially, the industry was based on black tiger shrimp (*Penaeus monodon*). However, it has now shifted to white leg shrimp (*Penaeus vannamei*).

In West Bengal, *P. vannamei* is farmed commercially in the coastal districts of Purba Medinipur, South 24 Parganas, and North 24 Parganas. India is a major shrimp producer, with seafood exports worth ₹605.24 billion in 2023–2024. Frozen shrimp exports totaled 716,000 tonnes, contributing more than 66% (₹400.13 billion) of total seafood export earnings.

Penaeid shrimp are the main species in India's brackishwater aquaculture. In 2020–2021, India produced 852,000 tonnes of farmed shrimp, of which *P. vannamei* accounted for 816,000 tonnes (Courtesy: Dr D. De, Principal Scientist, ICAR, Government of India).

West Bengal has 59,490 hectares of brackishwater aquaculture. This includes 7,171 hectares in Purba Medinipur, 17,759 hectares in South 24 Parganas, and 34,560 hectares in North 24 Parganas. In 2024, shrimp production in the state reached 70,366 tonnes. Scientific shrimp farming covers 4,500 hectares in Purba Medinipur, 770 hectares in South 24 Parganas, and 800 hectares in North 24 Parganas (Courtesy: Dr T. K. Ghoshal, Principal Scientist, ICAR, Government of India). In 2019, *P. vannamei* contributed nearly 72% of India's total shrimp export value.

With an estimated shrimp production of nearly 850,000 tonnes in 2023, India exported a similar volume. This accounted for more than 15% of the global shrimp trade (Courtesy: Yahira Piedrahita, Executive Director, National Chamber of Aquaculture).

In 2010, *P. vannamei* made up less than 5% of India's total shrimp production. By 2018, its share had risen to about 90%. According to M. M. Mondal, a progressive shrimp farmer in Purba Medinipur, farmers in West Bengal first adopted *P. vannamei* in 2013–2014. *P. monodon* was rarely preferred. *P. vannamei* has a smaller harvest size than *P. monodon.*

Approximately 30,000 shrimp farmers in West Bengal practice scientific farming. In 2018, the state's *P. vannamei* production reached about 85,000 tonnes, with a market value of ₹400 billion. In 2019, shrimp farming was affected by environmental hazards such as a super-cyclone. Despite this, production still reached 97,000 tonnes.

In Purba Medinipur, key *P. vannamei* farming sites include Vill. Bhuniapada, Vill. Thakurchak-Soula (under Junput Coastal PS, Contai-I CD Block), and Vill. Kalichak (under Contai-2 or Deshapran CD Block). The authors have visited these locations.

West Bengal is India's second-largest producer of farmed shrimp, after Andhra Pradesh.

## Common diseases in shrimp farms in West Bengal

Shrimp diseases arise from four key factors: pathogens, the host, an unhealthy environment, and stressors or triggering factors. Low dissolved oxygen, poor water exchange, high stocking density, elevated water temperature, excessive turbidity, and overloading the pond's carrying capacity contribute to disease outbreaks.

White spot syndrome virus (WSSV) is a highly virulent, fast-replicating DNA virus. It has caused major losses in *P. monodon* aquaculture in West Bengal and other coastal states. WSSV leads to white spot disease in *P. monodon*, which begins with small white spots on the inner carapace and spreads across the body in advanced stages. The virus is more pathogenic at lower temperatures and spreads rapidly. During summer, infected *P. monodon* may survive without mortality.

*Healthy P. monodon harvested from ponds in South 24 Parganas (above) and Purba Medinipur(below).*

*Aerators in operation in four adjacent shrimp culture ponds.*

In *P. vannamei*, WSSV infection is indicated by a whitish gut from day 25–30 of culture. A healthy shrimp has a blackish gut when the gastrointestinal tract is full. White faeces appear as floating strings in pond margins and corners, signalling white faeces Syndrome (WFS). Infected *P. vannamei* develop a pale gastrointestinal tract.

Microsporidian infection caused by *Enterocytozoon hepatopenaei* (EHP) leads to slow growth, reduced appetite, and chronic mortality. It spreads directly from shrimp to shrimp. The infection weakens the hepatopancreas, reducing its ability to absorb nutrients. The hepatopancreas turns pale. EHP is strongly linked to WFS. Infected *P. vannamei* excrete white faeces and, after one month, develop a soft-shell abnormality unrelated to moulting.

WFS is fully correlated with EHP and also linked to *Vibrio* bacteria. EHP and Vibrio infections together result in WFS. White faeces indicate a highly infectious stage of EHP in *P. vannamei* monoculture ponds. Other issues shrimp farmers face in West Bengal include ammonia-related problems in pond water and bottom soil, as well as loose shell disease. In loose shell disease, affected shrimp develop spongy abdomens, and the hepatopancreas shrinks.

Running mortality syndrome, not caused by viruses, appears when *P. vannamei* reach 10–15 grams, around day 60 of culture. Another condition, resembling red gut disease, occurs between days 30 and 40. Infected shrimp swim to the water surface even when aeration and dissolved oxygen levels are normal. They stop eating, and their faeces turn red. A red or pink gastrointestinal tract signals disease in *P. vannamei*.

In South 24 Parganas, some brackishwater farmers practise modified-extensive polyculture. They grow *Catla catla*, *Lates calcarifer* (in small numbers), *Mystus gulio*, *Metapenaeus brevicornis*, *Macrobrachium rosenbergii*, *Liza tade*, *L. macrolepis*, *P. monodon*, and *P. vannamei* in the same water body. They believe that if shrimp production declines due to disease, marketable-sized fish will compensate for the loss.

## Emerging problems and concerns for *P. vannamei* farmers

Shrimp farmers in West Bengal have reported several challenges. These include low harvest yields, increased feed requirements, high feed conversion ratios (FCR), abnormal shrimp behaviour, weakness, slow growth, and poor feed consumption.

Farmers purchase *P. vannamei* seeds in oxygen-packed containers from hatcheries in Andhra Pradesh, Tamil Nadu (locally known as “Andhra” and “Chennai” seeds), Odisha, and international suppliers approved by the Government of

India. However, these seeds are not always tested using polymerase chain reaction (PCR) for major shrimp pathogens. As a result, farmers cannot be sure that the post-larvae they stock are resistant to specific diseases. Market prices for harvested *P. vannamei* also fluctuate unpredictably.

Only shrimp farms registered with the Coastal Aquaculture Authority's Farm Registration Section are authorised to receive specific pathogen-free (SPF) *P. vannamei* seeds. Many farmers in Purba Medinipur and other districts are not registered, making them ineligible for SPF seeds.

Shrimp farming is under threat, leading to a decline in production. Commercial shrimp culture has dropped by 30% compared to a decade ago. Many farmers in West Bengal have suffered heavy financial losses. Frustrated and discouraged, some are abandoning shrimp farming.

A significant number of shrimp farmers are shifting to other forms of aquaculture. These include brackishwater polyculture with *P. monodon* and mullets (*L. tade*, *L. parsia*, *L. macrolepis*), *M. gulio* monoculture, monosex tilapia culture, mud crab farming and fattening in brackishwater ponds, and Indian major carp farming in freshwater ponds.

The decline in shrimp farming is driven by several factors. These include poor-quality *P. vannamei* seed, disease outbreaks, improper farm management, and environmental hazards. Most shrimp farmers in Purba Medinipur struggle to obtain high-quality seeds.

Apart from these issues, other critical factors affecting shrimp farming include rising production costs. The increasing expenses for shrimp seed, feed, medicine, and fuel for aerators and other farm operations have pushed many farmers into financial crisis. The cost of shrimp production in West Bengal is higher than in other coastal states.

To maintain adequate dissolved oxygen levels in farm ponds, farmers rely on diesel generators, which increases costs. Most farms do not have an electricity connection registered in the farmer's name. Diesel pumps are also used to draw canal and creek water into *P. vannamei* ponds during high tide. With rising fuel prices, these costs continue to escalate.

*P. vannamei* farming is now highly dependent on commercial aquaculture products marketed by private companies. It also requires more formulated feed than *P. monodon*. To cover initial input costs, many farmers take large loans from village moneylenders (Mahajans), Gram Panchayats, or fish feed dealers from private companies. These loans carry high interest rates, reducing overall profits.

*First author observing growth of P. vannamei.*

*Close view of a aerator in operation in shrimp pond.*

Many *P. vannamei* farmers in the three coastal districts of West Bengal struggle to repay loans due to lower-than-expected shrimp production and profits. Healthy, marketable shrimp fetch high prices in international markets, but farmers receive only a small fraction of the value. Buyers and middlemen dictate the selling price, often depriving farmers of fair earnings. This discourages shrimp producers and negatively impacts their livelihood.

Recently, the *P. vannamei* farming industry has faced setbacks due to price fluctuations, despite strong market demand. Rapidly increasing shrimp production has led to market price declines. Farmers sell their shrimp directly to exporters or middlemen but lack access to real-time market information, pricing trends, and export potential. Middlemen buy shrimp at low prices and sell them to exporters at higher rates, earning commissions while farmers bear financial losses. Many shrimp farmers do not receive a fair price for their harvest, affecting their economic stability.

In addition to disease outbreaks, declining profit margins, and rising costs, unpredictable weather conditions present a major challenge. The West Bengal coast is prone to cyclones, which cause high shrimp mortality. Severe cyclonic storms such as Aila (25 May 2009), Amphan (19–20 May 2020), Bulbul (9–10 November 2019), and Yaas (25–26 May 2021) coincided with spring tides, leading to floods and coastal inundation. These disasters have caused severe damage to commercial *P. vannamei* farming in semi-intensive and intensive systems across the three coastal districts in recent years.

## Steps to address these challenges

To ensure the long-term sustainability of shrimp farming in West Bengal, several strategic measures must be taken.

The first step is to establish cold storage facilities in key shrimp farming areas. Many farmers are forced to harvest prematurely when their farms are at risk of disease outbreaks. This results in smaller shrimp being sold urgently (emergency harvest), often at very low prices set by buyers and exporters. Since shrimp is highly perishable, farmers have no choice but to sell at these rates. Cold storage facilities would extend the shelf life of harvested *P. vannamei*, preventing distress sales. Ice plants and processing units should also be set up near farming regions to ensure harvested shrimp remain in good condition.

The West Bengal Fisheries Department should organise more training programmes at the block level. These programmes would provide shrimp farmers and underemployed rural youths with knowledge of the latest developments in shrimp farming science and technology.

*A shrimp farm in Purba Medinipur.*

Considering the coastal geography of West Bengal, authorities should review the *Coastal Regulation Zone Act* to allow sustainable shrimp farming without unnecessary legal obstacles. Regulations could be modified in specific areas to ensure uninterrupted farming.

Private sector companies supplying shrimp feed and farm inputs should address farmers' concerns and needs. The rising cost of shrimp feed, medicines, and pond treatment products makes farming less viable. These products should be made available at reasonable prices.

If shrimp farmers can maintain their livelihoods, the entire shrimp trade and related industries will remain active. Farmers should be made aware of the opportunities in brackishwater aquaculture and provided with the necessary support. Subsidies for seed, feed, and electricity supply could help reduce production costs.

Garlic, a commonly available natural remedy, is known to enhance disease resistance in *P. monodon* and *P. vannamei*. Its use in shrimp farming should be promoted as a low-cost method to improve shrimp health.

## Health benefits of eating shrimp

*P. vannamei*, *P. monodon*, and *P. indicus* contain the carotenoid nutrient astaxanthin, which helps strengthen arteries and reduces the risk of heart attacks. Shrimp contains no trans fats.

According to a study published in the International Journal of Fisheries and Aquaculture (July 2013) by scientists from CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University, *P. vannamei* is a good source of omega-3 long-chain fatty acids and protein. It provides high-quality protein, calcium, essential minerals, and bioactive compounds, while being low in calories and fat. Shrimp is also beneficial for brain health and thyroid function. It contains essential nutrients such as vitamin B12, selenium, zinc, and phosphorus.

Dr. P. Bandyopadhyay, in his article Future of Indian Shrimp Industry and Expectation in 2020 (Bengal Aqua Expo Souvenir, February 2020), highlighted several health benefits of farmed shrimp consumption. These include weight loss, anti-aging properties, improved bone health, and reduced risk of cardiovascular diseases. Shrimp can help lower blood pressure and reduce the chances of heart disease.

Researchers Dr. D. Das, Dr. J. Islam, and Dr. A. Shinn have also identified shrimp as a nutritious food, rich in digestible protein and highly unsaturated fatty acids (EPA and DHA). It also has cholesterol-lowering properties, making it a healthy dietary choice.

## Promoting farmed shrimp consumption in India's domestic market

Mr. Y. Piedrahita, Executive Director of the National Chamber of Aquaculture, highlighted this issue in his article Shrimp Producers in India Are Betting on the Local Market to Keep the Industry Afloat, published in the April 2024 issue of AQUACULTURA. Given the significant health benefits of farmed shrimp, promoting domestic consumption is one of the key strategies proposed to support the shrimp farming industry in India.

Dr. D. Das, Dr. J. Islam, and Dr. A. Shinn, in their article Now Is the Time for India to Increase Its Consumption of Locally Produced Shrimp (Aquaculture Spectrum, June 2020), argued that raising awareness of shrimp's health benefits will boost domestic demand. They emphasised the need to develop strategies for popularising shrimp and shrimp-based products in India. The dietary preferences of India's affluent middle class and urban consumers are shifting towards "safe food," creating an opportunity to supply high-value, ready-to-eat shrimp products.

To achieve this, strategic marketing initiatives are necessary. These include attractive packaging, clear shrimp nutrition labels, and best management practices (BMP) and Hazard Analysis and Critical Control Points (HACCP) certifications. Mass media campaigns—through social media, television, and print media—should also be used to promote shrimp consumption.

Mr. Piedrahita further noted that as India's population grows, so does its awareness of health and nutrition. This presents a promising opportunity to promote fish and seafood consumption. To expand domestic shrimp sales, shrimp must be readily available, affordable, and recognised as a desirable protein source. Encouraging a shift in consumer dietary preferences is essential.

Large-scale information campaigns are needed to highlight the benefits of eating shrimp. Leading companies like Falcon Marine Exports in Bhubaneswar, Odisha, and Zhingalala, a shrimp-specialty restaurant in Surat, Gujarat, have already started initiatives to boost local shrimp demand. The Prawn Farmers Federation of India (PFFI) has submitted an action plan to the Indian government to develop the domestic shrimp market. PFFI aims to establish efficient distribution networks, ensure a steady supply of high-quality shrimp at reasonable prices, and meet consumer demand nationwide.

Mr. V. Balasubramaniam, Secretary General of PFFI, believes this approach will help stabilise shrimp prices for farmers while benefiting households, hotels, and the food industry. He sees this as an ideal time to promote shrimp consumption, particularly smaller shrimp sizes, which are preferred in Indian cuisine. Expanding local sales would ensure fair prices for consumers while maintaining profits for producers.

Dr. M. Krishnan and Dr. S. Chandra Babu, in their article COVID-19 Opens Up the Domestic Market for Indian Shrimp (Aquaculture, March 2022), highlighted how India's shrimp industry adapted to local demand when exports collapsed during the COVID-19 lockdowns. Since 15 March 2020, Indian shrimp farmers have realised the potential of the domestic market. The authors presented two case studies, one at the farm level and one at the industry level, demonstrating how the global shrimp market disruptions created new domestic demand.

Organisations such as the Marine Products Export Development Authority (MPEDA), the National Fisheries Development Board (NFDB), and the Andhra Pradesh Aquaculture Authority are now actively working to develop and promote the domestic shrimp market. The All-India Shrimp Farmers Association is also leading efforts to organise shrimp production and sales through e-commerce and retail store networks.

*Below: Shrimp farm in South 24 Parganas.*

# Leveraging indigenous minor carp for sustainable aquaculture in Northeast India

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Northeast India comprises Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. It covers about 7.9% of India's total land area. Two-thirds of the region consists of hilly terrain, including the mountains of Arunachal Pradesh and Sikkim. The fertile valleys of the Brahmaputra, Barak, and Imphal rivers lie in the lowlands. The region receives heavy rainfall during the southwest monsoon. Summers in the valleys are hot and humid, while the hills and mountains experience long, cold winters.

This diverse geography and climate support rich fisheries resources. The region has torrential hill streams, an extensive river system, and lakes at both high and low altitudes. Reservoirs and floodplain wetlands also play a key role in sustaining fish biodiversity. Northeast India is a global hotspot for freshwater fish diversity. Researchers have recorded between 267 and 422 species in the region.

Aquaculture production in Northeast India is mainly concentrated in the valley regions. Mid- and high-altitude areas contribute only a small share. In 2022–23, the region accounted for just 4.6% of India's inland fisheries production. Minor carp production was about 11,000 tonnes in the same period (HFS 2023, 2023).

The average fish productivity in the region is 1.5 tonnes per hectare per year, which is below the national average of 3 tonnes per hectare per year (Debnath, 2022). More than 97% of the population consumes fish, creating a large gap between supply and demand. The current per capita fish consumption in the region is about 10.9 kg, lower than the national average of 13.9 kg. To meet demand, fish is imported from Andhra Pradesh and other Indian states.

## Fish farming in northeast India

Aquaculture in the region mainly involves carp-based polyculture, with catfish playing a minor role. Several indigenous carp species inhabit the natural water bodies of Northeast India. Although many fish species have potential for aquaculture, fish and seed producers typically focus on 12–15 species of carp, catfish, and prawn.

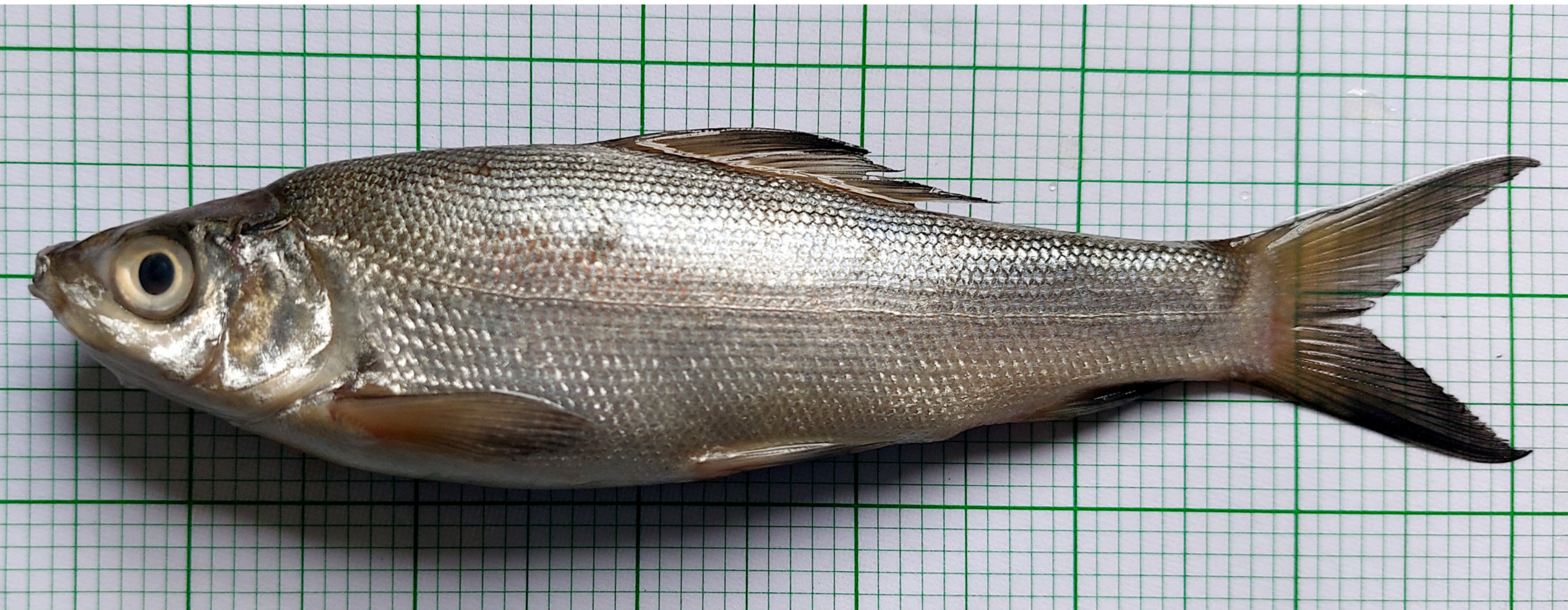
The most commonly cultured species are Indian major carps (IMC), including rohu, mrigal, and catla, along with three exotic major carps—silver carp, grass carp, and common carp. IMC species are mostly farmed in low-altitude areas, as they struggle to adapt to the cold climate of the hills. Some local minor carp species, such as pabda, pengba, gonius, and bata, are also being introduced into aquaculture due to their local importance and market value.

Standardising breeding and culture techniques for indigenous minor carp could boost fish production, not only in the hilly states but also in the valleys.

## Constraints of aquaculture in northeast India

The development of aquaculture in Northeast India faces several challenges, particularly in the hill regions and parts of the valleys. The difficult terrain, cold climate, poor soil water retention, unpredictable rainfall, and monsoon patterns all pose obstacles. Flood-prone plains, small to medium-sized fish ponds, and a short period suitable for fish culture add to the difficulties.

*Labeo gonius.*



*Osteobrama belangeri.*

Composite fish culture, commonly used in low-altitude areas, is not suitable for the hills due to low water temperatures, which are unfavourable for Indian major carps. Many valley and plain areas, which are ideal for aquaculture, are prone to flooding and have highly permeable soils.

Other major challenges include the lack of quality fish seed and the untimely availability of seed for suitable species. There is also a shortage of locally produced feed ingredients, cost-effective nutritionally balanced artificial feed, live food, and larval feed. The high cost of commercial feed further worsens the situation.

Most farmers in the region have limited resources and rely on small to medium-sized ponds, many of which are seasonal. To sustain aquaculture and meet fish demand, farmers need to adopt species that can adapt to local climatic conditions, have a short marketable culture period, and accept artificial feed.

## Minor carp culture in northeast India

Minor carps are commercially important fish from the Cyprinidae family. They have high potential for aquaculture in the region, particularly in areas with a short culture period. According to the Handbook of Fisheries Statistics, 2023, minor carp production in 2022–23 was about 11,000 tonnes.

These fish perform better than Indian major carps at lower temperatures, making them suitable for hilly areas. They grow well in shallow waters, which is ideal for regions with seasonal ponds and flood-prone areas. Most minor carp species are omnivorous and readily accept artificial feed.

Minor carp are widely consumed in the region due to their taste and texture. They have high nutritional value, with good levels of protein, fatty acids, and minerals. Consumer preference and strong market demand make them an attractive option for aquaculture.

The marketable size of minor carp is 100–300 g, compared to 700–800 g for major carps. This makes them well suited for short-term culture. In carp polyculture systems, minor carp are compatible with major carps and help increase overall production.

## Indigenous minor carp species

Northeast India has a rich diversity of indigenous minor carp species, including *Labeo bata*, *L. gonius*, *L. dyocheilus*, *Cirrhinus reba*, *Osteobrama belangeri*, *Bangana devdevi*, and *B. dero*.

*Labeo bata*, *L. gonius*, and *C. reba* are widely used in aquaculture across the region. They are commonly farmed in both polyculture and composite systems alongside major carp species. *O. belangeri* is commercially farmed only in Manipur due to local preference.

*L. dyocheilus*, *B. devdevi*, and *B. dero* are considered potential candidates for aquaculture. These species are valued for their compatibility with other fish, good growth performance, strong market demand, and role in increasing production and income. Their cultivation could also support conservation efforts.

## Feeding habits of minor carp

Minor carp are primarily herbivorous, feeding on algae, aquatic plants, zooplankton, and diatoms. They readily accept plant-based diets and can utilise plant protein sources. Various protein-rich agro-industry by-products can be used to formulate low-cost, farm-made feed for these species.

The ability of minor carp to consume artificial feed, especially plant-based ingredients, makes them a popular choice for small and medium-scale fish farmers. Their acceptance of plant-based feed helps reduce the culture period and lowers feed costs.

## Minor carp culture

Minor carp are mainly cultured alongside other carp species in polyculture or composite culture systems. They require the same management practices as major carps. They are compatible with major carps in composite fish culture and are well suited for integrated fish farming, such as paddy-cum-fish culture.

Minor carp can also be cultured in open water bodies using pens and cages or in closed systems like biofloc. They are an important species for aquaculture as they can reach market size within six months. Since most of the region is suitable for fish farming for only 6–8 months a year, depending on location, their short culture period is a significant advantage.

Minor carp grow well at lower temperatures in hilly areas, adapt to shallow waters, and are suitable for short-duration farming in small seasonal ponds. Their rapid growth allows for two harvests per year. They are easily marketable, even at a smaller size, making them an attractive option for fish farmers.

## Seed production

Minor carp in the region breed during the southwest monsoon season. The seed production of *Labeo gonius*, *L. bata*, and *Cirrhinus reba* is well established due to developed hatchery management. These species respond well to synthetic hormones, making induced breeding easier. Their larval culture is similar to that of major carps, facilitating large-scale seed production.

The commercial seed production of *O. belangeri* is concentrated in the Manipur Valley. Successful breeding has also been reported at mid-altitudes (900 metres above sea level), highlighting its potential for aquaculture in mid-hill regions (900–1,200 metres above sea level) (Das & Singh, 2017).

*B. dero* has emerged as a promising species for aquaculture. The successful development of induced breeding techniques has enabled efficient spawn production in Manipur (Basudha et al., 2017). *B. devdevi* holds significant economic importance in Manipur. Researchers have successfully bred this species using synthetic hormone techniques, ensuring a steady seed supply for aquaculture (Bedajit et al., 2020).

*L. dyocheilus* is another potential species for the hilly regions, but its seed production technology is still under study to adapt it to local conditions. Developing induced breeding techniques and standardised protocols is essential to boosting seed production for indigenous fish species. Expanding the culture of local fish will help farmers diversify their aquaculture practices and meet growing market demand.

## Economic viability

Minor carp have a fast growth rate and reach market size within 5–6 months. They are easily sold at 100–300 g, making them ideal for short-duration culture in seasonal and hilly water bodies. Farmers can harvest two crops per year, allowing for quicker returns. Minor carp also have a higher market price compared to major carp.

*B. devdevi* and *B. dero* are in high demand in Manipur, fetching three times the price of Indian major carps (IMC) (Bedajit et al., 2020; Sobita & Basudha, 2020). Their simple culture system relies on supplemental feeds, making them suitable for small and medium-scale fish farmers, who form the majority in the region.

Minor carp readily accept plant-based agricultural by-products, reducing feed costs significantly. This is crucial given the high price of commercial feed. In polyculture systems, minor carp contribute to higher overall production and economic returns. Their market price is 20–30% higher than IMC, making them a valuable addition to aquaculture (Das & Mishra, 2016).

## Conclusion

There is great potential to improve aquaculture productivity in the region by introducing fast-growing fish species suited to local conditions. To meet the rising demand for fish and ensure sustainable growth, it is essential to identify indigenous species that can tolerate lower water temperatures, adapt to shallow waters, and reach market size within 7–8 months.

Indigenous minor carp are promising candidates for aquaculture. They are compatible with composite fish farming and have strong potential for commercial adoption. However, further research is needed to optimise their culture and establish them across different parts of the region.

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# Shaping the future of Indian aquaculture: A path to captive catfish seed success

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*Clarius batrachus fingerlings.*

A major development in Indian aquaculture in the late 20th century was the shift from focusing solely on major carps to a more diverse range of species. Catfish have become a key part of this expansion. Their unique taste makes them a delicacy. They also fetch high prices due to their flavour, soft flesh, and fewer bones. Some species are sold live, which improves their market value.

Since the late 1980s, aquaculture in India has grown into an industry. Entrepreneurs now farm carps, catfish, and prawns. Recently, the Government of India identified catfish farming as a national priority and encouraged diversification. However, despite its potential, many fish farmers struggle to culture catfish due to a lack of stocking material. Relying on wild seed collection is not sustainable. Captive seed production is necessary to meet demand. This chapter provides an overview of induced breeding and rearing methods for key catfish species. It offers practical guidance for farmers in the Indian subcontinent to produce catfish seed.

he Asian catfish (*Clarias batrachus*), commonly known as magur, is an air-breathing fish well adapted to harsh environmental conditions. This tropical species is typically found in swamps, marshes, and stagnant water bodies across the Indian subcontinent. Due to its hardy nature and ability to breathe air, it can be cultured at high stocking densities. In recent years, magur farming has gained popularity and is recognised as a valuable species for aquaculture diversification.

Healthy brood fish are maintained on a formulated feed containing 30% protein, with periodic water exchange. This species reaches maturity at about one year. Brood fish weighing 100–150 g can be used for breeding. Males and females are distinguished by secondary sexual characteristics. Gravid females have a round, swollen abdomen and a reddish, circular vent, while males have an elongated, pointed genital papilla. Magur breeds naturally during the monsoon, from June to August.

Females are induced to spawn using synthetic hormones such as Ovaprim, Ovatide, or WOVA-FH at a dose of 1.0–1.5 ml/kg of body weight. Alternatively, they can be injected with conventional carp pituitary extract at 30 mg/kg of female body weight. Females are ready for stripping 16–17 hours after injection. The stripped eggs are fertilised using a sperm suspension prepared by macerating testes in a 0.9% sodium chloride solution.

The species has low fecundity, producing about 600 eggs per gram of ovary weight. A healthy female weighing 100–150 g can lay 6,000–7,000 eggs. The eggs are adhesive and light brown in colour.

The flow-through hatchery consists of a metallic stand or a cemented platform, supporting a row of small plastic tubs with a diameter of 12 cm and a height of 6 cm. Each tub can hold 1,500–2,000 eggs for hatching. Water is supplied from an overhead tank through a common pipe, with individual control taps for each tub. Each tub has an outlet positioned at a height of about 4 cm.

The ideal hatching temperature is 27–30°C, and hatching occurs within 24–26 hours. After hatching, the larvae are washed thoroughly to remove eggshells. The yolk sac is absorbed within 3–4 days. The hatchlings are then transferred to circular or rectangular fibre-reinforced plastic (FRP) or plastic containers for further rearing.

Once the yolk is absorbed, the larvae readily feed on live mixed zooplankton and *Artemia* nauplii. Those reared on *Artemia* exhibit better growth. At 9–10 days old, the larvae start accepting formulated feed, which is introduced gradually while reducing live feed. An optimal stocking density of 1,000–1,500 larvae per square metre, along with two-thirds water renewal, ensures the best survival rates during the first 2–3 weeks. By this stage, they grow to 30–40 mg.

The fry are then transferred to cement tanks for further rearing until they reach the fingerling stage. Providing shelters, feeding crumbled feed, and regular water exchange are essential management practices to ensure healthy fingerling production.

## *Heteropneustes fossilis*

The catfish *Heteropneustes fossilis* (Bloch), commonly known as singhi, is not primarily piscivorous. In natural waters, its diet includes insects, ostracods, worms, algae, organic debris, and occasionally fish. Post-larvae feed on plankton. Singhi breeds in confined water bodies during the monsoon. Males and females reach sexual maturity at one year of age. No parental care has been reported.

Researchers have successfully induced breeding in singhi. Brood fish can be collected from the wild or reared in ponds on a diet containing 30–32% protein. Males and females are identified by the shape of the genital papilla, similar to *Clarias batrachus*. The dose for hypophysation varies from 60–200 mg of pituitary gland per kg of body weight, depending on female maturity. Some researchers have also reported successful breeding using synthetic or steroid hormones. Several inducing agents are effective, including:

- LHRHa and pimozide (50 µg + 5 mg/kg)

*Heteropneustes fossilis fingerlings.*

- Ovaprim (0.6–0.9 ml/kg)
- 17α-hydroxy-progesterone (8 mg/kg)
- 17α, 20β-dihydroprogesterone (2 mg/kg)

Stripped eggs are fertilised using sperm suspension, following the same method as in *C. batrachus*. Natural breeding is also possible without sacrificing the male. Both sexes of similar weight are injected with synthetic hormones such as Ovatide, Ovaprim, Gonopro, or Ova-FH. The dosage is 1 ml/kg for females and 0.5 ml/kg for males, administered in the evening. The injected brood pairs are released into tanks with a water shower. Fertilised eggs settle at the bottom and are collected the next morning for incubation.

Eggs have a diameter of 1.4–1.6 mm, and hatching occurs within 18–20 hours. The yolk sac is absorbed by the end of the third day, after which larvae begin feeding. Initially, larvae are fed boiled egg yolk, chopped or crushed molluscan meat, and mixed zooplankton. These feeds can be used alone or in combination to improve survival. After ten days, compound feed in dough form replaces live feed. The larvae are reared for 2–3 weeks before being stocked in outdoor tanks for fingerling production.

The fry are transferred to cement tanks with shelters, which satisfy the catfish's hiding behaviour. Crumbled feed containing 30–32% protein is provided near the shelters for easy access. Regular water exchange ensures good water quality. Well-fed fish reach a weight of 2–4 g within 2–3 months of rearing.

## *Wallago attu*

*Wallago attu*, commonly known as the freshwater shark, belongs to the family Siluridae. It is a large catfish found in rivers, reservoirs, and connected water bodies across the Indian subcontinent. This species is known for its impressive growth, reaching up to 2 m in length and 45 kg in weight. It is highly carnivorous and predatory. Its rapid growth, elongated silvery appearance, and high nutritional value make it a promising species for aquaculture.

*Wallago attu* breeds once a year during the monsoon in flooded river margins and reservoirs. It has also been observed breeding in large tanks after heavy rains, when runoff water flows into the tanks. Several studies have reported successful induced breeding.

Induced spawning has been achieved using LHRHa and Buserelin acetate (Hoe 766 vet). The female is given 150 µg/kg of body weight as the first dose, followed by progesterone at 100 µg/kg after six hours. The male is injected with 50 µg/kg of Hoe 766 vet at the time of the second injection for the female. Spawning occurs 11–15 hours after hormone injection.

Hypophysation has also been successful, using 16 mg (administered as 4+12 mg or 6+10 mg) of carp pituitary extract per kg of body weight for females. Males receive 5–6 mg (2+3 mg or 3+3 mg) per kg of body weight, leading to ovulation 5–6 hours after the second injection. A study at ICAR-CIFA found that a single injection of Ovaprim at 0.3 ml/kg for males and 0.5 ml/kg for females also resulted in successful induced spawning. Males and females are ready for stripping 8–10 hours after injection.

The sticky eggs hatch after 18–20 hours of incubation. The hatchlings are free-swimming and display cannibalistic behaviour. They prey on smaller or similarly sized larvae by biting the head or tail and swimming with the prey in their mouths. High stocking densities increase cannibalism, while lower densities improve survival during indoor rearing.

Larvae can be reared on live zooplankton, molluscan meat, fish muscle, or goat liver, either individually or in combination. Regular segregation improves survival. Farmers often release fry into ponds where weed fish are abundant. These serve as live feed and satisfy the catfish’s predatory instincts, allowing them to grow into fingerlings or juveniles.

## *Ompok* spp.

The genus *Ompok* includes *Ompok bimaculatus*, *O. pabo*, *O. pabda*, and *O. malabaricus*. These medium-sized catfish, belonging to the family Siluridae, are valued as food fish and have high consumer demand. However, limited research exists on their induced breeding and culture.

The first breeding and culture trials for *O. pabda* were conducted at the Kalyani Centre of ICAR-CIFA in West Bengal. Initial results showed that mature fish could be induced to spawn using carp pituitary extract or Ovaprim, either by stripping or natural hapa breeding. Spawning occurs 6–8 hours after injection. A higher dose of Ovaprim (3–4 ml/kg) improves egg release. Hatching takes place within 18–20 hours.

*Ompok bimaculatus*, commonly known as the buffer fish, can be induced to spawn in hatchery conditions. Mature fish weighing 200–300 g are given a single intramuscular injection of Ovaprim at 0.5 ml/kg for both males and females. Spawning occurs naturally in the hatchery 5–6 hours after injection, with high fertilisation rates. A female weighing 200–300 g produces 3,874–4,150 eggs. The eggs are small (1.22 mm in diameter) and hatch in 24–25 hours. Hatchlings measure 2.4–2.6 mm in length.

*O. bimaculatus.*

Larvae begin feeding on the fourth day. They can be fed boiled egg yolk or live feed. Mixed zooplankton, *Artemia* nauplii, and chironomid larvae are also effective. Larvae reach 40 mg in 20–25 days and are then transferred to small tanks or cement cisterns for fingerling production. At this stage, they readily accept formulated feed with fish meal as the primary ingredient. The fish grow to 3–5 g within 45–60 days.

*Ompok malabaricus* is another small catfish with aquaculture potential. It matures at a weight of 80–115 g and spawns during the monsoon. Spawning can be induced using various agents, including:

- Carp pituitary extract (90–110 mg/kg)
- Ovaprim or Ovatide (0.3–0.7 ml/kg)
- Human chorionic gonadotropin (HCG) (3,000–5,000 IU/kg)

The latency period for spawning is 6–12 hours. Fecundity ranges between 3,800 and 5,000 eggs per female. Captive rearing trials have used plankton soup, *Tubifex* worms, chironomid larvae, mosquito larvae, and earthworms as feed.

## *Mystus cavasius*

*Mystus cavasius* is found in water bodies across Southeast Asia. It is a promising species for freshwater aquaculture diversification in the Indian subcontinent due to its high market demand and excellent taste. Brood fish can be raised in small ponds or cement tanks at a stocking density of 3–4 fish per cubic metre. This omnivorous species is fed a diet containing 30–35% protein at a rate of 2–3% of body weight to ensure healthy broodstock for seed production.

This catfish reaches sexual maturity within its first year and breeds during the monsoon. Brood fish weighing 50–100 g are ideal for captive breeding. Males are identified by their elongated genital papilla, while females have a swollen abdomen. *Mystus cavasius* is induced to spawn using synthetic hormones such as Ovatide, which is injected at a dose of 1.0–1.5 ml/kg of female body weight. Ovulated females are stripped 10–12 hours after injection. The testes

*Mystus cavasius fingerlings.*

from the male are macerated in a normal saline solution to prepare a sperm suspension, which is mixed with the stripped eggs for fertilisation.

Fecundity ranges from 10,000 to 22,000 eggs per female weighing 40–80 g. The sticky, fertilised eggs hatch within 24 hours at temperatures of 28–32°C. Both sexes can also be induced to spawn naturally in captivity when injected with the same hormone dosage. In such cases, a male-to-female ratio of 2:1 is maintained.

Hatchlings are tiny, transparent, and measure 3.0–3.3 mm in length. The yolk sac is absorbed within two days, after which the larvae begin external feeding. Live feeds such as mixed zooplankton, *Artemia* nauplii, and chopped *Tubifex* worms are preferred during early rearing. Since this species grows slowly, lower stocking densities and regular water replenishment are recommended.

At 10–12 days old, larvae are gradually weaned onto formulated feed. After two to three weeks, the fry are transferred to cement tanks, where they continue feeding on formulated diets until satiation. They reach a weight of 2–3 g within two to three months and are then ready for grow-out culture in ponds.

## *Rita chrysea*

*Rita chrysea* is a medium-sized freshwater catfish belonging to the Bagridae family. It has a lead-grey body with a whitish ventral side and greyish bands on the dorsal side. This species is omnivorous and breeds during the monsoon. Brood fish weighing 50–60 g or more are suitable for induced breeding.

Only females are injected with a commercially available synthetic hormone, a combination of sGnRHa and domperidone, at a dose of 1 ml/kg of body weight. Stripping is carried out 13–15 hours after injection. The eggs are released in a mass resembling a grape cluster and measure 1.2–1.4 mm in diameter. A female weighing 90–120 g produces 10,000–13,000 eggs. Fertilisation is done using a sperm suspension prepared in the same way as for *Clarias batrachus*.

The fertilised eggs hatch within 22–24 hours. Hatchlings measure 3.5–4.3 mm in length and weigh 0.9–1.2 mg. The yolk sac is absorbed within 72 hours, after which the larvae require external feeding. Live mixed zooplankton and *Artemia* nauplii are the preferred feed at this stage.

Over three weeks, the larvae grow to 40–60 mg and exhibit hiding behaviour. The fry are transferred to outdoor tanks for fingerling production. A crumbled or dough-form compound feed containing 30–35% protein is placed near the shelter areas, as the fish tend to hide there. Oxygen depletion is commonly observed in the early morning during rearing. To prevent this, regular water renewal is necessary.

During the 2–3 month rearing period, the fish grow to 2–3 g, with a survival rate of 50–70%.

## *Horabagrus brachysoma*

*Horabagrus brachysoma* is a medium-sized bagrid catfish found in the water bodies of the Western Ghats, India. It is commonly known as the Asian sun catfish or yellow catfish due to its yellowish body and two black blotches located just behind the operculum. This species is valued as an ornamental fish in its juvenile stage and as a food fish when fully grown.

Its ability to adapt to different environments, mature in captivity, accept a wide range of food, and grow well in confined water makes it a promising species for aquaculture. However, overfishing and the destruction of spawning grounds have led to a decline in wild populations, and it is now considered an endangered species. Captive breeding is essential both for conservation and to meet consumer demand.

The brood fish readily accept artificial pelleted feed. They are fed a pelleted diet containing 30% protein at a rate of 2% of body weight. Periodic sampling is necessary to monitor feeding rates and brood health. Regular water exchange in brood ponds is essential to maintain a clean environment and support maturation.

Males reach maturity in their first year, while females mature in their second year. At first maturity, females typically weigh 50–60 g, but only 40–50% respond to induced breeding. It is

*Horabagrus brachysoma fingerlings.*

best to avoid breeding first-maturity females. If the female's age is unknown, those weighing more than 80 g should be selected.

For induced breeding, females receive a single dose of Ovaprim or Ovatide (a mixture of sGnRHa and domperidone) at 1.5 ml/kg of body weight to stimulate final oocyte maturation and ovulation. Stripping is carried out 12–14 hours after injection. The female should be stripped when eggs flow freely in a semi-fluid state. If the eggs appear too liquid, stripping has been delayed, leading to reduced fertilisation and lower hatch rates.

A well-fed female of 100 g can produce 18,000–19,000 eggs. The milt from a single male is sufficient to fertilise the eggs of a female of the same weight. Fertilised eggs hatch within 24 hours at ambient temperatures.

Larvae are reared in fibreglass tanks inside the hatchery until the fry stage. Feeding them with zooplankton or *Artemia* nauplii improves survival compared to pond rearing. The fry are then transferred to cement tanks and fed crumbled feed until satiation. Water is exchanged as needed. During 2–3 months of rearing, the fry grow to 2–3 g and are then sold to farmers or used for grow-out culture.

## *Pangasius pangasius*

*Pangasius pangasius* is primarily found in the river systems of the Indian subcontinent. It is a hardy fish that feeds on offal, gastropods, bivalves, and insects. It is often introduced into aquaculture ponds for biological control of molluscs. However, overexploitation has significantly reduced its natural population.

Limited research exists on its captive breeding. Recently, ICAR-CIFA successfully bred and reared this species in hatchery conditions, apart from a few attempts in Bangladesh. Males reach maturity at two years, while females require 3–4 years before they can be used for breeding. Proper brood care is crucial for successful induced spawning. Providing a suitable environment and feeding brood fish with a 30–32% protein diet are key management practices.

Brood fish weighing 1.5–2.0 kg are ideal for induced breeding. Synthetic hormones such as Ovaprim or Ovatide can be injected at a dose of 1.0–1.5 ml/kg of body weight to induce ovulation. Males exhibit free-flowing milt, and a single male of equal weight can fertilise the eggs of two females. This species has high fecundity, with over 100,000 eggs per kg of female body weight. The eggs are approximately 1 mm in diameter, sticky, and hatch within 22–24 hours.

The hatchlings are free-swimming, and their yolk sac is absorbed within three days. However, larvae exhibit cannibalism during early stages, leading to significant losses. To improve survival, larvae are fed live plankton, chironomid larvae, or *Artemia* nauplii. Within 15–20 days, they grow to 40 mg. The seed is then transferred to cement tanks or ponds for fingerling production. They readily accept floating feed and grow to 3–4 g within 5–6 weeks.

*P. pangasius fingerlings.*

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# Sustainable freshwater snail farming: Advancing nutrition security and rural livelihoods in Northeast India

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*A tribal woman harvesting river snails.*

Northeast India struggles with nutrition security, especially in rural and tribal areas. Data from the National Family Health Survey (NFHS-5) show worsening nutrition indicators across the region. Meghalaya has the highest stunting rate at 46.8%, followed by Nagaland (32.7%), Tripura (32.3%), and Mizoram (28.9%).

This crisis presents multiple concerns. Four northeastern states have seen an increase in stunting among children under five. Wasting and underweight rates have also risen in several states, including Assam, where underweight rates increased from 29.8% to 32.8%. Early breastfeeding initiation has declined in six of the eight northeastern states. A growing double burden of malnutrition adds to the problem, as under-nutrition now coexists with rising obesity rates. This situation harms child development and future economic productivity. Research shows that stunted children earn about 20% less as adults. A 1% reduction in adult height due to childhood stunting is linked to a 1.4% drop in economic productivity.

Food and nutrition security challenges in Northeast India are worsened by the region's unique agricultural conditions and environmental vulnerabilities. Despite having the highest per capita consumption of calories and carbohydrates in India, the region suffers from a serious nutritional imbalance.

This issue arises from the region's dependence on agriculture, which is highly vulnerable to climate variations. These changes affect both crop yields and diversity. As a result, while caloric intake is high, deficiencies in essential proteins and micronutrients are widespread. This imbalance highlights the need for innovative, locally adapted solutions. Such approaches must not only provide sustainable sources of high-quality nutrition but also enhance the resilience of local livelihoods against environmental challenges.

*Local children collecting freshwater snails from paddy fields in Northeast India.*

## Understanding the nutritional crisis

Nutritional challenges in Northeast India arise from several interconnected factors. Poor maternal health, weak healthcare infrastructure, limited access to diverse foods, and socioeconomic constraints all contribute to persistent malnutrition. Anemia is a major concern, affecting both children and pregnant women. This condition harms immediate health and long-term development.

Climate change worsens the problem by reducing agricultural productivity. Northeast India's agriculture is highly sensitive to climate variations, which impact both crop yields and nutritional quality. To address this, climate-resilient food sources must be explored. These should provide essential nutrients while ensuring environmental sustainability.

## Freshwater snails: A promising Solution

Research from the ICAR Research Complex for NEH Region's Tripura Centre identifies freshwater snails as a potential solution to regional nutritional challenges. Several indigenous species have been found to offer excellent nutritional value, particularly in protein and minerals.

The apple snail (*Pila globosa*) has the highest protein content at 15.59%. The Bengal trumpet snail (*Bellamya bengalensis*) and the costuled river snail (*Brotia costula*) contain between 11.18% and 13.14% protein. While these levels are lower than some fish species, they exceed many plant-based protein sources and compare well with traditional livestock products.

The mineral profile of freshwater snails highlights their exceptional nutritional value, especially their high calcium content. With calcium levels ranging from 142.50 to 312.50 mg per 100 g, these snails provide significantly more calcium than common sources like beef, eggs, and milk.

Their iron content is also notable, ranging from 4.0 to 6.8 mg per 100 g. This compares well with iron-rich foods like organ meats and provides much more iron than fish. Additionally, these snails offer essential minerals such as phosphorus (55.39–121.17 mg per 100 g), potassium (118.20–182.28 mg per 100 g), and zinc (1.47–2.17 mg per 100 g). This well-balanced mineral composition makes freshwater snails a valuable option for addressing widespread micronutrient deficiencies in the region.

**Table 1: Nutritional composition of selected freshwater snails from Tripura.**

| Component | *Pila globosa* | *Bellamya bengalensis* | *Brotia costula* |
|---|---|---|---|
| **Proximate composition (%)** | | | |
| Moisture | 73.80 ± 4.87$^{b}$ | 65.80 ± 9.49$^{a}$ | 69.86 ± 3.68$^{ab}$ |
| Crude protein | 15.59 ± 1.14$^{b}$ | 13.14 ± 1.82$^{a}$ | 12.91 ± 2.52$^{a}$ |
| Lipid | 1.15 ± 0.17$^{b}$ | 0.96 ± 0.14$^{a}$ | 0.82 ± 0.16$^{a}$ |
| Ash | 3.82 ± 1.80$^{a}$ | 8.11 ± 2.56$^{b}$ | 7.28 ± 2.15$^{b}$ |
| Carbohydrate | 5.62 ± 5.83$^{a}$ | 11.97 ± 6.96$^{b}$ | 9.12 ± 2.81$^{ab}$ |
| **Mineral content (mg/100g)** | | | |
| Calcium | 312.50 ± 12.67$^{c}$ | 227.13 ± 31.96$^{b}$ | 236.07 ± 23.66$^{b}$ |
| Phosphorus | 121.17 ± 10.17$^{c}$ | 93.53 ± 1.65$^{b}$ | 116.87 ± 9.76$^{c}$ |
| Potassium | 182.28 ± 8.02$^{d}$ | 143.80 ± 8.81$^{b}$ | 161.87 ± 7.11$^{c}$ |
| Magnesium | 18.50 ± 4.12$^{ab}$ | 21.43 ± 0.74$^{b}$ | 17.93 ± 2.84$^{ab}$ |
| Iron | 6.86 ± 3.45$^{b}$ | 4.81 ± 1.21$^{a}$ | 5.07 ± 1.85$^{a}$ |
| Copper | 0.84 ± 0.08$^{b}$ | 0.69 ± 0.19$^{a}$ | 0.73 ± 0.35$^{ab}$ |
| Zinc | 2.17 ± 0.35$^{b}$ | 1.57 ± 0.21$^{ab}$ | 1.47 ± 0.31$^{a}$ |
| Manganese | 5.33 ± 1.10$^{b}$ | 3.17 ± 0.35$^{a}$ | 3.13 ± 0.31$^{a}$ |

*Values are presented as mean ± standard deviation. Values in the same row with different superscript letters (a, b, c, d) are significantly different (p<0.05). Data sourced from Debnath et al., Fishery Technology 53 (2016): 307-312.*

## Production systems and management

Freshwater snail farming can be implemented through three distinct production systems, each suited to different operational needs.

The pond-based culture system integrates snail farming with existing fish ponds. It maximises resource use by utilising unused ecological niches and organic waste. This system requires careful environmental management, with pH levels between 6.5 and 8.5, water temperatures of 24–30°C, and dissolved oxygen levels above 5 ppm. These conditions reduce the need for supplementary feeding while ensuring sustainability.

The paddy-cum-snail culture system uses rice fields for snail production during the growing season. It improves nutrient cycling, enhances rice yields, and provides an additional protein source. This method is particularly beneficial for small and marginal farmers, as it makes use of existing infrastructure.

The backyard cultivation system involves raising snails in cemented tanks. This method is ideal for households with limited space. Controlled environments allow for intensive production through careful water quality and feeding management. It makes snail farming accessible to urban and peri-urban farmers who lack access to ponds or paddy fields.

*Mature apple snails (Pila globosa), showcasing their distinctive shell morphology and size characteristics that make it suitable for aquaculture.*

## Economic analysis

A multi-tank freshwater snail farming system can be set up using three cemented tanks, each measuring 3 m × 2 m × 1 m. Based on stocking density guidelines and industry experience, each tank can support 100–120 adult snails for optimal growth and reproduction.

With a quarterly harvest cycle, each tank can produce an estimated 200–250 kg of snails per year. This suggests a total system yield of 600–750 kg annually.

*Mature costuled river snail (Brotia costula), displaying its distinctive ribbed shell pattern and robust appearance, which set it apart from other freshwater snail species.*

*Adult Bengal trumpet snail (Bellamya bengalensis), showing its characteristic spiral shell structure and natural coloration patterns.*

## Nutritional impact analysis

A backyard snail farming system with three cemented tanks can produce up to 1,800 kg of snails annually. If 50% is reserved for home consumption (900 kg per year), this provides a daily availability of 2.47 kg of whole snails. With an edible meat yield of 40%, this translates to 0.99 kg of consumable meat per day for family nutrition.

The nutritional impact analysis highlights significant contributions to daily dietary needs for a family of five. The protein content of *Pila globosa* (15.59%) supplies approximately 62.4–93.6% of daily protein requirements, with children benefiting the most from their portions. This increased protein intake represents a major improvement in household nutrition security.

The mineral content also offers substantial benefits. A 100 g serving of *P. globosa* provides about 31% of an adult's daily calcium requirement, making it a valuable source for families with limited dairy access. Its iron content is particularly high, supplying up to 86% of daily iron needs for adult men and 38% for women. This helps address anemia, a widespread issue in the region. Zinc intake is also significant, covering 20–43% of daily needs depending on age and gender.

With half of the production available for sale (900 kg per year), backyard snail farming creates income opportunities while ensuring household nutrition. The consistent daily availability of nutrient-rich food (0.99 kg of meat) provides year-round access to essential nutrients, establishing a sustainable foundation for both nutritional security and economic stability.

## Integration and resource optimisation

Integrating snail farming with laying hen operations creates valuable synergies in rural agricultural systems. A typical rural household keeps 10–15 laying hens, which require consistent calcium supplementation for optimal egg production. Snail shells, containing up to 312.50 mg of calcium per 100 g along with essential trace minerals, provide an excellent natural supplement.

A three-tank snail farming system producing 1,800 kg of snails per year generates about 1,080 kg of shells. This is enough to supplement multiple small-scale laying operations. When properly processed and ground, these shells can fully replace commercial calcium supplements in poultry feed. This reduces production costs while maintaining high egg quality and consistent laying patterns.

**Table 2: Economic analysis for multi-tank backyard freshwater snail farming in Tripura.**
**System specifications: 3 tanks, each 3 m × 2 m × 1 m = 6 m³**

| Category | Details | Amount (Rs.) |
|---|---|---|
| Initial investment | Cemented tanks construction (3 tanks including labour) | $517 |
| | Centralised water supply and drainage system | $92 |
| | Water quality monitoring equipment | $57 |
| | Basic equipment (nets, containers, harvesting tools) | $57 |
| | Initial broodstock (1,800-2,160 snails) | $52 |
| | Aeration system (air pump, tubing, stones) | $86 |
| Total initial investment | | **$862** |
| Annual operating costs | Supplementary feed | $166 |
| | Water and electricity charges | $124 |
| | Tank maintenance and repairs | $69 |
| | Labor (part-time hired help + family labor) | $276 |
| | Marketing and packaging expenses | $832 |
| | Water quality management (testing, treatments) | $41 |
| Total operating cost | | **$759** |
| Annual revenue | Production (1,800 kg @ US$1.725/kg) | $3,105 |
| Net annual profit | | **$2,346** |
| Key financial indicators | Monthly income potential | $195 |
| | Return on investment (%) | 272 |
| | Investment recovery period | 4-5 months |
| | Profit margin (%) | 75.5 |

*1 Indian Rupee (INR) = 0.01150 US Dollars.*

This integration is especially relevant in Northeast India, where backyard poultry farming is a key part of rural livelihoods. Small-scale farmers can create an efficient closed-loop system where snail farming provides two benefits: primary income from meat sales and cost savings from shell utilisation. Research shows that hens fed with processed snail shell supplements produce eggs with shell quality and laying frequency similar to those receiving commercial calcium supplements.

Additionally, this integrated approach creates new employment opportunities in shell processing, feed preparation, and local distribution.

## Implementation strategy and recommendations

The successful adoption of freshwater snail farming in Northeast India requires a coordinated approach across four key areas.

First, research and development should focus on establishing standardised breeding protocols, optimising locally sourced feed formulations, and assessing environmental impacts to ensure sustainable production.

Second, extension services must provide comprehensive training programs that integrate traditional knowledge with modern aquaculture techniques. These programs should cover production methods, health management, and post-harvest handling. Regular monitoring and feedback mechanisms will help improve effectiveness.

Third, market development is essential. Establishing strong value chains through collection centers, standardised grading systems, and efficient distribution networks will enhance market efficiency. Value-added products and consumer education campaigns highlighting the nutritional benefits of snails will help expand demand.

Finally, government support is crucial for scaling up snail farming. Existing programs through NAFDB and NABARD provide 100% subsidies for Northeast Indian farmers, making snail farming more accessible. These initiatives should be strengthened with quality certification systems and market linkage support to ensure long-term viability.

## Conclusion

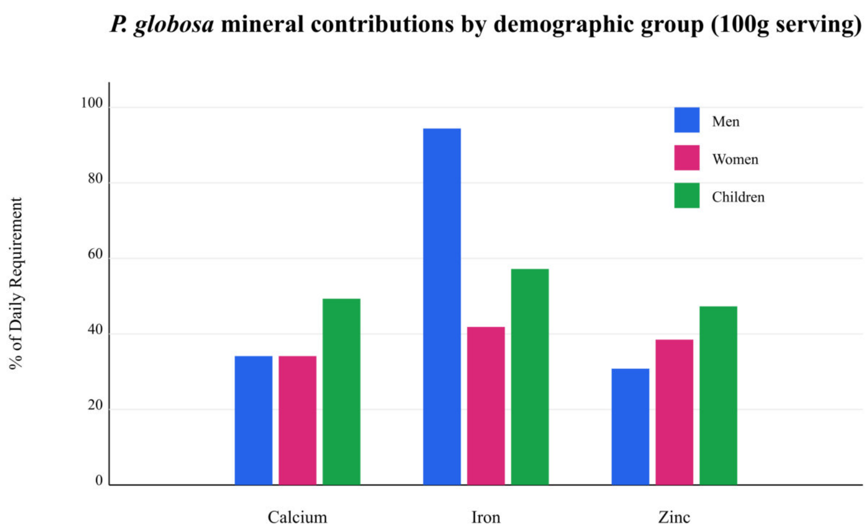
Freshwater snail farming offers a practical solution to Northeast India's nutritional and economic challenges. It provides high protein and mineral yields along with strong economic returns. However, successful implementation requires strict biosecurity measures. Proper sanitation, regular health monitoring, and quality control can help prevent disease risks.

The region's cultural acceptance of snail consumption supports market development. Value-added products, such as ready-to-eat snail meat and processed calcium supplements, can further expand demand. The low entry barriers and simple technical requirements make snail farming an excellent opportunity for women and youth entrepreneurship.

Integrating snail farming with existing agriculture, particularly poultry farming, increases economic viability by utilising snail shells as a calcium source for laying hens. To fully realise these benefits, collaboration between research institutions, extension services, and policymakers is essential. With the right support, freshwater snail farming can improve nutrition security, create sustainable livelihoods, and empower marginalised communities, making it a valuable tool for regional development in Northeast India.

*High-quality freshwater snails produced in a cemented tank system, demonstrating the successful implementation of controlled cultivation methods for optimal growth and yield.*

**Figure 1: Daily mineral contributions from a 100 g serving of *Pila globosa* meat across different demographic groups, showing the percentage of the recommended daily allowance (RDA) met for calcium, iron, and zinc.**



# Promotion and protection of small fish species through farming: An initiative in Tripura

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*ICAR-CIFA scientists provide training to fish farmers.*

Small fish species are a valuable source of minerals and vitamins, particularly for rural communities. They are often referred to by different terms: SIS (small indigenous species), SIFS (small indigenous fish species), and SIFFS (small Indigenous freshwater fish species). Small fish are defined as species that reach a maximum length of 25 cm at maturity. Unlike larger fish, they are consumed whole, including the head, bones, eyes, and viscera, with no wastage.

India has recorded 104 small freshwater fish species, including 62 food fish and 42 ornamental species (Felts et al., 1996; Sarkar and Lakra, 2010). Despite their high nutritional value, these fish are often labelled as weed fish, trash fish, or poor man's fish. In many cases, they have been removed to make way for carp farming and treated as incidental catch (Chattopadhyay and Mandal, 2023).

## Food value of small fish species: Nutritional excellence for human health

Small fish are an easily digestible source of protein, rich in minerals and vitamins. They provide both micronutrients and macronutrients. Micronutrients include iron, calcium, zinc, iodine, phosphorus, selenium, fluorine, and cobalt. These elements are highly bioavailable, meaning they are easily absorbed by the human body. The protein content of small fish ranges from 14–22% of fresh weight. They are more affordable than other sources of animal protein, and their production cost is low, making them accessible to farmers (Chattopadhyay and Mandal, 2023).

Fish oil, which makes up 0.5–7% of fresh weight, helps reduce the risk of cardiovascular disease. It contains omega-3 polyunsaturated fatty acids (PUFAs), including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Although the human body requires only small amounts of micronutrients, they are essential for preventing malnutrition. Small fish are a unique dietary source of these nutrients. They are rich in vitamins A, B, C, D, E, and K. For example, *Amblypharyngodon mola* contains 2,680 µg of vitamin A—fifty times more than other fish species. Eating Mola supports vision, eye health, cell growth, immune function, reproduction, and foetal development.

The vitamins and minerals in 1 kg of small fish are roughly equal to those found in 50 kg of larger fish, such as Indian major carp (Mohanty et al., 2011; Mohanty et al., 2013). The calcium in small fish is as bioavailable as that in milk (Thilsted, 2010). Pregnant women who eat small fish once a week have a 3.6 times lower risk of delivering low birth weight (LBW) or premature babies.

## Sustainable Development Goals

The United Nations has set several criteria for the Sustainable Development Goals (SDGs). In many developing countries, small-scale fisheries and aquaculture remain the primary source of fish for rural communities. This sector plays a crucial role in food and nutritional security, particularly through the contribution of small indigenous fish species.

Small fish offer many benefits. They have high nutritional value, are compatible with carp culture, thrive on low trophic levels, and can self-recruit. They also have strong market demand and remain affordable. Farming small fish species can contribute to achieving several United Nations SDGs.

Recognising the importance of small fish as a rich source of protein, vitamins, and minerals, ICAR-CIFA has launched an initiative to promote and protect them through farming. This approach supports food security, rural livelihoods, and biodiversity conservation.

## Promotion of small fish species: A step towards farming

Small fish populations are rapidly declining due to habitat loss, dewatering, fragmentation of water bodies, wetland encroachment, and urbanisation. The filling of small water bodies, use of insecticides, pesticides, hazardous agricultural chemicals, industrial and domestic pollution, siltation, and the introduction of exotic species further threaten their survival. To prevent further decline, a strategic plan has been developed, focusing on breeding, feeding, and rearing.

### Breeding of small fish species: An established technique

Breeding is the reproductive process between male and female fish to produce offspring. In controlled breeding, suitable male and female brooders are selected for reproduction. Many small fish species reproduce naturally through self-recruitment. However, when natural breeding is disrupted, alternative methods are needed.

Indian major carps, which cannot breed in stagnant water, are induced to spawn using hormonal treatments. This method has revolutionised fish breeding. Several small fish species face difficulties in reproducing, so specific breeding techniques have been developed (Table 1; figures overleaf).

The breeding process involves the following steps:

- Collecting the desired small fish species in sufficient numbers.
- Selecting healthy males and females through careful observation.
- Keeping broodstock under controlled conditions.
- Monitoring their health at regular intervals.
- Choosing the right breeding time, typically the rainy season.
- Encouraging natural breeding by simulating ecological and environmental conditions.
- Using artificial breeding methods if natural breeding fails.
- Selecting suitable broodstock.
- Measuring fresh weight of brooders.
- Determining appropriate hormonal doses for males and females.
- Administering hormonal treatments.
- Releasing males and females into controlled breeding pools.
- Using aquatic plants as breeding substrates to support egg attachment in both natural and artificial breeding.
- Rearing hatchlings.

### Feeding – a challenge for small fish larvae

Feeding newly hatched larvae is a challenge, even for larger fish species, as their small mouth gape makes it difficult to accept formulated feed. Instead, they rely on plankton. Similarly, small fish larvae must be fed plankton to match their natural feeding behaviour.

To meet this need, live food organisms, which serve as natural feed for fish larvae, are cultured. Selected phytoplankton and zooplankton are grown in fibre-reinforced plastic tanks using a combination of outdoor methods, different manures, fertilisers, and environmental manipulation. The following live foods have been established for mass production:

- *Graesiella emersonii* (phytoplankton and single-cell protein).
- *Brachionus calyciflorus* (rotifer).
- *Cyclops* (copepods).

*Anabas testudineus.*

*Macrognathus aral.*

*Amblypharyngodon mola.*

*Gudusia chapra.*

*Clarias magur.*

*Heteropneustes fossilis.*

*Macrognathus pancalus.*

*Mystus cavasius.*

*Mystus vittatus.*

- *Moina* (cladocerans).

Live food cultures provide several advantages:

- Larvae can be fed either a single live food species or a combination of multiple live foods sequentially.
- Co-feeding of inert diets alongside live food is possible for selective fish larvae.
- Natural feeding behaviour is supported, minimising feeding stress.

Feeding small fish larvae with live food ensures they receive appropriate nutrition based on their natural feeding preferences. This method has been tested successfully in several small fish species.

### Rearing: Environmental simulation for sustainable husbandry

Rearing small fish species in monoculture or mixed culture systems is still being developed. Monoculture is often not economical due to the slow growth and small size of many indigenous fish species. Before introducing a mixed culture, it is necessary to study species interactions, including:

- Habitat preferences.
- Space-sharing behaviour.
- Cannibalism.
- Competition for food.
- Feeding preferences and overlaps.

Mixed culture is generally preferred as it optimises space usage and increases yield per unit area compared to monoculture. The Regional Research Centre, ICAR-CIFA, Rahara, has already conducted trials on selected small fish species. Profitable small fish farming is achievable when mixed culture is managed efficiently to ensure production exceeds farming costs.

*Ompok bimaculatus.*

*Puntius sophore.*

Soil and water quality must be continuously monitored, including water depth and temperature, to adapt to climate variations. Feeding with live food helps maintain ecological balance. Additionally, selected aquatic plants should be introduced to simulate a natural environment that supports the survival and growth of small fish species.

## Training farmers in Tripura on small fish breeding and feeding

Tripura is part of India's northeastern region, covering 10,491 km². It is almost surrounded by the deltaic basin of Bangladesh. Tripura has a warm and humid tropical climate with five distinct seasons: spring, summer, monsoon, autumn, and winter. Summer begins in mid-March and peaks in April–May, followed by pre-monsoon rains. Temperatures range from 10°C to 35°C, with high humidity throughout the year. Annual rainfall varies from 1,920 to 2,855 mm.

Tripura has a population of 3,673,917 (Census 2011), and fish is a major source of protein. In 2019–20, per capita fish consumption in the state was 29.29 kg, the highest in India. Water resources include ponds, tanks, lakes, reservoirs, canals, wetlands, and rivers, covering 37,382 ha. Of this, 29,503 ha is used for culture fisheries, while 7,879 ha falls under capture fisheries. The state produced 82,000 metric tonnes of fish in 2020–21.

### Key training components for small fish culture

Tripura was selected for small fish culture due to its abundant fishery resources and skilled human resources familiar with aquaculture. A total of 25 fish farmers were chosen from different parts of the state. They had prior experience in carp breeding, rearing, and culture. The training, titled "Production of live fish food organisms and culture of small indigenous fish species with emphasis on mola *Amblypharyngodon mola*, chapila *Gudusia chapra*, punti *Puntius* spp., pankal, *Macrognathus* spp. and tangra, *Mystus* spp."

### Breeding and rearing

The training began with a discussion on the importance of breeding small fish species to generate interest. Farmers were already familiar with these species as culinary delicacies and became enthusiastic after learning about their medicinal and nutritional benefits.

Scientists conducted hands-on training, using audiovisual aids where necessary, especially for small fish rearing. Farmers were trained in broodstock selection, identification of males and females, and species-specific hormone dosage for breeding.

### Live fish food production and feeding small fish

Farmers received hands-on training on producing live fish food in outdoor systems, focusing on mass culture of phyto-plankton and zooplankton. Different mesh-sized plankton nets were used to separate zooplankton through a sieving method. The Sedgewick-Rafter plankton counting cell was used to measure plankton density.

For phytoplankton production, selected fertilisers were used in a 10:1:1 ratio, including:

- Ammonium sulphate.
- Urea.
- Single super phosphate.

Farmers were trained in feeding individual live food organisms to small fish and using co-feeding techniques. Feeding live food aligns with the natural behaviour of small fish, improving their survival rate and growth.

### Soil and water quality management

The environment plays a crucial role in small fish rearing. Water quality management was a key discussion point. Farmers learned how to monitor and maintain water quality to ensure a healthy environment, which directly affects fish health.

For small water bodies, the following materials were recommended to enhance water productivity through phytoplankton growth:

- Lime.
- Cattle dung.
- Mustard oilcake.
- Groundnut oilcake.

Farmers were also trained in monitoring ammonia levels and controlling them to maintain fish populations. Good-quality water was emphasised as a factor that can support natural breeding.

**Table 1: Important SIFS with their farming potential in Tripura**

| Species | Family | Local name | Farming strategy |
|---|---|---|---|
| Amblypharyngodon mola | Cyprinidae | Mola | Introduction of adult fish; self-recruitment; polyculture |
| Anabas testudineus | Anabantidae | Koi | Semi-artificial breeding; monoculture, polyculture |
| Clarias magur* | Clariidae | Magur | Natural, semi-artificial, and artificial breeding; monoculture, polyculture |
| Gudusia chapra | Clupeidae | Chapila | Environmental management; introduction of adult fish; self-recruitment; polyculture |
| Heteropneustes fossilis | Heteroneustidae | Singhi | Natural, semi-artificial, and artificial breeding; monoculture, polyculture |
| Macrognathus aral | Mastacembelidae | Tara baim | Introduction of adult fish; self-recruitment; semi-artificial breeding; environmental management |
| Macrognathus pancalus | Mastacembelidae | Pankal baim | Introduction of adult fish; self-recruitment; semi-artificial breeding; environmental management |
| Mystus cavasius | Bagridae | Sadatengra | Semi-artificial breeding; polyculture |
| Mystus vittatus | Bagridae | Lal tengra | Semi-artificial breeding; self-recruitment; polyculture |
| Ompok bimaculatus** | Siluridae | Pabda | Semi-artificial and artificial breeding; environmental management; polyculture |
| Puntius sophore | Cyprinidae | Jatpunti | Environmental management; introduction of adult fish; self-recruitment; polyculture |

*IUCN status: *Endangered, **Near Threatened, Others: Least Concerned.*

*R.N. Mandal demonstrating segregation of plankton.*

## Farming of small fish – a pathway to livelihood generation and gender equity

In Tripura, backyard water bodies provide an ideal setting for small fish farming. Small water bodies (<0.1 ha) are suitable for the mixed culture of small fish species, allowing different species to occupy their respective ecological niches. Studies indicate that small fish farming either enhances overall production or does not negatively impact major cultured species.

The culture of *Amblypharyngodon mola*, *Puntius sophore*, *Osteobrama cotio cotio*, and *Gudusia chapra* alongside carps has shown a synergistic effect, leading to increased profitability. Wahab et al. (2002) reported that introducing *P. sophore* did not affect the productivity of rohu and catla, but the productivity of mrigal increased by 50%, while common carp production decreased by 20%. Additionally, *P. sophore* had no impact when stocked with either common carp or mrigal. Further studies by Roos et al. (2007a, 2007b) showed that co-culturing *A. mola* with carps improved overall fish production.

However, integrating catfish species with carp at the larval stage requires further investigation, as catfish exhibit cannibalistic behaviour that could significantly impact carp populations. Small fish farming provides opportunities for greater women's participation, promoting gender equity. Once farmers are trained in breeding and culturing small fish species, they become more efficient in managing their rearing. Success in small fish farming depends on breeding, feeding, and maintaining a suitable environment, which ICAR-CIFA has taken the initiative to promote.

## Conclusion

The establishment of small fish farming offers several benefits:

- Farming in backyard water bodies is feasible.
- More women can participate in fish farming.
- Employment opportunities increase.
- Rural households gain a steady source of protein.
- Small fish consumption provides essential minerals and vitamins, benefiting human health, especially pregnant and breastfeeding mothers.
- Selling small fish generates income, supporting the rural economy.

*Arabinda Das delivers the lectures on breeding and rearing of small fishes.*

- Biodiversity conservation of small fish species is ensured.
- Natural farming methods can help mitigate climate change.

Further research and development in small fish farming are essential, particularly in rural areas. Widespread participation from rural communities can ensure sustainable growth in this sector. Mass awareness programs are crucial for the protection and promotion of small fish farming.

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# FAO programme supports national innovation and investment plans for aquaculture transformation

FAO has signed a technical cooperation project (TCP) to support development of national innovation and investment plans (NIIP) for aquaculture transformation. The project will be carried out in cooperation with the governments of India, the Philippines, Thailand and Vietnam, with NACA as a coordinating agency. The inception workshop will be held via Zoom on 27 January, 2025.

Aquaculture can be an environmentally responsible, low carbon footprint form of food production, but, as with all forms of agricultural food production, it may have environmental and social impacts that require remediation or mitigation. However, persistent and emerging challenges have the potential to impede aquaculture from meeting the projected demand for aquatic food and contributing to the broad range of Sustainable Development Goals (SDGs) in the future.

Recognising these challenges, the Food and Agriculture Organization of the United Nations (FAO) has developed a Blue Transformation Roadmap which outlines a vision for FAO's work on aquatic food systems till 2030, covering the three core components of aquaculture, capture fisheries and value chain transformation.

In 2022, FAO Regional Office for Asia and the Pacific (FAORAP) and the Network of Aquaculture Centres in Asia-Pacific (NACA) prepared a regional guidance and roadmap for aquaculture transformation for Asia and the Pacific region so called "White Paper" and later published by FAO. The White Paper is aligned with the strategic goals of the Blue Transformation Roadmap and provides guidance on translating goals into actions that support sustainable intensification and expansion of aquaculture, relevant to the context of Asia and the Pacific region. The White Paper emphasised the importance of accelerating innovation and investment in aquaculture transformation in the region, through enhanced regional cooperation and national-level actions, including the need for greater attention to gender equality and social inclusion in innovation and investment in aquaculture.

In 2023, FAORAP and NACA also prepared an action guide to further support countries with aquaculture transformation actions, following the priority recommendations in the White Paper, including: 1) at national level, guidance on preparation of National Innovation and Investment Plans, aligned to regional targets for aquaculture transformation, but tailored to national priorities and contexts; and 2) at regional level, recommendations for an Aquaculture Transformation Monitoring, Evaluation and Learning System (ATMS) to track overall progress towards the aquaculture transformation targets proposed in the White Paper and accelerate cross-border learning and collaboration.

The aquaculture transformation process to date has been recognised and well supported by the governments in the region through the first and second High-Level Meeting on Aquaculture Transformation in Asia and the Pacific Region (HLM-1 and HLM-2).

During the 33rd NACA Governing Council Meeting (5-8 March 2024, New Delhi), the progress in aquaculture transformation was discussed in one main agenda item among the NACA government Members. The meeting identified the need to accelerate innovation and mobilise more investment funds for aquaculture transformation across the region, followed by the request for FAO technical assistance through NACA to support this initiative.

This TCP thus aims to assist the pilot with the participating countries on preparing NIIPs and developing the regional monitoring system or ATMS to be based on the learning from the participating countries. This TCP also aims to support wider dissemination of the results and use across the region.

NIIPs will highlight countries' selected priority areas to be further developed till 2030. The NIIPs are expected to be instruments, guiding needs for new investment areas on innovations and enhancement of partnerships among the governments and private sector in transforming aquaculture.

The ATMS will be implemented strategically as a tool for successful transformation of aquaculture at country and regional levels. It will guide actions, measure impacts, and foster improvement within the sector. The ATMS will keep track the efforts and progress made in Asia and the Pacific region in transforming aquaculture into more efficient, inclusive, resilient and sustainable aquatic food systems.

2026 is expected to serve as the baseline year for monitoring progress, with the first regional ATMS report in 2028.

# 14th Asian Fisheries Forum, 12-15 February 2025 register now!

The Asian Fisheries and Aquaculture Forum (AFAF) is a scientific forum organised by the Asian Fisheries Society (AFS) once every three years to understand the global trends and address issues and challenges faced by the fisheries and aquaculture sector. The main purpose of this Forum is to provide an international platform for eminent scientists, young researchers, and other stakeholders across the globe to share their research experiences and innovative ideas.

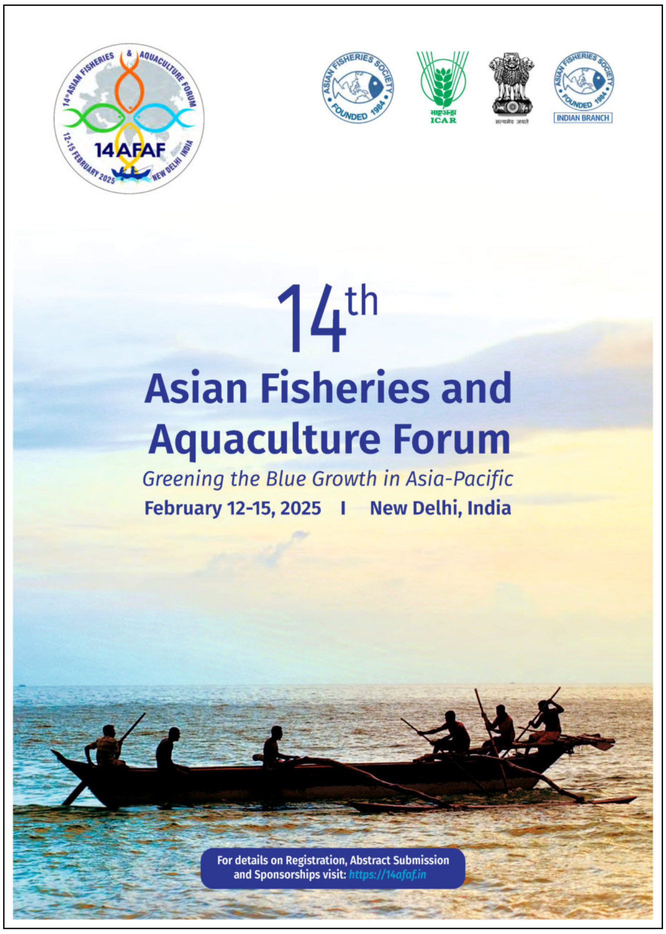
By facilitating the exchange of diverse range of knowledge and expertise, the 14th Asian Fisheries and Aquaculture Forum (14AFAF) with the Theme "Greening the Blue Growth in Asia-Pacific" aims to address key issues towards developing sustainable fisheries and aquaculture. We cordially invite you to join us for the 14AFAF scheduled during 12-15 February 2025, at the ICAR Convension Center, New Delhi, India.

Keynote speakers are Prof. S. Ayyapan, former Deputy Director General, Indian Council of Agricultural Research, and Dr. Eduardo Leano, Director General, NACA. Plenary speakers include:

- Prof. Neil Loneragan, Murdoch University
- Prof. Jun Zou, Shanghai Ocean University
- Dr Essam Yassin Mohammed, Director General, WorldFish
- Prof. Nicholas Robinson, Deakin University
- Prof. Soottawat Benjakul, Prince of Songkla University
- Prof. Alice Ferrer, University of the Philippines Visayas
- Dr. Krishna Salin, Asian Institute of Technology
- Dr. Iddya Karunasagaar, FAO Reference Center for Antimicrobial Resistance and Aquaculture Biosecurity
- and many more!

The technical sessions are:

- Resource Assessment and Management for Sustainable Fisheries
- Sustainable Aquaculture Intensification and Diversification
- SMART Aquaculture for Resource-use Efficiency
- Fish Genetics, Genomics & Biotechnology
- Aquatic Animal Nutrition, Feed Technology and Alternate Feed Resources
- Aquatic Animal Health Management and Antimicrobial Resistance
- Aquatic Biodiversity, Environment and Ecosystem Services




- Impact of Climate Change on Fisheries & Aquaculture and Resilient Strategies
- Post-harvest Processing, Value-addition, and Food Safety
- Socio-economic Dynamics & Extension in fisheries and aquaculture
- Gender in Fisheries & Aquaculture
- Fisheries Education, Skill Development and Technology Incubation
- Fish Marketing, Value Chains and Trade
- Fisheries Policy, Law, and Governance
- Aquaculture in China

For more information and registration, please visit the 14th AFAF website:

http://www.14afaf.in

# Saudi International Marine Exhibition (SIMEC)
# 3-5 February 2025, Riyadh

In implementation of directives of His Excellency Minister of Environment, Water & Agriculture of holding a fisheries exhibition, the National Fisheries Development Program will organise an event to highlight the importance and sustainability of the fisheries sector, and how to leverage and fully exploit these untapped resources to advance the associated economic sectors. The event will further underline numerous advantages of the Saudi Arabia's strategic location by organising a major exhibition that will bring to together various sectors and activities in one place, will be held with aim attracting international best experience and global expertise to discuss new developments and emerging issues in the international arena. It will mainly focus on aquaculture, marine fisheries and other significant topics.

No other national event or gathering has ever brought together all sectors and activities associated to marine fisheries and aquaculture sector in one place. SIMEC offers:

- The first ever specialised exhibition in Saudi Arabia focusing on fisheries, aquaculture and related maritime activities and industries.
- Networking with key stakeholders and decision makers in in the fields of fisheries, aquaculture and related activities and industries.
- Ideal platform for trade talks and commercial agreements between importers and exporters of live, chilled and frozen seafood products.
- Unmatched connection point between the National Fisheries Development Program (NFDP) and private sector partners.
- Unique opportunity for establishing effective partnerships with the sector's leading local and international companies, key players and networking with industry experts and professionals.
- Innovation showcase featuring state-of-the-art products and cutting-edge aquaculture technologies.
- Prestigious event as a peerless showcase and promotion for new products and related services.

For more information visit the SIMEC website:

https://en.simec-expo.com/

# Workshop on Sustainable Brine Shrimp *Artemia* Cultivation, 17 February, Tashkent

Although the drying up of the Aral Sea and the salinisation of a lot of agricultural lands in different regions in Uzbekistan and Kazakhstan have major negative consequences, there is a high potential to develop a new profitable industry and create new job opportunities in this region: the environmental-friendly and sustainable pond farming of brine shrimp *Artemia*, a well known source of food in the farming of fish and crustacean species around the world.

The regional project ECO ARAL (Ecologically oriented development of the Aral Sea Region) financed by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by GIZ has initiated a pilot project in Karakalpakstan to showcase the feasibility of a sustainable *Artemia* cultivation in environmentally friendly earth ponds. The *Artemia* project is implemented in cooperation with the International Innovation Center for the Aral Sea Region in Nukus under the Ministry of the Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan, the Academy of Science in Nukus, Ghent University (Belgium) and Can Tho University (Vietnam).

This workshop aims to show the outcomes of the implemented *Artemia* pilot project, present guidelines and recommendations important for such a new business sector, lessons learned and discuss prospects of Artemia production to further develop aquaculture sector in Uzbekistan and Kazakhstan.

Speakers include:

- Alisher Shukurov, Deputy Minister of Agriculture.
- Patrick Sorgeloos, Ghent University, Belgium
- Meezanur Rahman, WorldFish
- Simon Wilkinson, NACA
- Nguyen Van Hoa, Can Tho University

For more information, please download the flyer from: https://artemia.info/news/?id=125

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# Status, technological innovations, and industry development needs of mud crab (*Scylla* spp.) aquaculture

**Lovatelli, A., Shelley, C., Tobias-Quinitio, E., Waiho, K. & Chan, D. (eds).**

This document contains the proceedings of the technical workshop entitled Status, technological innovations, and industry development needs of mud crab (*Scylla* spp.) aquacultureâ€  held from 27 to 30 November 2023, in Singapore, and organised by the Fisheries and Aquaculture Division of the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Aquaculture Innovation Centre (AIC), Temasek Polytechnic.


The workshop was a direct result of the growing interest by FAO Members engaged at different levels in mud crab aquaculture and the desire to exchange innovative hatchery production and farming solutions that would improve the overall production outputs. The sustainable expansion and technically advanced production of this valuable crustacean would support existing farming activities, contribute to the production of aquatic food, secure revenues for rural coastal communities, as well as generate new employment opportunities.

This document provides a summary of the workshop, highlighting key opportunities and challenges in the development of mud crab aquaculture, along with a series of follow-up actions and recommendations to support growth in the sector. It also includes a brief global overview of the status of mud crab aquaculture development as well as reviews detailing the development status in major producing countries. Additionally, the document features technical reports on advancements in hatchery-produced seedstock, farming systems for both soft-shell and hard-shell crabs, value chains, marketing, and topics related to management, conservation, transportation, and the future quality and handling standards of the industry. These reviews offer valuable insights into recent experiences and ongoing activities within the field of mud crab aquaculture.

The exchange of information and innovative farming and handling practices during the workshop will be captured in the second edition of the FAO Mud Crab Aquaculture Manual, due out in early 2026, reflecting the spirit of collaboration and information sharing.

The proceeding of the workshop is intended for national authorities, including government bodies and research institutions, as well as academia and private sector stakeholders, aiming to foster engagement and collaboration in promoting and supporting the further expansion of this aquaculture subsector through a comprehensive review of its key challenges and opportunities.

The proceedings are available for free download from:

https://doi.org/10.4060/cd3976en

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NACA is a network composed of 20 member governments in the Asia-Pacific Region.



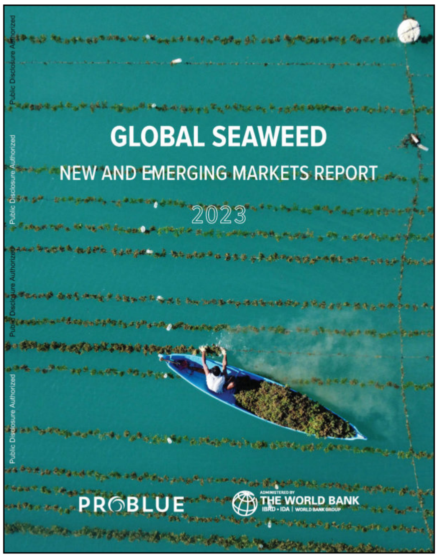
# Global Seaweed: New and Emerging Markets Report 2023

With its ability to sink carbon, sustain marine biodiversity, employ women, and unlock value chains, seaweed farming demonstrates how development, climate, and nature work together to generate value and uplift communities.

Seaweed farming can help build a world free of poverty on a livable planet and has enormous growth potential.This report has identified ten global seaweed markets with the potential to grow by an additional USD 11.8 billion by 2030. Yet, much of the seaweed sector's value remains untapped - it has clear growth potential beyond its current markets.

Today, most farmed seaweed is used for direct human consumption, as fresh feed in aquaculture, or as hydrocolloids. However, seaweed-farmed products may be able to displace fossil fuels in sectors such as fabrics and plastics; can provide ecosystem services, such as carbon sequestration and nitrogen cycling; and can generate socioeconomic benefits in fragile coastal communities.

Further, the market is currently dominated by a handful of Asian countries, which produce 98 percent of farmed seaweed by volume globally. Opportunities for growth in new regions and applications are high.




The seaweed sector has clear growth potential beyond its current markets and can help shape a world free of poverty on a livable planet. Enhanced seaweed production and improved value chains can contribute to meeting at least nine of the 17 U.N. Sustainable Development Goals (SDGs). For example, seaweed farming can sink carbon, sustain marine biodiversity, and employ women.

At a time when global resources are increasingly overstretched, it is particularly important that the world makes the most of those resources – such as seaweed – that can both be swiftly regenerated and potentially help to regenerate the ecosystems that support them.

Seaweed farming in new markets and with new applications can support development, climate, and nature work to generate value and uplift communities.

The report is available for free download from:

https://www.worldbank.org/en/topic/environment/publication/global-seaweed-new-and-emerging-markets-report-2023