# SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA

## A PREVENTION-LED PATHWAY

Mainstreaming preventive approaches to reduce disease and antimicrobial dependence and improve sustainability



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# A summary

## Freshwater aquaculture in India and the 'prevention-led pathway'

Supporting nearly 30 million people, the Indian fisheries sector produced 19.77 million tonne (MT) of fish in 2024-25, generating Rs 73,890 crore (US $8.46 billion) in export earnings. Inland fisheries accounted for 77 per cent (15.16 MT) of this output, predominantly driven by freshwater aquaculture of Indian Major Carps (IMCs). But despite its massive scale and support from the Pradhan Mantri Matsya Sampada Yojana (PMMSY), the freshwater sector remains largely unorganised and vulnerable to disease outbreaks. Diseases cost the IMC sector alone an estimated US $996 million.

To combat this, the sector must transition to a 'prevention-led pathway' focusing on eight prevention pillars — water quality, biosecurity, disease management, quality seed, improved varieties, quality feed, alternatives and vaccination. This shift is critical to curb farm-level antibiotic misuse, mitigate the escalating global Antimicrobial Resistance (AMR) crisis, and ensure long-term economic and environmental sustainability.

## Managing and monitoring water quality

Water quality is the primary defense against disease outbreaks across all culture stages.

- **Gaps and constraints:** Farm-level monitoring is inadequate, mostly limited to basic pH and dissolved oxygen checks, while critical parameters like alkalinity are ignored. High-density technologies like Re-circulatory Aquaculture Systems (RAS) and Bio-floc Technology (BFT) suffer from a critical engineering-biology disconnect (such as under-designed biofilters); other concerns include high capital and operational costs and aggressive subsidy-driven rollouts lacking technical vetting.
- **Recommendations:** Institutionalise routine testing through a national 'Pond Health Card' scheme supported by decentralised district-level laboratories. Scale up the commercial use of low-cost, multi-parameter field minilabs, such as CIFA's AquaQuant. Scale and safeguard RAS and BFT adoption, such as through mandating pre-installation technical training and minimum eligibility criteria for farmers receiving subsidies under PMMSY.

## Biosecurity barrier

Biosecurity proactively blocks pathogen entry and reduces horizontal disease transmission across farms.

- **Gaps and constraints:** Field-level adoption is fragmented. Small-holder farmers view biosecurity as an emergency intervention rather than routine prevention, deterred by



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upfront capital costs (CAPEX) for infrastructure like intake filtration and bird netting, and delayed return on investment.

- **Recommendations:** Develop national standard operating procedures (SOPs) and state-level codification for biosecurity. Integrate dedicated financial subsidies and performance incentives within PMMSY to help farmers offset the CAPEX of biosecurity infrastructure. Enforce compliance audits using a state-developed biosecurity scorecard.

## Disease management

Complex pathogens and sub-standard rearing practices drive heavy disease burdens.

- **Gaps and constraints:** Severe access gaps to diagnostic laboratories and point-of-care kits force farmers to rely on visual symptoms and input dealers for treatment advice. This drives empirical, inaccurate treatments and antibiotic misuse, resulting in surging AMR in aquatic pathogens. To add to this, fisheries graduates are not formally recognised as licensed 'fish doctors' to prescribe treatments.
- **Recommendations:** Establish a statutory 'National Fisheries Council', modelled on the Veterinary Council of India, to officially authorise qualified fisheries graduates as licensed aquatic health professionals. Expand decentralised aquatic animal health laboratories and mobile testing units. Incentivise the widespread adoption of existing portable diagnostic tools while accelerating R&D for cost-effective on-farm disease detection. Formulate standardised national treatment guidelines strictly adhering to prohibited antimicrobial lists.

## Access to quality fish seeds

Seed quality (spawn, fry, fingerlings) directly dictates fish resilience and survival.

- **Gaps and constraints:** The sector faces a deficit of quality broodstock. Hatcheries suffer from inbreeding depression, mixed spawning and poor design, which damages eggs and facilitates disease transmission. Seed quality is inconsistent due to unmonitored inter-state transfers and a lack of reliable traceability.
- **Recommendations:** Implement the 2025 'Guidelines on Hatchery Accreditation and Seed Certification' across all states. Establish decentralised seed production hubs (hatcheries, broodbanks) such as through Fish Farmer Producer Organisations (FFPOs). Operationalise the 'National Framework on Traceability in Fisheries and Aquaculture' to monitor uncertified seed flow. Strengthen broodstock management by establishing guidelines and certifying broodstock farms.

## Selective breeding for improved varieties

Selective breeding enhances traits like faster growth and disease resistance (such as AhR Jayanti Rohu, CIFA Amrit Catla etc).

- **Gaps and constraints:** Scaling up these varieties is hindered by limited seed availability and hatchery-level inbreeding. Farmers face adoption friction because buyers cannot visually distinguish improved strains from native ones, failing to command a premium price. Breeding programmes have historically prioritised growth over disease resilience.



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- **Recommendations:** Expand the availability of disease-resilient breeds through public-private multiplier networks. Prioritise emerging aquatic pathogens and environmental stress tolerance in future R&D breeding programmes.

## Access to quality and affordable feed

Feed constitutes 60-70 per cent of operational expenses in intensive aquaculture.

- **Gaps and constraints:** Raw material shortages and high price volatility force local manufacturers to use inferior ingredients. Small-holders lacking capital rely on credit from local dealers for sub-standard feed. Bureau of Indian Standards (BIS) feed specifications are currently voluntary, and farmers lack extension guidance on precision feeding leading to feed wastage and degradation of water quality.
- **Recommendations:** Make BIS feed specifications mandatory for all feed manufacturers, requiring full ingredient disclosure and strict declarations regarding the absence of antibiotics. Enact dedicated state-level Fish Feed Acts. Subsidise AI and IoT (Internet of Things)-driven precision feeding tools and support R&D for low-cost alternative proteins.

## Preventive and therapeutic alternatives

Alternatives like probiotics, immunostimulants, and bacteriophages prevent disease without driving AMR.

- **Gaps and constraints:** High costs limit uptake among small-holders, who rely instead on low-cost traditional disinfectants. The absence of a regulatory framework allows unstandardised products with unverified claims to flood the market, causing inconsistent field efficacy and eroding farmer trust.
- **Recommendations:** Consolidate evidence and create a statutory framework to regulate the manufacturing and marketing of non-antibiotic alternatives, requiring mandatory registration on an open-access online dashboard. Integrate scientifically validated alternatives into national preventive health programmes, supported by small-holder subsidies and strong extension training.

## Building immunity through vaccination

Vaccines offer targeted disease prevention, preserving antibiotic efficacy.

- **Gaps and constraints:** No commercial fish vaccines are currently approved for use in India. Development is slowed by diverse fish species and mutating pathogens. Crucially, there is no formal regulatory pathway within the Central Drugs Standard Control Organisation (CDSCO) to approve fish vaccines.
- **Recommendations:** Fast-track a dedicated regulatory approval pathway for aquatic vaccines through the CDSCO and ICAR. Focus R&D on multi-valent and oral/immersion vaccines. Prepare for the commercial deployment of near-ready vaccines such as through cold chain infrastructure.



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## BEST PRACTICES IN SUSTAINABLE FRESHWATER AQUACULTURE

Field evidence proves that preventive, non-chemical approaches yield significant commercial success.

- **Integrated circular farming (Assam):** Bahbari Farms utilises a zero-waste model integrating fish, poultry and forestry. Replacing commercial feeds with duckweed and *moringa* reduces operational costs and builds climate resilience.
- **Water management (Uttar Pradesh):** A *Pangasius* (a freshwater fish) farmer halted poultry waste feeding, applied zeolite and probiotics, and reduced mortality below two per cent, earning Rs 30-33 lakh.
- **Phytoplankton revival (Odisha):** A farmer cured a severe phytoplankton crash using a 72-hour fermented organic formulation, restoring dissolved oxygen and securing a 60 per cent profit margin.
- **Redesigned BFT (Odisha):** Modifying separate circular BFT tanks into a unified rectangular system reduced overcrowding stress for *Pangasius*, yielding 6.5 tonne and Rs 2.5-3.0 lakh in profit.
- **High-value RAS (Haryana):** Intensive culture of high-value *Singhi* (a freshwater fish) in an RAS tank achieved over 90 per cent survival and a three-tonne yield, proving RAS viability for premium species.

## Overarching recommendations on governance

To mainstream the 'prevention-led pathway':

- The Department of Fisheries, Government of India should finalise and notify the draft 2020 'National Fisheries Policy', with adequate emphasis on preventive practices across the eight identified pillars in this report.
- Simultaneously, the department should constitute a statutory 'Freshwater Aquaculture Authority' — parallel to the successful Coastal Aquaculture Authority (CAA) — to regulate inputs, bridge Centre-state jurisdictional gaps, and mandate sustainability standards. The Andhra Pradesh State Aquaculture Development Authority (APSADA) is a state-level example.
- As states are responsible for inland fisheries, state fisheries departments must take the lead in making aquaculture grow sustainably by enacting proactive, localised legislations, like the Seed Act of Kerala, Assam and Andhra Pradesh and Feed Act of Andhra Pradesh.
- State fisheries departments must actively upskill extension professionals on preventive practices to successfully drive farm-level adoption.



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# 1. Introduction: From prevention to sustainability in freshwater aquaculture

Supporting nearly 30 million people (predominantly fishers and fish farmers), the Indian fisheries sector plays a vital role in national economic growth, food and nutritional security, livelihood support, and export earnings. As the world's second-largest aquaculture producer, India accounts for nearly eight per cent of global fish production. Driven by major 'Blue Revolution' initiatives over the past decade by Central and state governments, this rapidly transforming sector contributes approximately 7.4 per cent to India's agricultural Gross Value Added (GVA) and generated export earnings of Rs 73,890 crore (US $8.46 billion) in 2025-26.[1] This is despite the lower attention received by the Indian fisheries sector historically, compared to the dairy and poultry sectors.

The inland fisheries sub-sector — of which freshwater aquaculture is a major component — generated over 77 per cent of the country's total 20 MT of fish output in 2024-25, representing a 140 per cent growth since 2014-15. Marine fisheries contributed the remaining 23 per cent, but has been prioritised with respect to preventive and regulatory strategies due to its higher export profile.[2] On the other hand, the freshwater sector has remained largely unorganised, small-holder centric, slow in innovation translation from lab-to-pond, and weak in policy framework.

In this report, the 'prevention-led pathway' is a roadmap for sustainable freshwater aquaculture that prioritises disease prevention. It centres on essential practices such as water quality management, implementing biosecurity, timely disease diagnosis and management, access to high-quality feed and seed, improved varieties, alternative treatments and vaccination.

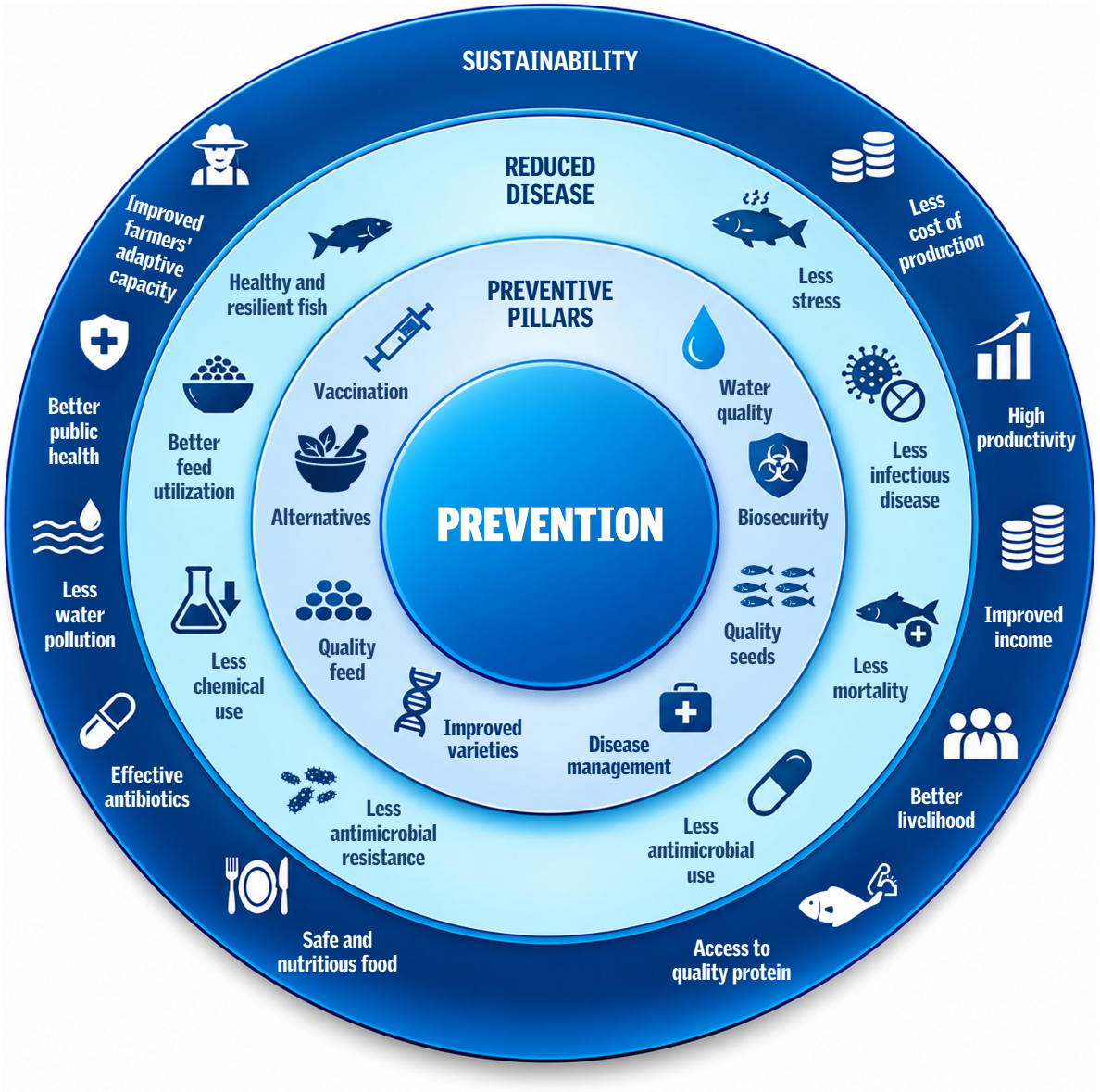
Beyond curbing antibiotic misuse, keeping antibiotics effective and mitigating antimicrobial resistance (AMR) — a global One Health crisis driven in part by the way aquaculture is practiced — these measures can reduce fish mortality and farm-level chemical dependence while improving health and resilience in the aquaculture sector. Eventually, these can lead to sustainable outcomes in freshwater aquaculture such as better income, livelihood and adaptive capacity of fish farmers; safe food, better nutrition and health for consumers; and less polluted water and environment (*see Figure 1: A framework for 'prevention-led pathway' to sustainable freshwater aquaculture*).



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To maximise these gains and ensure that this ongoing transformation in freshwater aquaculture leads to sustainable growth, these preventive approaches must be mainstreamed from their present uneven stage of adoption. This report assesses their current state of practice and policy, identifies gaps and challenges, and outlines required action. It aims to inform future policy making, regulatory frameworks, research and innovation and practitioners.

**Figure 1: A framework for 'prevention-led pathway' to sustainable freshwater aquaculture**






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# 2. The research approach

The findings presented in this report are based on extensive primary research and close assessment of secondary information. Insights were developed through interactions with over 100 experts and stakeholders in 2024-26.

## Research modalities:

- Field visits in select districts of Andhra Pradesh, Odisha, Kerala, Uttar Pradesh and Haryana
- Engagement with stakeholders from freshwater fisheries over a three-day CSE workshop
- Interaction with experts from freshwater and brackishwater fisheries through a day-long online technical consultation
- Engagement with sector experts through in-person meetings and online interactions
- Responses received from Department of Fisheries, Government of India, under the Right to Information Act, 2005
- Secondary research for official and other data, from government reports, scientific publications and independent papers

## Inputs received from following stakeholder groups:

- Scientific and academic experts: ICAR institutes (predominantly those involved in freshwater fisheries) and state universities
    - o ICAR institutes: CIFA, CIFE, CIFRI, NBFGR, Central Institute of Fisheries Technology (CIFT), Central Institute of Brackishwater Aquaculture (CIBA) and Central Marine Fisheries Research Institute (CMFRI)
    - o State universities: Cochin University of Science and Technology, Kerala; Kerala University of Fisheries and Ocean Studies, Kerala; G B Pant University of Agriculture and Technology, Uttarakhand; Kurukshetra University, Haryana; Sardar Vallabhbhai Patel University of Agriculture and Technology, Uttar Pradesh; Dau Shri Vasudev Chandrakar Uttar Pradesh University of Veterinary and Animal Science, Uttar Pradesh; Guru Angad Dev Veterinary and Animal Sciences University and Punjab Agricultural University, Punjab; West Bengal University of Animal and Fishery Sciences, West Bengal
- Fisheries ministries and departments: Central government and state fisheries departments of 10 states (Uttar Pradesh, Haryana, Odisha, Andhra Pradesh, Kerala, Punjab, Rajasthan, Chhattisgarh, Madhya Pradesh, Bihar)
- Fish farmers: Small and large pond farmers, farmers operating bio-floc technology and re-circulatory aquaculture systems, hatchery and broodbank owners
- Private and public sector companies: Feed and feed alternative manufacturers, vaccine manufacturers, independent consultants

The report holds a synthesis of all the information and the insights generated and analysed by its authors. Details of the key experts are provided in the acknowledgement section at the end of this report.



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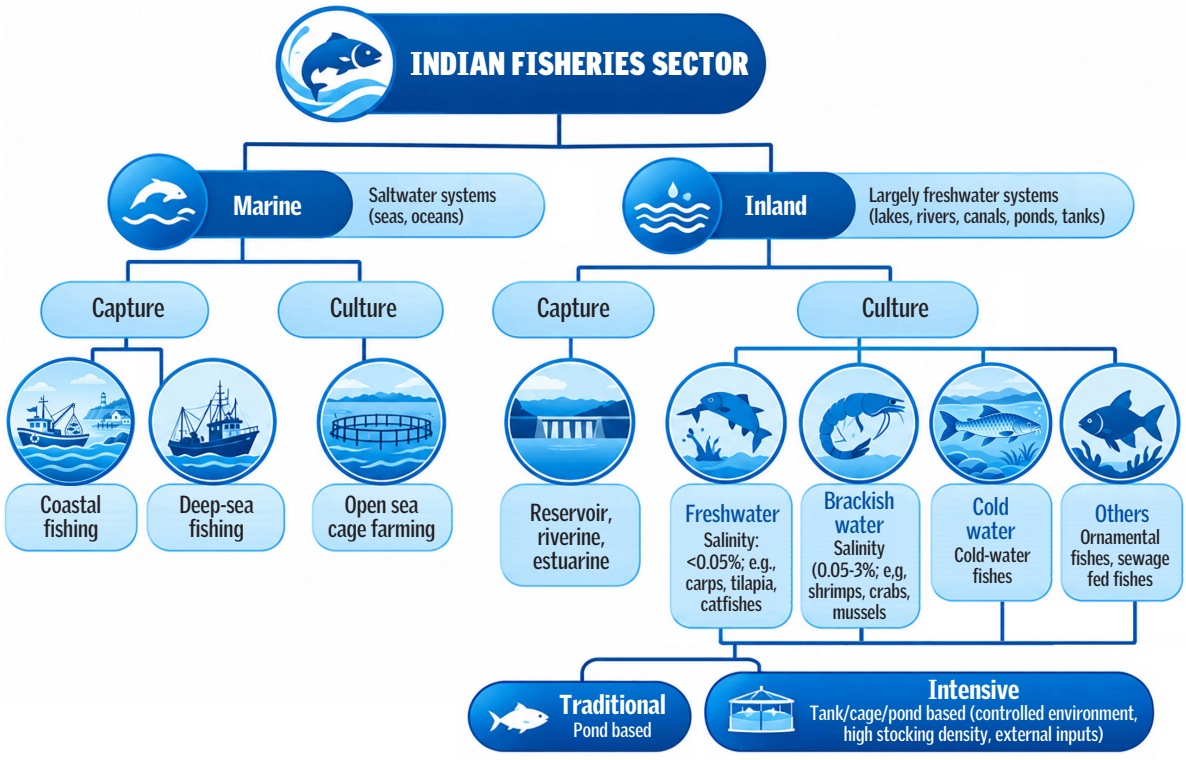
# 3. Overview: The Indian fisheries sector and freshwater aquaculture

## Scale and economic impact

The Indian fisheries sector comprises marine (seas, oceans) and inland (lakes, rivers, canals, ponds and tanks) ecosystems, where fish are either captured from their natural habitats or cultured under controlled conditions. With 19.77 MT of fish production in 2024-25, India is the world's second-largest producer, contributing eight per cent of global fish production.[3]

The sector supports livelihoods of 30 million people and contributes 7.4 per cent to India's Agriculture Gross Value Added. In 2024-25, seafood exports reached 1.69 MT (including 43.6 per cent frozen shrimp, 20 per cent frozen fish and 14.9 per cent dried items), valued at US $7.45 billion.[4] Between 2005 and 2019, annual per capita fish consumption grew by over 80 per cent, increasing from 4.9 kg to 8.9 kg[5] (*see Figure 2: The fisheries sector in India*).

**Figure 2: The fisheries sector in India**






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## Inland fisheries and species diversity

Inland fisheries primarily include freshwater and brackishwater fish. In 2024-25, inland fisheries accounted for 15.16 MT, which was 77 per cent of the total fish production in the country. Between 2019-20 and 2024-25, the inland sector grew at an average annual rate of 7.7 per cent. In 2022, culture-based production made up about 86 per cent of the inland yield (13.11 MT), with the remainder coming from capture.[6]

In 2024-25, the top inland fish-producing states were Andhra Pradesh (32 per cent), West Bengal (13.2 per cent), Uttar Pradesh (8.7 per cent), Bihar (6.3 per cent), Odisha (6.2 per cent), and Chhattisgarh (5.8 per cent). In 2019-20, about 82 per cent (23.11 million) of India's total fish farmers (28 million) were associated with inland fisheries.[7]

India's inland waters host over 900 identified freshwater fish species.[8] Native Indian Major Carps (IMCs) — rohu (*Labeo rohita*), catla (*Labeo catla*) and mrigal (*Cirrhinus mrigala*) — form the backbone of Indian freshwater aquaculture. In 2024-25, these accounted for 54.5 per cent (8.26 MT) of total inland fish production. In addition, exotic carps, catfish and murrels together contributed 20.3 per cent, minor carps added up to three per cent, while other freshwater species (such as tilapia, *pangasius*, shellfish etc) accounted for 22.18 per cent[9] (*see Table 1: Common freshwater fishes in India*).

Andhra Pradesh, Uttar Pradesh, West Bengal, Odisha and Chhattisgarh produced about 67 per cent of the total IMCs (8.26 MT) (*see Graph 1: Top 10 IMC producing states in 2024-25*).

**Table 1: Common freshwater fishes in India**

| Category | Origin | Key species – local/Indian names (scientific names) |
|---|---|---|
| Indian Major Carps (IMCs) | Native | Rohu (*Labeo rohita*), Catla (*Labeo catla*), Mrigal (*Cirrhinus mrigala*) |
| Minor carps and barbs | Native | Calbasu (*Labeo calbasu*), Bata (*Labeo bata*), Gonius (*Labeo gonius*), Fringe-lipped carp (*Labeo fimbriatus*), Reba (*Cirrhinus reba*), Sarana (*Systomus sarana*) |
| Catfishes | Native | Magur (*Clarius magur*), Singhi (*Heteropneustes fossilis*), Pabda (*Ompok pabda*), Pangasius (*Pangasius pangasius*), Butter catfish (*Ompok bimaculatus*), Wallago (*Wallago attu*) |
| High-value indigenous fishes | Native | Murrel (*Channa striata*), Koi (*Cyprinus rubrofuscus*) |
| Prawns | Native | Giant freshwater prawn (*Macrobrachium rosenbergii*) |
| Exotic carps | Exotic | Common carp (*Cyprinus carpio*), Grass carp (*Ctenopharyngodon idella*), Silver carp (*Hypophthalmichthys molitrix*) |
| Exotic commercial fishes | Exotic | Nile Tilapia (*Oreochromis niloticus*), Pacu |



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**Graph 1: Top 10 IMC producing states in 2024-25**




*Source: Handbook of Fisheries Statics, 2025*

## Government initiatives and institutional framework

The sector holds strong growth potential. The Pradhan Mantri Matsya Sampada Yojana (PMMSY) — a flagship scheme for sustainable and responsible development — is led by the Department of Fisheries, Government of India, with support from state governments. Its initial five-year budget (2020-21 to 2024-25) was Rs 20,050 crore, with an extension planned through 2030-31.[10]

Under PMMSY, the Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana (PM-MKSSY) operates as a four-year (2023-24 to 2026-27) Central sector sub-scheme with a Rs 6,000 crore outlay. The National Fisheries Digital Platform (NFDP) serves as a single-window portal to formalise the aquaculture sector by providing fishers with work-based identities, institutional credit and insurance incentives. Additionally, the Fisheries Infrastructure Development Fund (FIDF) offers concessional financing for infrastructure, while the Kisan Credit Card for fisheries provides working capital and short-term credit.

Key scientific stakeholders for freshwater aquaculture are the Indian Council of Agricultural Research (ICAR)-led fisheries institutes such as Central Institute of Freshwater Aquaculture (CIFA), Central Institute of Fisheries Education (CIFE), Central Inland Fisheries Research Institute (CIFRI), National Bureau of Fish Genetic Resources (NBFGR) and ICAR fisheries universities. The National Fisheries Development Board coordinates activities around fish production, aquaculture, training, technology etc.



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## THE DRAFT 'NATIONAL FISHERIES POLICY', 2020

In 2020, the government at the Centre announced that it would introduce a 'National Fisheries Policy' as a comprehensive and integrated framework to bring together the 'National Policy on Marine Fisheries', 2017; the Draft 'National Inland Fisheries and Aquaculture Policy', 2019; and the Draft 'National Mariculture Policy', 2019; alongside post-harvest management.

However, so far, the final overarching policy has not yet been notified, though a version circulated for stakeholder comments remains available in the public domain.[11] As per this version, the draft of the overarching policy aimed to provide a holistic 10-year framework for the sustainable development of the fisheries sector, covering a wide-range of aspects (including preventive measures) in both marine and inland capture fisheries as well as aquaculture.

## THE PRADHAN MANTRI MATSYA SAMPADA YOJANA (2020-21 TO 2024-25)

**Objectives**

1. Harness the potential of the fisheries sector in a sustainable, responsible, inclusive and equitable manner
2. Enhance fish production and productivity through expansion, intensification, diversification and productive utilisation of land and water
3. Modernise and strengthen value chain including post-harvest management and quality improvement
4. Double fishers and fish farmers' incomes and generate meaningful employment
5. Enhance the contribution of the fisheries sector to Agricultural GVA and exports
6. Ensure social, physical and economic security for fishers and fish farmers
7. Build a robust fisheries management and regulatory framework

**Strategic priorities**

1. Aquatic health management
2. Ornamental fisheries
3. Coldwater fisheries
4. Seaweed cultivation
5. Marine fisheries
6. Inland fisheries
7. Fishermen's welfare
8. Infrastructure and post-harvest management

**Targets**

1. **Fish production and productivity**
   - Increasing fish production to 22 million metric tonne by 2024-25 from 13.75 million metric tonne in 2018-19.
   - Enhancing aquaculture productivity to five tonne/hectare from current national average of three tonne.
   - Augmenting domestic fish consumption from five kg to 12 kg per capita.

2. **Economic value addition**
   - Increasing contribution of fisheries sector to the Agriculture GVA to about nine per cent by 2024-25 from 7.28 per cent in 2018-19.
   - Doubling export earnings to Rs 1,00,000 crore by 2024-25 from Rs 46,589 crore in 2018-19.
   - Facilitating private investment and growth of entrepreneurship in the fisheries sector.
   - Reduction of post-harvest losses from the reported 20-25 per cent to about 10 per cent.

3. **Enhancing income and employment generation**
   - Generating 55 lakh direct and indirect employment opportunities along the value chain.
   - Doubling the incomes of fishers and fish farmers.



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# 4. Managing and monitoring water quality

Water quality management is the primary defence against disease outbreaks across broodstock, hatchery and grow-out facilities. As land and water constraints drive intensification of freshwater aquaculture, maintaining optimal water quality has become critical and it depends upon several interacting variables: water source, operational inputs, stocking density, water exchange protocols and prevailing weather conditions.

## Ground-level practices and testing bottlenecks

At the farm level, farmers attempt water quality management after assessing fish behaviour and fish feeding response, checking pond water level and aeration. This involves managing water levels, carrying out basic water exchange, altering aeration, measurement of water parameters, water transparency, inspecting pond bunds, and monthly estimates of fish growth to decide on the feed quantity to be administered.

However, on-farm water monitoring remains inadequate. Farmers, if they test, limit it to basic parameters like pH and dissolved oxygen (DO), overlooking critical variables such as total alkalinity. Pond amendments (such as lime) are often applied without prior chemical assessment. Ground-level fishery extension services rarely enforce routine monitoring (*see Table 2: Key water quality parameters*).

Access to institutional water testing for freshwater aquaculture is restricted geographically and financially. Institutions such as CIFA (Odisha), the Agency for Development of Aquaculture

**Table 2: Key water quality parameters**

| Parameter | Optimum range |
|---|---|
| pH | 7.5-8.5 |
| Total alkalinity | 80-200 ppm |
| Hardness | 100-180 ppm |
| Dissolved oxygen | >5 ppm |
| Unionised ammonia | 0-0.1 ppm |
| Ionised ammonia | 0-1 ppm |
| $NO_2$-N | 0-0.5 ppm |
| $NO_3$-N | 0.1-3.0 ppm |
| Hydrogen sulphide | <0.002 ppm |

Source: CIFA presentation at CSE workshop



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in Kerala (ADAK) and the Kerala University of Fisheries and Ocean Studies (KUFOS) offer such services.

To bridge this access gap, cost-effective portable testing is a potential solution. For example, CIFA has developed the AquaQuant-portable Minilab — a low-cost field kit providing 100 tests across nine critical parameters for Rs 4,500.[12] These are pH, total alkalinity, total hardness, free carbon dioxide, total ammonia, nitrite, nitrate, dissolved phosphate and dissolved oxygen. While the commercial launch remains pending, the kit offers a complete test package tailored for freshwater culture, offering quantitative results along with a decision support system that provides recommendations based on test results. CIFA is also conducting trainings to create a cadre of para-aqua-technicians who can offer such water testing services and advisory support.

On the other hand, several private-sector testing kits (primarily drop/strip based) are available for farmers but these kits cover only one or few tests, provide qualitative results and are needed to bought separately.

## Adoption of high-density aquaculture technologies

Re-circulatory Aquaculture Systems (RAS) and Bio-floc Technology (BFT) offer advanced water quality control and lower water consumption compared to traditional earth ponds.

RAS treats and re-circulates over 90 per cent of culture water through continuous mechanical and biological filtration. BFT uses beneficial microorganisms to convert nitrogenous fish waste into consumable microbial biomass, minimising water exchange and nutrient loss. Both systems significantly reduce the environmental pollutant load of farm discharge.



*Circular BFT unit, Modinangar, Uttar Pradesh*



NEERAJ KUMAR

*RAS unit, CIFA, Odisha*



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Most operational units rely largely on PMMSY subsidies. Due to high capital expenditure (CAPEX), particularly for the medium and large-size systems, and continuous operational costs, RAS and BFT adoption is currently concentrated in nursery and seed rearing, fingerling production and broodstock maintenance rather than in full-cycle grow-out farming. These short-cycle stages yield higher turnover and minimise continuous bio-load pressure on the infrastructure.

Results of a 2024 survey with 20 RAS operators of Haryana, published by researchers at Chaudhary Charan Singh Agricultural University, Haryana highlighted skill deficit, with 70 per cent demanding specialised operational training, and 55 per cent citing lack of functional demonstration units/prototype farms as a major success barrier.[13]

To overcome economic and operational constraints, the scientific community is trying to refine these technologies to lower operational expenses (OPEX) and improve the scope of applications beyond traditional species. In January 2026, a commercial tropical RAS facility for cold-water rainbow trout was launched in Hyderabad, proving the technical viability of high-value culture under ambient tropical conditions.[14]

## Policy framework and subsidies

At the national level, the revised 'Guidelines for Responsible Farming of Tilapia in India' have been available since 2020, which suggest maintaining a daily record of select water quality parameters such as pH, temperature, dissolved oxygen (DO) and nitrites and nitrates ($NO_2$-$NO_3$).[15] The 2025 'Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes' also provides optimum water quality parameters for hatcheries and seed farms.[16]

At the state level, Kerala's 'Standard Operating Procedures for Aquatic Animal Health Management' notes the importance of water quality monitoring and provides clear protocols.[17] Assam and Madhya Pradesh disease management guidelines point towards managing water quality parameters (pH and dissolved oxygen) or disinfecting water (with lime or bleaching powder) to prevent infections.

The Pradhan Mantri Matsya Sampada Yojana (PMMSY) promotes RAS and BFT under 'more crop per drop' mandate, and provides subsidies (40-60 per cent of the unit cost) for backyard, small, medium and large models (*see Table 3: PMMSY subsidy categories and cost of RAS and BFT*).

As of March 2026, 12,081 RAS units and 4,205 BFT units have been approved under PMMSY.[18] Out of the 10,175 established RAS units during 2020-21 to 2024-25, 56 per



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**Table 3: PMMSY subsidy categories and cost of RAS and BFT**

| RAS /BFT category | Unit specification | Unit cost (Rs lakh) |
|---|---|---|
| Large | RAS: 8 tanks of minimum 90 $m^3$/tank (40 tonne/crop) | 50 |
| | BFT: 50 tanks of 4 m diameter × 1.5 m height | |
| Medium | RAS: 6 tanks of minimum 30 $m^3$/tank (10 tonne/crop) | 25 |
| | BFT: 25 tanks of 4 m diameter × 1.5 m height | |
| Small | RAS: 1 tank of 100 $m^3$ capacity | 7.5 |
| | BFT: 7 tanks of 4 m diameter × 1.5 m height | |
| Backyard mini-RAS | Mini RAS unit | 0.5 |

Source: PMMSY operational guidelines 2020

cent were backyard mini-RAS units and 25 per cent were small RAS units. The remaining 19 per cent were medium and large. Nearly 90 per cent of the backyard mini-RAS systems are in Uttar Pradesh. During the same period, 4,174 BFT units were established, with nearly 80 per cent small units, about 70 per cent of which were set up in Kerala, Madhya Pradesh, Jharkhand, Bihar and Haryana (in that order).

Earlier, in 2025, the Department of Fisheries, Government of India had issued the 'Bio-floc, Re-circulatory Aquaculture Systems and Nursery based Aqua Farming Systems Guidelines', for site selection, tank/pond design, water quality management, feed protocols, biosecurity and waste discharge.[19]

## Systemic gaps

- **Contaminated source water vulnerabilities and compounded water quality mismanagement:** Unscreened entry of external pathogens and on-farm mis-management is a concern. Contaminated source water from rivers, canals and reservoirs can introduce external pathogens and chemical pollutants directly into culture systems. External contamination, if exacerbated by poor internal water quality management — specifically unmanaged ammonia/nitrite spikes, dissolved oxygen (DO) crashes, pH instability, and heavy organic waste accumulation — can create acute physiological stress and trigger disease outbreaks. Shared water sources, flooding during monsoon or discharge of untreated aquaculture effluents can further facilitate pathogen spread.
- **Chronic monitoring deficits and testing bottlenecks:** Water quality monitoring remains un-integrated into daily farm operations and often overlooked in extension messaging. Limited access to lab-based water testing and low-cost but reliable field-based kits forces farmers to manage complex water quality parameters with limited testing support. At the national level, there are no guidelines specific to water quality monitoring for Indian Major Carps (IMCs) culture for grow-out farms.



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## Challenges related to RAS and BFT

- **Capacity gaps, vendor exploitation, and aggressive rollout:** Lack of practical demonstration units and trained experts leaves farmers with partial understanding of operating these technologies. Knowledge gaps persist on system design, filtration, aeration, stocking density, water quality management, microbial balance, routine operation and maintenance. There is limited pre-installation training and inadequate post-installation extension support. Misleading information from private vendors and informal sources add to poor decision-making. Rapid, subsidy-driven deployment under PMMSY without rigorous farmer vetting and pre-installation training has prioritised target completion over long-term sustainability and commercial viability.
- **Critical engineering-biology disconnect and operational volatility:** System manufacturers possess basic engineering capability, but lack fish biology expertise leading to inadequate system optimisation such as improperly sized tanks, under-designed biofilters, inefficient pumping systems, and poor overall integration. Farmers and service providers fail to calculate critical biological load metrics — including mass balance, oxygen demand, feed-to-waste conversion, stocking density, and biofilter capacity — resulting in operational volatility such as water quality collapse.
- **BFT incompatibility with IMCs:** BFT is reported to be incompatible with IMCs, while its application is found suitable to a few resilient species like tilapia, *pangasius*, and magur.
- **Prohibitive financial structure and low-margin market realities:** High CAPEX and OPEX due to continuous power requirements (24/7 aeration and pumping), intensive filtration maintenance, and high feed costs inflate the unit cost of production, leading to economic mismatch with market realities, particularly for small fish farmers. The high cost structure of RAS and BFT demands premium pricing and high-value species to break even. However, India's domestic market is built on low-margin, high-volume fish, rendering these technologies economically unviable for the average small-holder.



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# 5. Biosecurity barrier

The Food and Agriculture Organization of the United Nations (FAO) defines biosecurity as a "strategic and integrated approach that encompasses the policy and regulatory frameworks (including instruments and activities) for analysing and managing relevant risks to human, animal (including aquatic) and plant life and health, and associated risks to the environment".[20] In the context of aquaculture, proactive biosecurity blocks pathogen entry (via infected seed, contaminated source water, equipment or personnel), reduces disease amplification, and prevents horizontal transmission across hatcheries, nurseries and grow-out systems. It is an effective, economical and sustainable disease management approach.

Biosecurity practices can be understood in three tiers:

- **External biosecurity** prevents primary pathogen entry through pathogen-free broodstock and seed, water intake filtration, strict access controls for visitors and vehicles and vector containment (birds, wild fish, livestock).
- **Internal biosecurity** minimises intra-farm disease transmission via pond isolation, rigorous equipment disinfection, facility sanitation, controlled personnel movement, biosecure feed management and systematic waste disposal.
- **Operational biosecurity** maintains host health and immune resilience through optimal water chemistry, precision nutrition, routine health screening and emergency disease response.

## Current field practices and regulatory frameworks

Biosecurity adoption remains fragmented across India's freshwater aquaculture systems. While state-run hatcheries, research institutions and commercial farms often enforce measures like boundary fencing, restricted entry, sanitation, bird netting and periodic water replacement, the adoption among small-holder fish farmers remains sporadic and reactive. Common field-level vulnerabilities include improper disinfection, unhygienic equipment sharing, lack of visitor control, improper disposal of dead fish, and encroachment by wild birds, amphibians and stray livestock.

As per a response received from the Department of Fisheries, Government of India, under the RTI Act, "currently there aren't any schemes for biosecurity management in freshwater aquaculture. However, in PMMSY-II, biosecurity measures are proposed."

At present, biosecurity provisions are sporadically mentioned across various regulatory and advisory instruments – one example is the 'Prevention and Control of Infectious and Contagious Diseases in Animals Act (2009)', which included fisheries in 2014.[21] The



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2020 revised version of 'Guidelines for Responsible Farming of Tilapia in India' and 2021 'Guidelines for Import of Pangasius Seed and Broodstock in India' broadly mention aspects like disease control, quarantine, disinfection and movement of aquatic animals.[22,23]. In 2025, 'Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes' mentioned biosecurity provisions for seed production units.[24]

At the state level, freshwater fish biosecurity *per se* is not comprehensively codified in terms of disease reporting, mandatory biosecurity practices, quarantine, stocking densities or water quality limits. States lack explicit disease-specific enforceable freshwater biosecurity rules.[25]

However, states like Kerala have integrated biosecurity in its aquatic animal health management framework.

## Adoption barriers and capital constraints

- **Inconsistent adoption due to practice barriers and limited awareness about benefits:** Farmers predominantly view biosecurity as an emergency intervention during an outbreak rather than a routine preventive shield. Their risk perception during non-outbreak period is low. Lack of dedicated training programmes, field demonstrations, and adoption incentives leaves farmers unaware of the economic return on proactive risk mitigation. This is further compounded by supply-chain bottlenecks, including limited access to disease-free seed, diagnostic laboratories and fish health services.
- **Capital constraints and deferred return on investment:** Comprehensive biosecurity requires additional upfront capital (CAPEX) for infrastructure, such as intake filtration systems, anti-bird netting, perimeter fencing, and quarantine holding tanks, alongside recurring operational expenses (OPEX) for diagnostic testing and chemical disinfectants. Because the financial returns of biosecurity are indirect (avoided losses rather than immediate growth gains), cash-constrained small-holders consistently prioritise short-term yield over long-term risk reduction.



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# 6. Disease management

Disease occurrence in aquatic production systems is driven by a complex interplay of biological pathogens, environmental conditions, and sub-standard rearing practices, including compromised water quality, elevated microbial loads, nutritional deficiencies, and excessive stocking density. Pathological agents are classified into bacterial, viral, parasitic and fungal categories (*see Table 4: Common diseases in Indian freshwater aquaculture*).

Disease outbreaks inflict heavy productivity and financial losses on farm operations. A 2025 ICAR study, based on a nationwide assessment using farmer surveys conducted during April 2021–March 2022, estimated the national economic loss in Indian Major Carp (IMC) culture at US $996 million.[26] Diseases of multi-factorial etiology accounted for the largest share of financial loss in IMCs (45.4 per cent), followed by bacterial infections (35.3 per cent), fungal diseases (8.7 per cent), parasitic infestations (7.0 per cent), and direct environmental stress (3.5 per cent). Bacterial infections showed the highest prevalence in *pangasius* cage culture (38.5 per cent), followed by IMC farming (25.8 per cent) and tilapia systems (7.1 per cent).

**Table 4: Common diseases in Indian freshwater aquaculture**

| Bacterial | Viral | Parasitic | Fungal |
|---|---|---|---|
| Columnaris disease *(Flavobacterium columnare)* | Tilapia lake virus disease (Tilapia Lake Virus) | White spot disease or Ichthyophthiriosis *(Ichthyophthirius multifiliis)* | Saprolegniasis or cotton wool disease *(Saprolegnia parasitica)* |
| Aeromoniasis *(Aeromonas* spp.) | Koi herpesvirus disease (Koi Rana Virus) | Argulosis (Argulus or fish lice) | Gill rot disease or Branchiomycosis (*Branchiomyces* sp.) |
| Edwardsiellosis *(Edwardsiella tarda)* | Tilapia parvovirus disease (Tilapia Parvo Virus) | Dactylogyrosis *(Dactylogyrus* sp.) | Epizootic ulcerative syndrome *(A. invadans)* |
| Fin and Tail Rot (*Aeromonas* sp., *Vibrio* sp., *Pseudomonas* sp.) | *Macrobrachium rosenbergii* nodavirus and *Macrobrachium rosenbergii* Golda virus | Gyrodactylosis *(Gyrodoactylus* sp.) | |
| Bacterial gill disease (*Flavobacterium branchiophilum)* | Disease caused by Goldfish haematopoietic necrosis herpes virus | Myxozoan infection (*Myxobolus* sp., *Henneguya* sp., *Sphaerospora* sp., *Thelohanellus* sp.) | |
| | Spring Viremia of Carp and Viral Hemorrhagic Septicemia (Rhabdovirus) | Lernaeasis (*Lernaea* sp. or anchor worm) | |
| | Carp pox disease (carp pox virus CyHV-1) | Trichonodinos (*Trichodina* sp., *Trichodinella* sp., *Tripartiaella* sp., *Glossatella* sp.) | |



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Prophylactic treatments such as with probiotics, immunostimulants, nutritional supplements and environmental modifiers represented the largest share of disease-related expenditure (50.3 per cent), followed by direct production loss (23.9 per cent) and therapeutic interventions (17.3 per cent).

## Treatment practices, antimicrobial use and field diagnostics

Viral diseases do not have any treatment and require management only. For bacterial disease management, the All India Network Project on Fish Health (July 2015 to June 2026) had recommended specific antibiotics including oxytetracycline, florfenicol, oxolinic acid, sulphadimethoxime + trimethoprim, and sulphadimethoxime + ormetroprim, alongside antiparasitic compounds such as formalin, hydrogen peroxide, ivermectin, and albendazole for parasitic disease management.[27]

However, in 2023, CIFE researchers reported the use of enrofloxacin, oxytetracycline, cephalexin, doxycycline and erythromycin in Indian freshwater aquaculture farms.[28] In 2021, a CSE report also highlighted use of enrofloxacin, ciprofloxacin and oxalinic acid.[29] CSE researchers found antibiotics being used in several freshwater farms which they visited across different states between 2024-25.

Data (2019-2022) from the All India Network Project on AMR in Livestock and Fisheries highlights surging resistance in key aquatic pathogens, including *Aeromonas* sp. (against cefoxitin and cefotaxime), *E coli* (against amoxiclav, ampicillin), *S aureus* (against penicillin G and ciprofloxacin), Coagulase negative *Staphylococci* (against penicillin G, cefoxitin); these were isolated from the freshwater fisheries sector.[30]

Disinfectants such as potassium permanganate, copper sulphate, formalin and sodium chloride solution also play a prominent role in preventing and managing disease. CIFA has commercialised CIFAX, a chemical formulation to prevent and control ulcerative conditions.

CIFA has also developed low-cost diagnostic kits to enable rapid field screening, which include 'spot-agglutination kit' and 'Dot-ELISA kit' for on-farm diagnosis of *edwardsiellosis*, *aeromoniasis* and bacterial gill disease in carps. CIFA's 'White Tail Disease diagnostic kit' detects carriers and early or latent infection in freshwater giant prawn (*M rosenbergii*).[31]

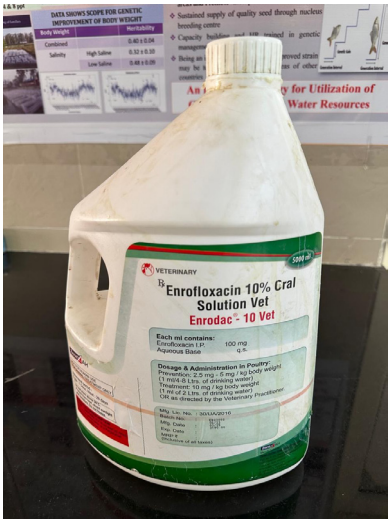
## Institutional support and surveillance infrastructure

Institutional support for aquatic animal health is structured through multi-tier national programmes and state directives.

- The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) under PMMSY combines active fish disease surveillance with farmer reporting. The 'Report Fish Disease' (RFD) mobile application allows farmers to report diseases on their own. Under PMMSY, until



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*Enrofloxacin used in BFT, Hisar, Haryana*




*Tetracycline used in pond, Puri, Odisha*




*Enrofloxacin used in pond, Bulandshahar, Uttar Pradesh*

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*Combination of pefloxacin and enrofloxacin used in pond and BFT, Ghaziabad, Uttar Pradesh*




*Combination of sulphamethoxazole and trimethoprim used in pond and BFT, Ghaziabad, Uttar Pradesh*

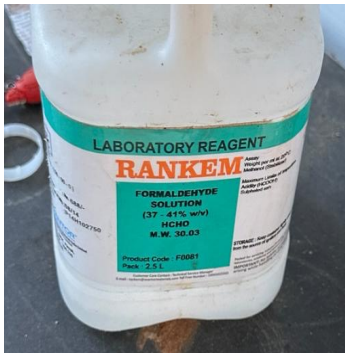
NEERAJ KUMAR

2024, 19 disease diagnostic laboratories, 31 mobile testing units, and six referral centers were established.[32] A 'Diagnostic Manual for Aquatic Animal Diseases of National Concern' has helped standardise disease diagnosis and surveillance across NSPAAD laboratories.

- In 2022, the Department of Fisheries, Government of India wrote to chief secretaries of all states and Union territories to appropriately regulate the sale and use of antibiotics in aquaculture in view of growing antimicrobial resistance and reports of antibiotic use/misuse.[33]



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*Formaldehyde used in hatchery, Puri, Odisha*




*Cypermethrin used in pond, Puri, Odisha*




*Malachite green used in pond, Puri, Odisha*




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*CIFAX used in BFT, Hisar, Haryana*




*Deltamethrin used in pond, Ghaziabad, Uttar Pradesh*




*Disinfectant used in pond, Bulandshahar, Uttar Pradesh*



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*Potassium permanganate powder used in pond, Ghaziabad, Uttar Pradesh*

- States like Kerala, Assam, Bihar and Madhya Pradesh mention the use of disinfectants and antibiotics in their disease management guidelines (such as SOPs, training module).[34,35]

## Diagnostic accessibility and extension constraints

- **Access gaps to diagnostics adding to empirical treatment:** Farmers treat diseases based on visible symptoms or local experience as inaccessibility to diagnostic laboratories due to distance, cost and time make them rely on advice from fellow farmers, input suppliers or local dealers. Accessibility to effective point-of-care diagnostic support is also a concern. This often results in inaccurate or delayed diagnosis, inappropriate use of antibiotics, chemicals and other therapeutics.
- **Limited clinical guidance and support on the ground:** While disease management guidance exists in certain states and at the institutional level, the national-level standard treatment guidelines for freshwater fishes is reported to be under development. The



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## NATIONAL ACTION PLAN ON ANTIMICROBIAL RESISTANCE (NAP-AMR) 2.0

The NAP-AMR 2.0 (2025-2029) was released in November 2025.[36] It builds on the first NAP-AMR (2017-2021) and provides an updated, more practical framework for tackling AMR through a One Health approach, which includes the fisheries and aquaculture sector. The plan highlights the need to strengthen AMR and antimicrobial-use surveillance in aquatic production, improve laboratory and diagnostic capacity, promote prudent and evidence-based antimicrobial use, and strengthen biosecurity and disease prevention to reduce the need for antibiotics. It also recognises the environmental pathway from aquaculture, including the release of antimicrobial residues and resistant organisms into surrounding water and ecosystems.

concern, however, is that the developed guidelines do not adequately reach their target audiences. Limited access to fisheries extension officers due to their additional administrative responsibilities adds to the problem. Besides, fisheries graduates are not formally recognised as 'fish doctors' unlike their veterinary counterparts, and therefore cannot formally prescribe treatment. The absence of a Fisheries Council in India limits their professional authorisation.



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# 7. Access to quality fish seeds

Fish seed represents early development stages of fish categorised based on size:

- Spawn/eggs (up to eight mm for IMCs)
- Fry (early fry: 9-25 mm; fry: 26-50 mm; advanced fry: 51-100 mm for IMCs)
- Fingerlings (>100 mm for IMCs)

Hatcheries produce fish seed, and seed farms raise them to stock aquaculture farms. A seed production unit can include a hatchery or a seed farm or both.

Seed quality is a key determinant of fish health. Good quality seeds have higher survival, faster growth, enhanced resilience to environmental stress, reducing disease and mortality. Their quality depends on factors such as broodstock health and its genetic purity; seed size uniformity, active behaviour, pathogen-free status; and good hatchery management.[37]

In India, there are over 3,000 freshwater hatcheries for carp seed production, in addition to those meant for striped catfish, magur, singhi, pabda, murrel, freshwater prawn etc.[38] Experts indicate that this capacity remains insufficient and geographically concentrated in few states such as Andhra Pradesh and West Bengal.

Over 1,400 hatcheries have been sanctioned since 2014-15, out of which 895 fish and scampi hatcheries (freshwater fisheries) were approved under PMMSY (2020-21 to 2024-25). About 60 per cent of these newly established hatcheries are concentrated in five states — West Bengal (25 per cent), Assam (12 per cent), Uttar Pradesh (9.4), Odisha (8.1 per cent) and Jharkhand (5.7 per cent).[39]

The *Handbook of Fisheries Statistics 2025* reports total national fish seed production during 2024-25 of 77.89 billion, with West Bengal being the biggest producer (33 per cent) followed by Assam (24 per cent) and Jharkhand (12 per cent).[40] However, proportion of seeds from freshwater species is not separately mentioned.

Accreditation of hatcheries and certification of fish seeds is considered an important approach to assure quality fish seed. Accreditation confirms that specific set of standards for hatchery management are met. A certified seed is a progeny of the broodstock produced by an accredited hatchery or a fry raised by an accredited seed farm, certified as compliant with specified norms.[41]



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## Seed procurement practices and the policy framework

Farmers can buy seeds from state government hatcheries as well as private hatcheries, which are more in number. Relying on seed hubs such as West Bengal and Andhra Pradesh — that are active in seed production owing to a large number of private hatcheries — is common across states facing supply deficits or seeking seeds of specific species or improved varieties. Seed demand has increasingly evolved from seasonal monsoon-dependent fry stocking to year-round use of advanced fingerlings. Hatchery accreditation and seed certification processes in freshwater fisheries is in a nascent stage with processes initiated in few states.

Historically, some states such as Kerala, Bihar and Andhra Pradesh have taken initiatives to ensure seed quality through Seed Acts, which go beyond freshwater fish seeds.[42-44] These laws cover aspects such as fish seed committees, state and regional seed centres, fish seed analysis laboratories, regulation and standards for seed, registration and licensing of seed farm and hatchery, and establishment of seed or broodfish banks.

At the national level, the PMMSY promotes seed quality through subsidies such as for establishments of broodbanks, new hatcheries, nursery/seed rearing ponds, and seed certification and accreditation of broodbanks, farms and hatcheries.[45] The Department of Fisheries' *Annual Report 2025* notes that the National Fisheries Development Board (NFDB) is implementing a Rs 4.52-crore pilot certification project of hatcheries, farms, broodbanks and feed mills in six states — Andhra Pradesh, Assam, Gujarat, Chhattisgarh, Karnataka and Tamil Nadu — through eight private certifying agencies.[46]

In 2025, the Department of Fisheries issued 'Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes'.[47] This national framework specifies accreditation procedure, species-specific benchmarks for accreditation (such as water quality, infrastructure, broodstock and seed assessment, operation and record maintenance), and biosecurity. The guidelines also note adoption barriers such as increased production costs due to accreditation, reduced profit margins due to low uptake of certified seeds and competition from uncertified seeds, and poor performance of certified seeds.

Earlier, in 2019, the ICAR had documented breeding and seed production technologies for finfishes and shellfishes.[48] However, this does not capture detailed operational guidelines around hatchery management. In contrast, hatchery management and certification are prominent aspects in brackishwater shrimp production. For example, the guidelines for certification of shrimp hatcheries in India outlines the steps for hatchery management.[49]



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### NATIONAL FRAMEWORK ON TRACEABILITY IN FISHERIES AND AQUACULTURE, 2025

This framework establishes a unified, digital, end-to-end traceability system across fisheries and aquaculture value chains.[50] It covers the entire value chain: seeds, inputs and production to harvesting, processing, transport, sale and export. The framework aims to support food safety, hygiene and quality assurance, regulatory compliance, sustainability, market access and consumer confidence. It proposes the use of Critical Tracking Events (CTEs) and Key Data Elements (KDEs) to record and link information across the value chain, supported by digital technologies and integration with the National Fisheries Digital Platform. It also sets out provisions relating to governance, data management, capacity building and phased implementation. Freshwater aquaculture is explicitly incorporated into the proposed national system alongside other fisheries and aquaculture value chains.

## Supply constraints, inbreeding and seed quality gaps

- **Inconsistent seed quality and limited access:** Seed quality remains highly variable due to a regional hatchery shortages leading to inter-state seed transfers, often resulting in seeds of mixed or poor-quality, high post-stocking mortality and uneven growth. Farmers' confidence in government hatcheries is often low because they prioritise seed volume over quality, while operating under staff and having technical constraints. Limited traceability or certification systems make monitoring of uncertified seed difficult. Shifting demand for different seed types (improved, mixed, stunted etc), climate variability (floods, droughts, heat waves etc) and changing water quality (hardness, salinity etc) can affect seed access, quality and survival.
- **Limited availability of quality broodstock:** Limited number of broodbanks or related infrastructure is a big reason. In addition, same broodstock used over successive breeding cycles with limited infusion of wild germplasm, leads to inbreeding depression. Mixed spawning due to multiple broodstock reared in the same pond reduces genetic diversity and loss of genetic vigour.
- **Inadequate hatchery management:** Incorrect hormone use, poor water quality and sub-optimal spawning adversely affect fertilisation, hatchability and larval quality. These are compounded by inadequate hatchery design (poor water circulation, water pressure and incubation) which can damage eggs. Irregularities and inadequacies in biosecurity and quarantine measures — limited disease screening and sanitation and hygienic egg handling — can increase disease risk and its transmission through infected seed.



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# 8. Selective breeding for improved varieties

India's aquatic ecosystem harbours over 2,800 indigenous fish and shellfish species, including more than 900 freshwater fish species. Also known as native or local species, these indigenous species have evolved and adapted to specific geographical regions and aquatic environments.[51] However, they are slow-growing, give lower yields and can still be vulnerable to common stress factors and pathogens like *Aeromonas hydrophila* in intensive aquaculture settings.

Over the years, some select freshwater fish species have been improved through selective breeding, with a focus on traits like improved productivity, faster growth, feed efficiency, nutritional quality and disease resistance. There are six such varieties in India and only two of them are said to have disease resistance characteristic, in addition to improved or faster growth. These are AhR Jayanti Rohu and CIFA Amrit Catla (*see Table 5: Improved freshwater fish varieties in India*).

**Table 5: Improved freshwater fish varieties in India**

| Improved variety (developer) | Native species | Improved variety characteristics |
|---|---|---|
| AhR Jayanti Rohu (CIFA) | Rohu (*Labeo rohita*) | Faster growth; subsequently improved for disease resistance against *A. hydrophila;* 14$^{th}$ generation produced in 2024 |
| CIFA-Amrit Catla (CIFA) | Catla (*Labeo catla*) | Improved growth, high survival and disease resistance; 4$^{th}$ generation produced in 2024 |
| CIFA-GI Scampi (CIFA) | Giant freshwater prawn (*M. rosenbergii*) | Improved growth and production performance |
| Genetically Improved Farmed Tilapia — GIFT (Rajiv Gandhi Centre for Aquaculture)* | Nile tilapia (*Oreochromis niloticus*) | Faster growth, improved production performance and stress tolerance |
| Amur Carp (Karnataka Veterinary, Animal and Fisheries Sciences University) | Common carp (*Cyprinus carpio*) | Improved growth and production performance |
| Mahamagur (CIFE) | Magur (*Clarias magur*) | Improved growth and production performance |

*Originally developed through the WorldFish programme



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The ICAR, in its 2014-23 achievements report, noted growth improvement[52]:

- More than 50 per cent in Jayanti Rohu after 13 generations;
- More than 50 per cent in improved freshwater prawn after 13 generations;
- More than 30 per cent in improved catla after two generations;
- More than 20 per cent in improved Indian magur after two generations.

## Institutional distribution and multiplication channels

The National Freshwater Fish Brood Bank (NFFBB) under the NFDB maintains a few improved varieties and supplies broodstock and seeds to hatcheries and seed growers. In 2024, CIFA distributed about 54 lakh breeder seeds of AhR Jayanti Rohu, 14 lakh of CIFA-Amrit Catla and 1.85 lakh of CIFA-GI Scampi to NFFBB and other multiplier units.[53]Concurrently, the NFDB-Eastern Regional Centre (ERC) distributed 25.96 crore breeder seeds and 3.4 tonne broodstock of freshwater fishes including Jayanti Rohu, improved catla, Amur common carp, and GI-Scampi.[54] In 2024-25, the Tamil Nadu-based Rajiv Gandhi Centre for Aquaculture (RGCA) supplied about 11,000 broodstock fry and more than 8.5 lakh all-male seeds of Genetically Improved Farmed Tilapia (GIFT) to beneficiaries.[55]

## Adoption friction and breeding trait constraints

- **Limited availability of quality seeds of improved varieties:** Concerns at the hatchery level such as in-breeding depression, mixing of spawns of native species and improved varieties, and improper adherence to SOPs for breeding and rearing improved varieties can compromise genetic quality and performance. Experts suggest that the government efforts to scale up are gradual but slow.
- **Adoption friction for new/improved varieties:** Farmers hesitate to switch due to low market awareness and price uncertainty. While seed cost for improved varieties is comparable to native stock, farmgate prices often fail to command a premium because buyers cannot visually distinguish improved strains from native ones.
- **Species improvement less focussed on disease resilience:** Selective breeding initiatives are less focused on traits like disease resistance or stress tolerance, and more on growth and commercial productivity.



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# 9. Access to quality and affordable feed

In 2022, the Indian aquaculture sector used 20 million tonne (MT) of feed, of which 6.16 MT was compound feed, including 2.37 MT of pelleted feed and 13.95 MT of farm-made feed. The compound aquafeed was 14 per cent of the total — about 44 MT of compound feed — produced in India.[56]

## Feed formulations, technical innovations and standards

Feeding practices in India vary by farming system, species cultured and affordability. In addition to natural food sources like phytoplankton and zooplankton, small farmers often use supplementary feeds, which are farm-made, low-cost and prepared from locally available ingredients, but can be nutritionally unbalanced and inconsistent in quality.

On the other hand, commercially available compound feed is scientifically formulated and includes extruded and quality-controlled pelleted feed that provides balanced nutrition through essential proteins, fats, carbohydrates, vitamins, and minerals required for optimal fish growth, improved feed conversion and reducing disease occurrence. In intensive fish culture, dependent on commercial feed, the cost of feed is 60-70 per cent of the overall operational expenses (*see Table 6: Characteristics of farm-made and compound feeds*).

Feed analysis (composition, quality, contamination etc) is currently limited to central facilities such as NFDB's Aquatic Animal Health and Quality Testing Laboratory, and feed testing laboratories of CIFA, CIBA and CIFT, in addition to private sector laboratories.[57-60]

To address cost concerns of commercial feed, researchers and start-up companies are developing low-cost and sustainable feed alternatives. For example, Black Soldier Fly meal, duckweed, azolla, algae, microbial proteins and agro-industrial by-products such as DDGS (distillers dried grain soluble).[61] However, their adoption is limited. The Bhubaneswar-based Central Institute of Freshwater Aquaculture (CIFA) has also developed several feeds for optimal nutrition such as CIFABROOD (carp broodstock feed), CIFACA (carp grow-out feed), CIFAMA (magur fingerling feed) and GRAM-CA (grow-out farm made carp feed).[62]

Managing feed through optimisation is another approach to reduce the cost and waste as well as prevent water quality deterioration. Researchers and private companies are using IoT (Internet of Things) and AI (Artificial Intelligence) to optimise feed, precision feeding, pelletisation and automated distribution. This includes examples such as CIFA's Smart



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**Table 6: Characteristics of farm-made and compound feeds**

| Parameter | Farm-made feed | Compound feed |
|---|---|---|
| Ingredients | Locally available (e.g., rice bran, oil cakes, cereals, fish meal, kitchen and poultry waste) | Scientifically formulated (e.g., grains, oilcakes, meals, animal and industrial by-products, fats, vitamins, minerals, toxin binders). May contain pharmacologically active substances like antibiotics |
| Nutritional balance | Difficult to achieve | Designed to meet species- and stage-specific nutritional requirements |
| Digestibility | Variable | High |
| Feed conversion ratio (FCR) | High (could be 2.5-3.0) | Low (could be 1.2-2.0) |
| Feed cost | Low | High |
| Feed quality | Inconsistent; vary between batches | High and consistent |
| Characteristics | Powder, mashed form; rapid disintegration; less water stable | Pelleted extruded feed; floating and sinking, water stable |
| Feed wastage | High (undigested nutrients high) | Low, if feed is used appropriately and managed well |
| Impact on water quality | High; increased organic load, ammonia etc. | Low |
| Growth and productivity | Variable or slow growth; suited for extensive/semi-intensive systems | Faster growth; suited for intensive production |
| Fish culture cycle | Longer | Shorter and faster; offsets feed cost |
| Stress resilience | Less; nutritional deficiency/ imbalance can compromise physiological condition | More; balanced nutrition supports growth and immunity |
| Disease risk | High due to variable feed quality and contamination risk | Less due to high feed quality |

Note: FCR means feed conversion ratio. It is a measure of the fish's efficiency in converting feed mass into a desired output, such as fish meat. FCR is calculated by dividing total feed consumed by the resulting output mass (body weight gain or product yield) over a given period.

Feeder, which uses IoT, IP (internet protocol) cameras and mobile application to automate feed dispensing and track fish activity across ponds, RAS, and Bio-floc systems and the CIFE-Aquafeed Optima mobile application of CIFE, for cost-effective feed formulation. Private sector products comprising automated feeders, digital farm management and precision feed systems are also available. Other solutions like sonar biomass monitoring and AI-driven adaptive feeding are emerging as well.

## Policy frameworks and government programmes

- The Bureau of Indian Standards (BIS) provides feed specifications for six freshwater fish categories — carps, magur and singhi, freshwater prawns, *pangasius* and tilapia — comprising specifications for feed quality, nutrient composition, testing methods, packaging and labelling. It does not permit antibiotics and pharmacologically active substances. However, these standards are voluntary.



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### HARNESSING INSECTS AS AN ALTERNATIVE PROTEIN SOURCE

Unifly Insect Technology, a Delhi-based start-up, is developing insect-based feed ingredients to support sustainable aquaculture. The company uses Black Soldier Fly Larvae (BSFL) for commercial production and housefly larvae for small-scale applications. Insect meal is rich in high-quality protein, essential amino acids, beneficial fats such as lauric acid, micronutrients and antimicrobial peptides (AMPs), which improve gut health, immunity, feed efficiency, growth, stress tolerance and disease resistance in fish, leading to overall better fish health and lesser disease incidence.

Adoption of BSFL-based feed is limited, with some feed manufacturers beginning to incorporate insect meal into commercial feed formulations. There are examples of commercial murrel farmers using insect larvae as a feed additive. The company is also developing scientific insect-rearing systems and standardised feed formulations to ensure a consistent supply of quality insect protein.

- At the state level, Andhra Pradesh regulates fish feed through the Andhra Pradesh Fish Feed (Quality Control) Act, 2020 and associated rules. Together, they cover all relevant aspects including no use of antibiotics.[63]
- The PMMSY promotes species-specific feeds; establishment, accreditation and quality standards of feed mills; feed certification; availability of affordable and quality feed; and subsidy support for feed manufacturing units. Until December 2024, 1,091 fish feed mill/plants have been approved. The NFDB is also implementing feed mill certification.[64] The Fisheries Infrastructure Development Fund also supports development of fish feed mills.

## Cost volatility, quality control and management gaps

- **Quality control and cost volatility concerns limit access to safe and affordable fish feed:** Shortages in raw materials, price volatility, limited technical capacity of feed manufacturers and limited feed testing infrastructure affect feed consistency, supply and commercial viability and contamination risks. Often, high prices of raw ingredients (such as soybean meal, fish meal and maize) lead local manufacturers to use inferior ingredients to remain competitive. Small and medium farmers depend on credit from local feed dealers, who may not be selling top quality feed as small farmers cannot afford costly feed.
- **Poor feeding practices due to inadequate extension and guidance:** Farmers lack access to practical guidance on stage-specific nutrition, feed formulation, feeding frequency and schedules, storage and feed adjustments under varying environmental conditions. Adoption of good feeding practices are constrained, leading to feed imbalance, feed wastage, reduced feed efficiency, poor growth, deterioration of water quality and increased disease risks.



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# 10. Preventive and therapeutic alternatives

To conserve antibiotics and reduce their overuse, use of alternatives in freshwater aquaculture relies on two approaches:

- **To prevent disease**: Alternative products that improve overall growth and health of fish, thereby reducing disease risk. These include probiotics and prebiotics, immunostimulants, herbal preparations and organic acids.
- **To treat disease**: Targeted agents such as bacteriophages against a specific disease.

The mode of action, efficacy, cost and practical applicability of these alternatives are different (*see Table 7: Alternatives used in Indian freshwater aquaculture*).

## Field adoption practices

Adoption of alternatives among farmers is in early stages:

- In the case of progressive/large farmers, adoption is popular as they are aware of benefits of alternatives and are able to afford these. They are more likely to use probiotics, immunostimulants and herbal preparations. Herbal alternatives are often preferred as they are perceived as 'organic'. Farmers' reliance on dealer advice for dose and duration recommendations leads to inconsistent dosing and variable outcomes.

**Table 7: Alternatives used in Indian freshwater aquaculture**

| Type of alternative | Description/mode of action | Examples |
|---|---|---|
| Probiotics | Consortium of beneficial bacteria outcompeting pathogens for resources; water probiotic improves water quality; gut probiotic improves digestion, FCR, growth | *Bacillus* spp., *Lactobacillus* spp. |
| Prebiotics | Non-digestible carbohydrates that nourish beneficial gut bacteria; improve digestion, FCR, growth | Xylo-oligosaccharides (XOS), mannan-oligosaccharides (MOS), inulin, β-glucan |
| Synbiotics | Synergistic combination of probiotics and prebiotics | MOS and *B. subtilis*, XOS and *Lactobacillus* sp. |
| Herbal /medicinal preparations | Active ingredients or secondary metabolites from herbs/ plants having natural antimicrobial, immunostimulatory effects | Garlic, turmeric, neem, tulsi, aloe vera (or their extracts) |
| Immunostimulants | Compounds that directly stimulate immune response against pathogens | Beta-glucans, nucleotides, yeast extracts, minerals, amino acids, vitamins, and enzymes |
| Organic acids | Lowers gut pH to inhibit pathogenic bacterial growth | Citric acid, butyric acid, and formic acid |
| Bacteriophages | Viruses that infect and replicate within bacteria, ultimately destroying it | Lytic phages targeting *A. hydrophila* |

Source: Compiled by authors



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- In the case of small farmers, high costs of alternatives limit their uptake. Instead, they rely on cheap conventional disinfectants (common salt, lime and potassium permanganate) or home-prepared plant extracts (neem, turmeric, tulsi, garlic, ginger, sour curd etc) for disease management, turning only to commercial immunostimulants during active outbreaks. Available assessments have captured the cost of probiotics on shrimps. A 2014 study on impact of probiotics on shrimp culture noted an increased cost of cultivation by 20-40 per cent due to probiotic use.[65] Another survey of 182 shrimp farmers in Andhra Pradesh found a median expenditure of Rs 26,730 per hectare over a 12-week rearing period on probiotics alone.[66]

Alternative products are marketed by big and small private players and are commonly sold as feed supplements or feed additives, except few categories. Moreover, commercial development and field deployment of herbal products by private sector are constrained by limited investment due to difficulties in patenting naturally derived formulations.

While preventive alternative products in general are slow-acting with limited and variable efficacy as compared to drugs, their field efficacy can get jeopardised due to factors such as unregulated market offerings, unstandardised formulations and quality, and sub-optimal farm storage, which add to inconsistent field performance compared to conventional drugs.

## Scientific developments and the regulatory framework

The scientific community has been studying the effect of alternatives on freshwater fish growth, immunity, and survival, particularly in the case of rohu. For example, in 2024, scientists at CIFA reported that dietary supplementation of moringa leaf (*M oleifera)* extract significantly improved growth, enzyme activity and immune parameters in rohu.[67] Earlier in 2021, CIFA scientists evaluated the effect of mono or multi-microbe probiotics on these parameters in rohu fingerlings and noted positive outcomes.[68] In the same year, research from West Bengal University of Animal and Fishery Sciences noted an increase in immunity of rohu against *A hydrophila* upon dietary supplementation of vitamin E and probiotics.[69]

The Bhubaneswar-based Central Institute of Freshwater Aquaculture has developed alternative products such as CIFA L-Check (a herbal formulation to control argulosis/lice infection in fish), Paraherb (a formulation combining 12-18 medicinal plants for parasitic disease management) and Immunoboost-C (an immunostimulant to improve brood fish health and carp seed production).

The science of bacteriophages is emerging in freshwater aquaculture, with their identification, characterisation and genomic analysis underway against *A hydrophila.*[70-72] However, the Central Institute of Brackishwater Aquaculture (CIBA) has already developed two phage technologies (LUMIphage, V-phage) for shrimp diseases.



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*Probiotic used in hatchery, Modinagar, Uttar Pradesh*




*Soil and water probiotic used in BFT, Puri, Odisha*




*Soil and water probiotic used in pond, Ghaziabad, Uttar Pradesh*

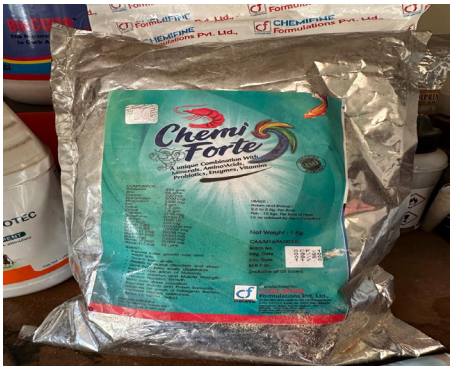
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*Feed additive (probiotic) used in pond, Ghaziabad, Uttar Pradesh*




*Feed additive used in pond, Bulandshahar, Uttar Pradesh*




*Combination of probiotics, vitamins, minerals, amino acids and enzymes used in pond, Bulandshahar, Uttar Pradesh*

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*Liver tonic used in pond, Ghaziabiad, Uttar Pradesh*




*Tulsi Panchang Juice used in pond, Puri, Odisha*




*Organic disinfectant used in pond, Modinagar, Uttar Pradesh*

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At the national level, there is no specific regulatory framework related to alternatives for freshwater aquaculture. Besides, the regulatory framework on feed along with which most alternatives are administered is also weak for freshwater aquaculture. At the state level, the Andhra Pradesh (Fish Feed) Quality Control Rules mentions that only additives approved by the BIS or the state government can be used in feed; use of any new additive will require an approval from the competent authority.

## High costs, adoption challenges and regulatory gaps

- **Cost of alternatives is a barrier to adoption, particularly among small-scale farmers:** Alternatives are often perceived as additional production expenses rather than essential farm investments because their benefits are generally preventive, indirect and difficult to measure immediately. Consequently, farmers tend to prioritise spending on more tangible inputs such as feed and seed. Perceived return on investment (ROI) on alternatives is low.
- **Limited farmers' trust in alternatives due to lack of standardisation and quality control:** This can lead to unverified claims, inconsistent quality and uncertain composition to enter the market, reducing farmer confidence. For example, concerns persist regarding concentration and identity of microorganisms in probiotics. Absence of standardised packages of practice comprising guidance on composition, dosage and frequency of application adds to the uncertainty.
- **Lack of consolidated scientific evidence hinders wider adoption:** This also means that effectiveness of alternatives under different field conditions not yet fully known, which is influenced by factors such as high temperatures, poor storage, fluctuating water quality.
- **Regulatory framework for alternative use in freshwater aquaculture is almost non-existent:** In contrast to mandatory registration of inputs, including alternatives in the case of coastal aquaculture, alternatives used in freshwater aquaculture are not mandated to be registered by law. The BIS requirements for Good Aquaculture Practices outlines compliance requirements for prebiotics, probiotics and immunostimulants in the case of shrimps, and not in the case of freshwater catfishes or carps. A defined regulatory framework for bacteriophage applications in aquaculture is also missing.



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# 11. Vaccination

Fish vaccination is being recognised as a potentially useful approach to mitigate economic losses by preventing disease outbreaks. However, there are no vaccines approved for commercial use in the Indian fisheries sector. Present efforts are centred on research and development of vaccines against specific pathogens affecting freshwater species (due to their well-developed immune systems compared to the primitive immune systems of shrimps). These vaccines are under different stages of development; a few are closer to being commercialised.

## The vaccine pipeline

Vaccine development is led by CIFA, CIFE, CIBA and a few universities. To date, technologies for five candidates (four bacterial, one viral) have been transferred to Indian Immunologicals Ltd (IIL) for field validation and commercial manufacturing. CIFA has also developed a vaccine for bacterial infection in brooders and a parasitic vaccine against *Argulosis*; these are besides the various research initiatives being carried out across academic institutions (*see Table 8: Status of fish vaccines in India*).

**Table 8: Status of fish vaccines in India**

| Vaccine | Developer (year) | Type | Preventable disease (causative organism) |
|---|---|---|---|
| **Vaccines developed; with Indian Immunologicals Limited for commercialization** | | | |
| CifaVac | CIFA (2023) | Bacterial, live-attenuated | Motile Aeromonas Septicemia (*A hydrophila*) |
| CIFE-Aeromonas V vac | CIFE (2023) | Bacterial, inactivated | Motile Aeromonas Septicemia (*A veronii*) |
| CIFE-Flavac | CIFE (2023) | Bacterial, inactivated | Columnaris (*F columnare*) |
| CIFE-Ed-Vac | CIFE (2023) | Bacterial, inactivated | Edwardsiellosis (*E tarda*) |
| CIBA-NodaVac-R | CIBA (2021) | Viral, subunit | Viral Nervous Necrosis for fin fish Asian Seabass (Nervous Necrosis Virus) |
| **Vaccines developed** | | | |
| CIFA-BroodVac | CIFA (2022) | Bacterial | Multiple bacterial infections in brooders |
| CIFA ArguVAX-I | CIFA (2025) | Parasitic | Argulosis (*Argulus*) |
| **Vaccines under research and development (some recent examples)** | | | |
| Tilapia Lake Virus (TiLV) vaccine | CIFA[73] | Viral, Formalin inactivated, ultrapellet vaccine | Tilapia Lake virus |
| Oral nanoparticle vaccine | Kerala University of Fisheries and Ocean Studies (2025)[74] | Bacterial | Motile Aeromonas Septicemia in Nile tilapia (*A hydrophila*) |
| Bivalent vaccine | Cochin University of Science and Technology (2025)[75] | Bacterial | Mixed bacterial infections (*A jandaei* and *E tarda)* |
| PLGA nanoparticle oral vaccine | Manipal Academy of Higher Education (2024) [76] | Bacterial, recombinant | Motile Aeromonas Septicemia in rohu (*A hydrophila*) |



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## Regulatory frameworks

The Central Drugs Standard Control Organisation (CDSCO) is expected to approve and regulate fish vaccines. A national regulatory framework for approving fish vaccines is said to be under development. A committee comprising scientists from CIFE and CIFA and other experts has been constituted. This committee is engaging with the CDSCO to establish guidelines and a regulatory framework for fish vaccine approval.

## Technical bottlenecks and adoption barriers

- **Fish vaccine development is complex and time-consuming:** Diversity of fish species, complex immune systems, multiple and mutating pathogens and emerging diseases make fish vaccine development difficult. Field validation is also tough because of varying farm conditions, pathogen load and water quality across regions.
- **Vaccine approval framework yet to be formalised:** Lack of a dedicated regulatory framework, assessment and standards, and an approval pathway for fish vaccines can impact and slow down the processes that lead to commercialisation of vaccines in the near future.
- **Operational and behavioural barriers expected to delay vaccine adoption:** The injectable vaccine delivery is labour-intensive, stressful for fish and will favour high-value species, whereas immersion and oral vaccines will require higher doses, boosters and careful monitoring. Broodstock vaccination alone may not provide sustained protection, requiring additional vaccination at later stages. Farmer uptake will face inertia from low immunisation awareness, easy availability of antibiotics, and lack of training. Farmers may not be willing to invest in vaccines for low-value freshwater fishes like IMCs, unless they are convinced, see benefits and find vaccines as an affordable solution.

### FISH VACCINES NOT IMPORTED

Globally, fish vaccines are available and used in countries like Brazil, Canada, Chile, Denmark, Greece, Indonesia, Italy, Mexico, Norway, Spain, the UK and the US.[77-79] These vaccines are injectable, dip or emulsion types, and target specific pathogens (bacteria or virus) in different fish species (such as salmon, tilapia, seabass, *pangasius*, trouts and catfish).

India does not import commercial fish vaccines. The focus is more on domestic development of indigenous vaccines. Experts suggest that importing foreign vaccines would involve strict quarantine regulations, potential pathogen strain mismatch, and higher costs (for instance, due to import duty). If allowed, imported vaccines will need to undergo validation and field trials in Indian farming conditions and on Indian fish species, against locally relevant fish pathogens. Their adoption will be impacted by cost, quality, and ease of administration.



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# 12. Case Studies

## Sustainable Freshwater Aquaculture Practices

## CASE STUDY 1

### Integrated circular model, Bahbari Farms, Sonitpur, Assam

Established in November 2023, Bahbari Farms operates a three-acre climate-resilient, integrated circular model. Owned by Arnab Pratim Dutta, the farm utilises a dual-pond layout consisting of one big pond (0.75 acre) dedicated to IMCs, and a small pond for catfish and water hyacinth production. The fish ponds serve as a key resource hub and are integrated with poultry and forestry units to recycle nutrients and reduce external inputs. Poultry litter is used to enrich fish ponds, improving natural productivity and supporting fish growth, while biomass from water hyacinth is harvested and reused as poultry feed supplement and organic mulch. Nutrient-rich pond water is also used for irrigating the food forest, enhancing soil fertility and maintaining moisture during dry periods.

To reduce dependence on commercial feeds, Bahbari Farms utilises locally available feed resources such as duckweed (20-40 per cent protein), moringa (>24 per cent protein), and sweet potato leaves (>20 per cent protein) as supplementary fish feed ingredients. The integrated approach demonstrates a low-input, resource-efficient model that reduces operational expenditure, optimises nutrient reuse and builds climate resilience (*see Figure 3: Layout of Bahbari Farms*).

**Figure 3: Layout of Bahbari Farms**






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# CASE STUDY 2

## Water testing and alternative use to prevent mortality in pangasius farm, Ghaziabad, Uttar Pradesh

Narendar Kumar manages four hectare (ha) of leased ponds (7-8 units) in Ghaziabad, stocking about 80,000 *pangasius* fingerlings (about 10 g). During the 2024 monsoon, fluctuating water quality, open-pond exposure and raw poultry waste usage triggered severe disease outbreaks in the fish, causing heavy mortality. In the following production cycle, Kumar adopted preventive health management practices by routine monitoring of pH, dissolved oxygen, ammonia and water color, backed by regular water exchanges, application of zeolite (25 kg per ha, biweekly) for ammonia control and potassium permanganate twice monthly for pond sanitation. Poultry waste-based feed was replaced with commercial feed fortified with probiotics, vitamin C, Agrimin (minerals and amino acids), Brotone (liver tonic), and Microsol (immunostimulants).

The mortality dropped below two per cent and about 80 tonne of *pangasius* (1.25-1.5 kg average weight) were harvested within six months (about 78,000 fish), yielding an estimated annual net profit of Rs 30-33 lakh.



*Narendar Kumar's pond rearing pangasius*




*pH and ammonia testing kit used in farm*




*Mineral and amino acid supplement used in farm*

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## CASE STUDY 3

### Revival of phytoplankton through fermented organic inputs in an IMC pond, Puri, Odisha

Alekh Babu, a retired engineer, cultures IMCs across two ponds in Puri district. In 2024, fluctuation in water quality and nutrient imbalance led to a major phytoplankton crash which turned one pond reddish-brown, disrupting natural primary productivity, compromising dissolved oxygen levels, and elevating fish stress leading to poor growth and disease.

Babu restored pond health by using a fermented organic formulation containing 200 kg cow dung, 25 kg mustard oil cake, 15 kg rice bran, 750 g yeast, 500 ml water and soil probiotics, two kg salt, 500 g lime, 400 g NPK, and 100 g sodium bicarbonate, fermented for 72 hours. The mixture was applied during daytime every 15 days based on pond conditions; plankton levels were monitored through water transparency checks.

Babu was able to fully restore the light-green phytoplankton bloom, stabilise the dissolved oxygen, and prevent secondary pathogen outbreaks. With an 18,000-fingerling stocking density, he made a profit margin exceeding 60 per cent.



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*Alekh Babu's adjacent ponds. The reddish brown on left shows phytoplankton crash (under treatment) while the one on right shows normal pond situation*



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# CASE STUDY 4

## Management of water quality parameters in a tilapia pond, Modinagar, Uttar Pradesh

Rajnish Kumar, an entrepreneur and fish farmer, cultured monosex Nile tilapia in a 1.25-acre earthen pond in Modinagar, Uttar Pradesh. Fry (0.25 g) were nursery-reared for about 50 days until they reached nearly 50 g before being stocked at 7,000-8,000 fingerlings per acre. During the initial production cycles, he observed fish stress, reduced feeding, and occasional night-time mortality, particularly during the summer. He addressed this by maintaining dissolved oxygen >5 mg/L via strategic aeration and pH (7.0-8.0), stabilising temperatures (26-30°C), partial water exchanges to balance ammonia levels, and regulating feed inputs. Survival reached 82 per cent, with fish growing to 750-850 g in 185-190 days, with total yield of six tonne.



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*Freshwater top-up carried out in Rajnish Kumar's pond to maintain water quality*



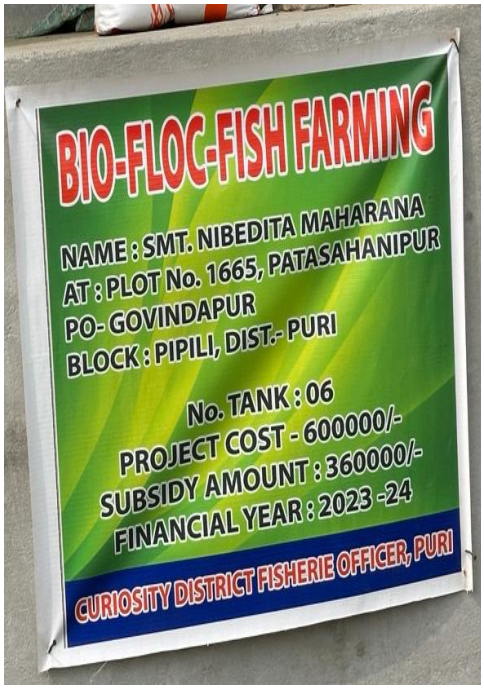
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## CASE STUDY 5

### Redesigning bio-floc systems to improve productivity in pangasius, Puri, Odisha

Nibedita Maharana, a fish farmer from Patasahanipur in Puri, developed an innovative bio-floc system by merging six 15,000-litre circular tanks into a single rectangular, pond-like unit. Conventional circular tanks provided limited swimming space for *pangasius* and IMCs, restricting their growth and increasing overcrowding, injuries and disease risks. With limited land, constructing grow-out ponds was not feasible.

Her modified 90,000-litre system provided greater space for fish movement and growth. She stocked around 9,000 *pangasius* seed (about 10 g each). Despite about 15 per cent mortality, she harvested 6,500 kg of fish weighing 800-1,000 g within six-seven months. Using commercial grow-out feed costing Rs 55-60/kg, she sold fish at Rs 80-100/kg, earning about Rs 7 lakh. Production costs were Rs 3.0-3.2 lakh, generating a net return of Rs 2.5-3.0 lakh per crop. The innovation demonstrates how farmer-led redesign of bio-floc systems can improve productivity where land is limited.




*State government-supported BFT facility of Nibedita Maharana, Odisha*



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*Operational modified rectangular BFT system rearing pangasius*



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# CASE STUDY 6

## Effective RAS operations for intensive culture of high-value fish, Nilokheri, Haryana

Neeraj Chaudhary, a fish farmer from Karnal in Haryana, is co-partner at the Sultan Fish Seed Farm, which operates hatchery, nursery, pond farming and re-circulating aquaculture systems (RAS). In 2024, the farm successfully cultured *singhi* (stinging catfish), a high-value freshwater species selling for over Rs 500/kg and reaching market size in six-eight months. About 3,200 fingerlings were stocked in an 18-foot-diameter RAS tank, achieving over 90 per cent survival and nearly three tonne of production.

The system uses mechanical and biological filters to remove solids and convert toxic ammonia into nitrate, while aerators and micro-bubble diffusers maintain oxygen levels. The farm regularly monitors dissolved oxygen (>5 mg/L), pH (7.0-8.0), ammonia and temperature. Filter sludge is reused as organic manure. Despite an initial investment of Rs 40-50 lakh, Chaudhary reported higher productivity, better biosecurity and survival, and substantial water savings, making RAS suitable for intensive culture of high-value fish.



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*Operational RAS unit rearing Singhi, Sultan Fish Farm, Haryana*



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# 13. Recommendations

## Mainstreaming 'prevention-led pathway' to sustainable freshwater aquaculture in India

India's freshwater aquaculture sector is a massive driver of production and livelihoods within the broader fisheries industry. Over the past decade, it has received considerable attention from the Central government. The creation of a dedicated department of fisheries and the launch of the heavily budgeted Pradhan Mantri Matsya Sampada Yojana (PMMSY) aim to unlock the untapped potential of both inland and marine fisheries. Coupled with state-level initiatives, the sector is becoming more organised and regulated amid rapid transformation.

This growth must remain sustainable — securing small-holder livelihoods, ensuring consumer health, and protecting the environment. Crucially, this expansion must avoid reliance on chemical-dependent practices, high production costs and ecological degradation.

A critical pathway to this sustainability is preventing on-farm disease outbreaks to reduce mortality and boost productivity, resilience and incomes. This preventive approach limits chemical entry into the food chain, curbing ecotoxicity and water pollution. Most importantly, it stops fish farms from becoming hubs for antimicrobial resistance (AMR), preserving the efficacy of antibiotics for fish, animals and humans alike.

Our research into current practices, policies, gaps and challenges underscores the need for targeted, concerted action. In this chapter, we outline overarching recommendations to address systemic gaps, alongside specific interventions for each of the eight pre-identified preventive pillars. Rooted in a 'prevention-led pathway' to sustainability, these actionable recommendations are designed to guide Central and state fisheries departments, as well as India's scientific and academic institutions.

## Overarching recommendations

### Expedite India's National Fisheries Policy

The Department of Fisheries, Government of India must finalise the 'National Fisheries Policy', drafted in 2020 but yet to be officially adopted. As national programmes align with the 2047 Viksit Bharat vision, the fisheries sector requires a well-articulated, updated policy framework for sustainable, long-term growth. Because this policy is expected to integrate the 2019 draft 'National Inland Fisheries and Aquaculture Policy,' it must maintain a strong focus on freshwater aquaculture.



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## Constitute a Freshwater Aquaculture Authority

India's seafood export success over the last two decades is largely credited to the Coastal Aquaculture Authority (CAA). Given that freshwater aquaculture is significantly larger in terms of production volume, livelihoods and domestic nutrition needs, the Department of Fisheries should establish a parallel 'Freshwater Aquaculture Authority'. This body would oversee, guide and regulate the sector, bridging jurisdictional gaps between Central and state departments and assisting in implementing the National Fisheries Policy. The Andhra Pradesh State Aquaculture Development Authority (APSADA) serves as a strong state-level model for this regulatory mechanism.

## Empower state fisheries departments to lead action

Because inland fisheries fall under state jurisdiction, state fisheries departments are best positioned to design and implement locally appropriate interventions supported by Central resources and should take the lead in making aquaculture grow sustainably. Proactive state legislation, such as Kerala's Fish Seed Act, 2014; Assam's Fish Seed Act, 2005; and Andhra Pradesh's Fish Feed (Quality Control) Act, 2020 and Seed (Quality Control) Act, 2006 demonstrate how states can drive progress independently.

The Department of Fisheries at the Centre can facilitate the replication of such successful models in other states. Crucially, the top 10 Indian Major Carp (IMC) producing states — Andhra Pradesh, Uttar Pradesh, West Bengal, Chhattisgarh, Odisha, Bihar, Madhya Pradesh, Jharkhand, Assam and Telangana — must actively mainstream this 'prevention-led pathway'.

## Enable extension cadre on 'prevention-led pathway'

The success of interventions to mainstream preventive approaches among a large part of fish farmers will depend upon the fisheries extension professionals. They are the critical link between the decision makers and practitioners. States fisheries departments must invest actively in up-skilling them on the preventive packages highlighted in this report.

### COASTAL AQUACULTURE AUTHORITY (CAA)

CAA was established as per the Coastal Aquaculture Authority Act, 2005 to regulate coastal aquaculture and minimise its environmental impacts. As part of its mandate, the CAA ensures registration of coastal aquaculture farms and hatcheries, seed, and aquaculture inputs including antimicrobials and pharmacologically active substances; guides on biosecurity and disease management; and regulates farm effluent discharge based on environmental standards. In early 2000, it had prohibited the use of 20 antimicrobials and pharmacologically active substances in shrimp aquaculture. In June 2026, the updated list includes 75 antimicrobials and pharmacologically active substances. It also monitors antibiotic residues in farmed seafood.



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### ANDHRA PRADESH STATE AQUACULTURE DEVELOPMENT AUTHORITY (APSADA) ACT, 2020

This Act, published on August 5, 2020, establishes APSADA, tasked with regulating and promoting the state's aquaculture sector including aquaculture business operations, licensing requirements, standardisation of quality for inputs like seed and feed.[80] The Authority is to be chaired by the Chief Minister of the state and its Chief Executive Officer would be known as the aquaculture controller, under this Act. The Act also empowers the Authority to attract investments, promote advanced technologies, and enforce compliance. It calls for establishment of a governance framework featuring technical and district-level committees.

## Specific recommendations

Detailed recommendations reflecting the 'prevention-led pathway' across pre-identified **eight preventive pillars** are presented below.

### Pillar 1: Managing and monitoring water quality

- **'Pond Health Card' scheme and decentralised diagnostics:** Institutionalise routine farm-level water quality monitoring through a 'Pond Health Card' scheme. This initiative should be anchored by a coordinated network of functional, decentralised testing facilities — established at the district level at a minimum — equipped with necessary apparatus, technical capacity, and standard operating procedures. Over the medium term, the 'Pond Health Card' scheme should deliver results of key water quality parameters directly to fish farmers while building a national database to track pond water quality trends.
- **Minilabs and on-farm testing kits for rapid diagnostics:** Expedite commercial use and scale up adoption of CIFA's AquaQuant-portable minilab, which offer quantitative results along with recommendations. Encourage research and development of similar mini-lab tools. In addition, strip/drop based kits for rapid qualitative diagnostics should be validated and made cost-effective for wider adoption but with adequate reliability.
- **Scale and safeguard RAS and BFT adoption:** Support the effective implementation of Recirculating Aquaculture Systems (RAS) and Biofloc Technology (BFT) by ensuring public subsidies reach well-deserved beneficiaries through minimum eligibility criteria, alongside mandatory pre-installation technical training. In parallel, implement key operational safeguards by:
  - Developing a dedicated pool of technical experts to assist farmers with post-installation operational concerns
  - Enabling formal certification and training programmes for tank designers, installers, and service providers
  - Expanding demonstration and prototype farms to showcase best management practices. Promote and scale up adoption of backyard RAS units in states other than Uttar Pradesh (wherein about 90 per cent of backyard RAS units established under PMMSY are located)
- **Prevention-focused water management guidance:** Develop and popularise prevention-focused national guidance on water quality management. This guidance should emphasise cost-effective, preventive solutions tailored to the culture of different freshwater species, with a clear focus on minimising reliance on antibiotics and other antimicrobials.



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## Pillar 2: Biosecurity barrier

- **National SOPs and state codification:** Develop, formalise, and implement a biosecurity framework at both national and state levels. This includes national-level guidance or Standard Operating Procedures (SOPs), based on which states—in accordance with their local scenarios—should codify key biosecurity principles and practices that are farmer-friendly.
- **Extension training and cost-benefit demonstrations:** States should support adoption through targeted training of fisheries extension officials and fish farmers. This should include on-farm demonstrations showcasing the positive cost-benefit aspects of biosecurity to small-holder farmers, who are typically averse to proactive biosecurity investments.
- **Financial subsidies and performance incentives:** States should consider integrating a set of financial subsidies (such as through the Pradhan Mantri Matsya Sampada Yojana — PMMSY) for farmers who plan to invest in biosecurity solutions, alongside performance incentives for those who effectively adopt them.
- **Compliance audits and biosecurity scorecard:** State codes should include provisions for routine inspections, audits to check for compliance based on a biosecurity scorecard, developed by the state. In the medium term, if needed, states may consider enforcing at least a basic, non-negotiable set of biosecurity practices across farms.

## Pillar 3: Disease management

- **Decentralised diagnostic support:** Strengthen disease diagnostic support for farmers by ensuring cost-effective and time-sensitive access through decentralised aquatic animal health laboratories, mobile testing units, and local expert opinion. Leveraging these facilities, farmers will be able to initiate targeted, diagnosis-based treatments.
- **Point-of-care diagnostic R&D:** Establish a robust research and development ecosystem for additional point-of-care diagnostics and their commercialisation. These portable, hand-held kits should reliably detect major high-mortality preventable diseases, while remaining cost-effective and easy to use by individual farmers or producer groups. In parallel, promote, incentivise and scale up use of existing and reliable point of care diagnostics such as developed by CIFA.
- **Standardised treatment guidelines with respect to antibiotics:** Formulate and popularise standardised treatment guidelines for infectious diseases across different freshwater fish species. Extension officials, health experts, and farmers should be trained on these guidelines, emphasising minimal antibiotic use and misuse, while adhering strictly to current regulations on permitted and prohibited antimicrobials and other pharmacological agents. For example, antimicrobials prohibited for use in food-animals, including aquaculture by CDSCO, FSSAI and Ministry of Commerce and Industry, through separate notifications/orders during 2024-25.



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- **Statutory National Fisheries Council:** Establish the National Fisheries Council as a statutory body to ensure that the drugs used in aquaculture are prescribed exclusively by experts and fish doctors. Modelled on the Veterinary Council of India, this council should formally recognise qualified fisheries graduates as licensed aquatic health professionals (fish doctors) authorised to prescribe treatments.

## Pillar 4: Access to quality fish seeds

- **Hatchery accreditation and seed certification:** Expand hatchery accreditation and seed certification across states such as through subsidies and incentives and ensure adoption and compliance with the national-level 'Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes'. States should also focus on building capacity, optimising interstate logistics, reducing production costs, improving affordability, and conducting compliance audits for private hatcheries.
- **Improved broodstock management:** Strengthen broodstock management by establishing guidelines and promoting good rearing practices, such as hygienic egg handling, water quality management, robust biosecurity, and preventive healthcare. Key interventions include certifying broodstock farms, preventing inbreeding depression, and forming public-private partnerships to ensure a reliable supply of high-quality broodstock at the state level.
- **Regulatory monitoring of seed quality:** State governments must actively curb the production and propagation of low-quality seed through routine inspections and audits. They should encourage use of certified Specific Pathogen Free (SPF) or Specific Pathogen Resistant (SPR) seed, seed quarantine, and disinfection protocols.
- **Decentralised seed production hubs and digital traceability:** To reduce over-dependence on a few concentrated regions and improve seed quality, logistics, and cost-efficiency:
  - Establish decentralised seed production hubs—including hatcheries, nurseries, broodbanks, and community seed banks—by leveraging Fish Farmer Producer Organisations (FFPOs)
  - Strengthen extension services by training fisheries officers in broodstock management, hatchery operations, seed selection, and disease prevention
  - Enable seed traceability such as guided by 'National Framework on Traceability in Fisheries and Aquaculture (2025)' and using National Fisheries Digital Platform (NFDP).

## Pillar 5: Selective breeding for improved varieties

- **Scale-up adoption of existing varieties:** Promote adoption of proven, disease-resilient freshwater breeds—such as AhR Jayanti Rohu and Amrit Catla—supported by the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and other central or state initiatives. This can be achieved by increasing the availability, accessibility, and cost-effectiveness of quality seed, conducting on-farm demonstrations, and improving farmer profitability and return on investment through better market access and pricing.



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### ANTIMICROBIALS PROHIBITED RECENTLY FOR USE IN FOOD-ANIMALS/AQUACULTURE

**In September 2025, Ministry of Health and Family Welfare (MoHFW)** prohibited the import, manufacture, sale and distribution of the following antimicrobials and group of such antimicrobials and their formulations for animal use (implying freshwater aquaculture)[81]

- Ureidopenicillins, ceftobiprole, ceftaroline, siderophore cephalosporins, carbapenems, penems, monobactams, glycopeptides, lipopeptides, oxazolidinones, fidaxomicin, plazomicin, glycylcyclines, eravacycline, omadacycline
- Carboxypenicillins and phosphonic acid derivatives were also banned in September 2026

**In May 2025, Ministry of Commerce and Industry** prohibited use of the following in culture of, or in any hatchery/feed manufacturing/preprocessing or processing units of shrimps, prawns or any other variety of fish and fishery products[82]

- Carboxypenicillins, ureidopenicillins, ceftobiprole, ceftaroline, combinations of cephalosporins with beta-lactamase inhibitor, siderophore cephalosporins, carbapenems, penems, monobactams, phosphonic acid derivatives, glycopeptides, lipopeptides, oxazolidinones, fidaxomicin, plazomicin, glycylcyclines, eravacycline, omadacycline

**In October 2024, Food Safety and Standards Authority of India** prohibited use of the following at any stage of production of meat and meat products, milk and milk products, poultry and eggs, aquaculture and its products[83]

- Glycopeptides, nitrofurans, nitroimidazoles, carbadox, chloramphenicol, colistin, streptomycin (and its metabolite dihydrostreptomycin), and sulphamethoxazole.

- **Continued R&D for emerging disease resilience:** Maintain a strong focus on developing new disease-resilient varieties. In response to existing disease burdens and emerging aquatic pathogens, ongoing and future selective breeding programmes should continue to prioritise disease resilience and environmental stress tolerance alongside growth and productivity.

## Pillar 6: Access to quality and affordable feed

- **Regulatory framework and quality control:** Strengthen the regulatory and quality control framework for freshwater fish feed by:
  - Making Bureau of Indian Standards (BIS) specifications mandatory for all feed manufacturing mills nationwide, enforcing strict compliance regarding full ingredient disclosure, mandatory safety and quality labelling—including a statutory declaration regarding antibiotics—and digital batch traceability
  - Encouraging state governments, in line with state-level regulatory models (such as Andhra Pradesh), to enact dedicated Fish Feed Acts. Provisions should include registering freshwater aquaculture inputs (including feed), certifying and auditing feed mills, and establishing a network of local laboratories for routine testing of feed safety, quality, and antibiotic presence.

- **R&D for affordable feed alternatives:** Promote a robust research and development ecosystem for nutrition-science based and cost-effective feed alternatives:



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- Scientific fisheries institutions should develop and lead the ecosystem to identify, test, validate, commercialise, and scale the adoption of new alternative protein/nutrition sources. In parallel, alternatives developed already such as Black Soldier Fly (BSF) meal and seaweed-based ingredients, should be appropriately validated and considered for wider adoption accordingly.
- Central and state governments should promote locally available, region-specific ingredients to improve feed affordability, while encouraging Fish Farmer Producer Organisations (FFPOs), cooperatives to collectively procure feed or establish commercially viable feed-milling units.

- **Precision feeding and digital technology:** Accelerate the adoption of modern technology to optimise feed application:
  - Provide subsidies and financial incentives for digital and mobile-based decision-support tools, automated feeding systems, and smart feeding advisories tailored to local pond conditions to improve Feed Conversion Ratios (FCR), boost productivity, and reduce environmental stress and pollution.
  - Identify, explore, and leverage Artificial Intelligence (AI)-based tools for automated feeding schedules, real-time water quality monitoring, early disease detection, and precision aquaculture management.

## Pillar 7: Preventive and therapeutic alternatives

- **Evidence generation and scientific consolidation:** The Department of fisheries and ICAR should lead the development of an R&D ecosystem tailored to the maturity of various alternative product categories—such as foundational research on emerging bacteriophages and extensive field validation for probiotics and botanical/herbal products. Central and state governments should encourage scientific documentation by private firms and research institutes, consolidating national data across species, farming settings, and product types into an online database showcasing verified safety and efficacy.
- **Regulatory framework and input registration:** Central policymakers should establish a comprehensive regulatory framework for non-antibiotic alternatives by:
  - Mandating the registration of all alternative therapeutic and preventive inputs (such as probiotics, prebiotics, immunostimulants, herbal preparations, and bacteriophages) on an open-access online dashboard displaying ingredient lists, indications, and manufacturer details
  - Creating a statutory framework to regulate the manufacturing, import, distribution, and marketing of alternative products to standardise quality, curb sub-standard or spurious products, and prevent misleading vendor claims
  - Making ICAR fisheries institutes responsible for developing practice guidelines, alongside post-market surveillance mechanisms to monitor ongoing field safety and efficacy.



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- **Financial incentives and scheme integration:** Integrate scientifically validated alternatives as core components of national preventive fish health management programmes. Support small-scale and marginal farmers by combining financial incentives, subsidies, registration assistance, and market access with strengthened extension services, farm demonstrations, and practical advisories to build farmer confidence**.**
- **Extension training:** Enhance technical capacity among fisheries extension officers so they can actively raise awareness regarding the economic and health benefits of preventive alternatives.

## Pillar 8: Building immunity through vaccination

- **Vaccine R&D ecosystem and pathogen database:** Strengthen fish vaccine research and development by prioritising foundational fish immunology and public-private partnerships. Focus on location- and species-specific multivalent vaccines targeting high-burden bacterial pathogens, while advancing modern approaches such as reverse vaccinology, oral, autogenous, and edible vaccines. Support this ecosystem by establishing a national database of aquaculture pathogens, updating academic curricula, and building specialised infrastructure.
- **Streamlined regulatory pathway and safety guidelines:** The Central Drugs Standard Control Organisation (CDSCO), in close coordination with ICAR fisheries research institutes, should fast-track a clear and dedicated regulatory pathway for approving commercial fish vaccines. This framework should establish comprehensive guidelines covering preclinical safety, potency, efficacy testing, multi-location field trial protocols, and vaccine import procedures.
- **Cold-chain infrastructure and national programme integration:** Prepare infrastructure for the large-scale deployment of near-ready commercial vaccines by establishing robust cold-chain logistics, distribution networks, and extension support. Drive early, widespread farm-level adoption through strategic government procurement, targeted subsidies, and public awareness campaigns, while formally integrating routine vaccination schedules into national fish health programmes.



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# References


1. Ministry of Commerce and Industry, 2026, Press Release on 'India's Seafood Exports Reach Record High of US$ 8.46 Billion in FY 2025–26'. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2267484&reg=48&lang=2, accessed on 27 August, 2026

2. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Handbook of Fisheries Statistics 2025. Available at https://www.dof.gov.in/static/uploads/2026/05/cdd10917cd28363050a12b28ce83db45.pdf, Accessed on 27 August, 2026

3. Ministry of Fisheries, Animal Husbandry and Dairying, 2026, Press release on 'Fish production has increased to 197.75 lakh tonnes in FY 2024-25 from 95.79 lakh tonnes fish production in FY 2013-14 increasing a significant 106%'. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2213532&reg=3&lang=1, Accessed on 27 August, 2026.

4. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Handbook of Fisheries Statistics 2025. Available at https://www.dof.gov.in/static/uploads/2026/05/cdd10917cd28363050a12b28ce83db45.pdf, Accessed on 27 August, 2026.

5. P A Padiyar et al. 2024, Fish consumption in India: Patterns and trends. WorldFish. Available at https://digitalarchive.worldfishcenter.org/server/api/core/bitstreams/51f0efb4-d94b-433f-89de-aec4ebff53a3/content , Accessed on 27 August, 2026.

6. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Handbook of Fisheries Statistics 2025. Available at https://www.dof.gov.in/static/uploads/2026/05/cdd10917cd28363050a12b28ce83db45.pdf, Accessed on 27 August, 2026.

7. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Handbook of Fisheries Statistics 2025. Available at https://www.dof.gov.in/static/uploads/2026/05/cdd10917cd28363050a12b28ce83db45.pdf, Accessed on 27 August, 2026

8. Ministry of Fisheries, Animal Husbandry and Dairying, 2026, Press release on 'Emphasis on Swadeshi in Blue Revolution under Fisheries Department'. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2210861&reg=6&lang=1, Accessed on 27 August, 2026.

9. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Handbook of Fisheries Statistics 2025. Available at https://www.dof.gov.in/static/uploads/2026/05/cdd10917cd28363050a12b28ce83db45.pdf, Accessed on 27 August, 2026.




SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 62 17/11/26 10:55 AM

10. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying. 2026, Twenty Ninth Report of the Standing Committee on Agriculture, Animal Husbandry and Food Processing (2025-26): Demands for Grants (2026-27), 18th Lok Sabha. Available at https://sansad.in/getFile/app/lsscommittee/Agriculture%2C%20Animal%20Husbandry%20and%20Food%20Processing/18_Agriculture_Animal_Husbandry_and_Food_Processing_29.pdf?source=app, Accessed on 27 August, 2026.

11. Ministry of Fisheries, Animal Husbandry and Dairying, 2020, National Fisheries Policy, 2020 Sixth Draft for Consideration. Available at https://www.dof.gov.in/static/uploads/2025/08/18e962b4f2c30aacc51cea04c681cf92.pdf, as accessed on 26 August, 2026.

12. ICAR Indian Council of Agricultural Research, 2025, Hands-on training programme on "Water Quality Testing by using ICAR-CIFA AquaQuant-portable Minilab for Freshwater Aquaculture. Available at https://cifa.nic.in/cifa/wp-content/uploads/2025/12/Training_Report_Malda_SCSP.pdf, Accessed on 27 August, 2026.

13. P. Singh, 2024, Constraints and challenges of fish farmers with a recirculatory aquaculture system (RAS) in Haryana State, India. Environment Conservation Journal. Available at https://journal.environcj.in/index.php/ecj/article/view/2552, Accessed on 27 August, 2026.

14. Ministry of Fisheries, Animal Husbandry and Dairying, 2026, Press release on 'Union Minister Shri Rajiv Ranjan Singh to Inaugurate the Smart Green Aquaculture Farm and Research Institute and state-of-the-art Re-circulatory Aquaculture System (RAS) Facility in Telangana'. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2211212&reg=3&lang=1, Accessed on 27 August, 2026.

15. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2020, Guidelines for Responsible Farming of Tilapia in India. Available at https://www.dof.gov.in/static/uploads/2025/ 08/5b11d46b28883fbf74f4738caae739ab.pdf, Accessed on 27 August, 2026.

16. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes, 2025. Available at https://www.dof.gov.in/static/uploads/2025/09/117559da68d3a380ac278dc9ae1c0fd0.pdf, Accessed on 27 August, 2026.

17. Department of Fisheries, Government of Kerala, 2020, Standard Operating Procedures for Aquatic Animal Health Management. Available at https://www.adak.kerala.gov.in/images/publications/SOP%20AAH.pdf, Accessed on 27 August, 2026.

18. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Annual Report 2024-25. Available at https://www.dof.gov.in/static/uploads/2025/08/4686b6bf87e0a1844293531a7ad72c74.pdf, Accessed on 27 August, 2026.



SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 63 17/11/26 10:55 AM

19. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Notification, 2025, Bio-floc, Re-circulatory Aquaculture Systems and Nursery based Aqua Farming Systems Guidelines, 2025. Available at https://egazette.gov.in/WriteReadData/2025/265873.pdf, Accessed on 27 August, 2026.

20. Food and Agriculture Organization of the United Nations, 2007, Biosecurity principles and components Part 1. Available at https://www.fao.org/4/a1140e/a1140e01.pdf, Accessed on 27 August, 2026.

21. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2009, The Prevention And Control of Infectious and Contagious Diseases in Animals Act, 2009. Available at https://cdnbbsr.s3waas.gov.in/s3feecee9f1643651799ede2740927317a/uploads/2025/07/20250722787617752.pdf, Accessed on 27 August, 2026.

22. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2020, Guidelines for Responsible Farming of Tilapia in India. Available at https://www.dof.gov.in/static/uploads/2025/08/5b11d46b28883fbf74f4738caae739ab.pdf, Accessed on 27 August, 2026.

23. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Guidelines for Import of Pangasisus *(Pangasianodon hypothalamus)* Seed and Broodstock into India. Available at https://www.dof.gov.in/static/uploads/2025/09/aad8cfe9aea9ea14d7d72e227e11eb2d.pdf, Accessed on 27 August, 2026.

24. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Guidelines On Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes. Available at https://www.dof.gov.in/static/uploads/2025/09/117559da68d3a380ac278dc9ae1c0fd0.pdf, Accessed on 27 August, 2026.

25. K. Pani Prasad, 2026, Presentation on 'Biosecurity in Freshwater Fish Farms and Hatcheries', delivered at Centre for Science and Environment's Training cum workshop on scaling up preventive approaches in the Indian freshwater fisheries sector to reduce disease and minimise antibiotic use. Available at https://cdn.cseindia.org/attachments/0.61957500_1769054776_dr-kpani-prasad.pdf, Accessed on 27 August, 2026.

26. P. K. Patil et al, 2025, Unveiling the economic burden of diseases in aquatic animal food production in India. Frontiers in Sustainable Food Systems. 9:1480094. Available at https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2025.1480094/full, Accessed on 27 August, 2026.

27. P. Swain, 2026, Presentation on 'How to scale up preventive approaches to minimise antibiotic use', delivered at Centre for Science and Environment's Training cum workshop on scaling up preventive approaches in the Indian freshwater fisheries sector to reduce disease and minimise antibiotic use. Available at https://cdn.cseindia.org/attachments/0.57183900_1768972098_pswain.pdf, Accessed on 27 August, 2026.



SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 64 17/11/26 10:55 AM

28. G. Gnaneshwar et al, 2023, Navigating antimicrobial use in Indian freshwater aquaculture: Regulatory frameworks and sustainable alternatives. Journal of Indian Fisheries Association. 50 (1). Available at https://epubs.icar.org.in/index.php/JIFA/article/view/141730, Accessed on 27 August, 2026.

29. A. Khurana, R. Sinha and D. Bhati, 2021, 'Conserving the use of Critically Important Antimicrobials in Food-Producing Animals, Centre for Science and Environment. Available at https://www.cseindia.org/conserving-the-use-of-critically-important-antimicrobials-in-food-producing-animals-10945, Accessed on 27 August, 2026.

30. Food and Agriculture Organization of the United Nations and Indian Council of Agricultural Research. 2024, Surveillance data of the Indian Network for Fishery and Animal Antimicrobial Resistance (INFAAR) – An analytical report (2019– 2022). Available at https://openknowledge.fao.org/server/api/core/bitstreams/f95db088-7f44-48f8-bcd7-78b2691c5379/content, Accessed on 27 August, 2026.

31. TNAU Agritech Portal, Commercialized technologies of CIFA. Available at https://agritech.tnau.ac.in/fishery/fish_cif_tech.html, Accessed on 27 August, 2026.

32. Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Press Release on 'Control Aquatic Animal Diseases'. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2114949&reg=48&lang=2, Accessed on 27 August, 2026.

33. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2022, Letter of the Fisheries Secretary to Chief Secretary of Fisheries Department of all states and UTs. Available at https://cdn.downtoearth.org.in/library/0.03149700_1642582342_d.pdf, Accessed 27 August, 2026.

34. Project Management Unit, Directorate of Fisheries, Government of Bihar, Fish disease management guidelines. Available at https://www.dof.gov.in/static/uploads/2025/09/2153d5665e077926e29173eb83c0a5a1.pdf, Accessed 27 August, 2026.

35. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Madhya Pradesh state's guidelines for fish disease management. Available at https://www.dof.gov.in/static/uploads/2025/09/f9f4f4b8be3b3d9d1518ff17b08a4608.pdf, Accessed on 27 August, 2026.

36. National Centre for Disease Control, Ministry of Health and Family Welfare, 2025, National Action Plan on Antimicrobial Resistance (2025-2029). Available at https://ncdc.mohfw.gov.in/uploads/pdf/amr10.pdf, Accessed on 27 August, 2026.



SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 65 17/11/26 10:55 AM

37. Food and Agriculture Organization of the United Nations, 2007, FAO Fisheries Technical Paper 501: Assessment of freshwater fish seed resources for sustainable aquaculture. Available at https://openknowledge.fao.org/server/api/core/bitstreams/2ccb43a9-cd96-4510-b29c-1f79ed4356e9/content, Accessed on 27 August 2026.

38. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Guidelines On Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes. Available at https://www.dof.gov.in/static/uploads/2025/09/117559da68d3a380ac278dc9ae1c0fd0.pdf, Accessed on 27 August, 2026.

39. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Handbook of Fisheries Statistics 2025. Available at https://www.dof.gov.in/static/uploads/2026/05/cdd10917cd28363050a12b28ce83db45.pdf, as accessed on 27 August, 2026.

40. ibid

41. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes. Available at https://www.dof.gov.in/static/uploads/2025/09/117559da68d3a380ac278dc9ae1c0fd0.pdf, Accessed on 27 August, 2026.

42. Government of Kerala, 2015, The Kerala Fish Seed Act 2014. Available at https://fisheries.kerala.gov.in/sites/default/files/inline-files/Act%204of%202015_0.PDF, Accessed on 27 August 2026.

43. Fishery Department, Government of Assam, 2005, The Assam Fish Seed Act, 2005. Available at https://fisheries.assam.gov.in/sites/default/files/swf1/dms5_The%20Assam%20Fish%20Seed%20ACT%202005.pdf, Accessed on 27 August 2026.

44. Government of Andhra Pradesh, 2006, The Andhra Pradesh Aquaculture Seed (Quality Control) Act, 2006. Available at https://www.indiacode.nic.in/bitstream/123456789/16348/1/act_no_24_of_2006.pdf, Accessed on 27 August 2026.

45. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2020, Pradhan Mantri Matsya Sampada Yojana: Beneficiary Oriented Sub-components/Activities of Centrally Sponsored Scheme Component. Available at https://static.pib.gov.in/WriteReadData/userfiles/PMMSY%20BookEnglish.pdf, Accessed on 27 August 2026.

46. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Annual Report 2024-25. Available at https://www.dof.gov.in/static/uploads/2025/08/4686b6bf87e0a1844293531a7ad72c74.pdf, as accessed on 27 August, 2026.



SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 66 17/11/26 10:55 AM

47. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, 'Guidelines on Hatchery Accreditation and Seed Certification of Freshwater Finfishes and Shellfishes'. Available at https://www.dof.gov.in/static/uploads/2025/09/117559da68d3a380ac278dc9ae1c0fd0.pdf, as accessed on 27 August, 2026.

48. Indian Council of Agricultural Research, 2019, ICAR Technologies: Breeding and Seed Production of Finfishes and Shellfishes. Available at https://icar.org.in/sites/default/files/2022-06/Fish-Breeding-Book.pdf, Accessed on 27 August 2026.

49. Marine Products Export Development Authority (MPEDA), Ministry of Commerce & Industry, 2020, Certification Scheme for Sustainable Aquaculture in India "SHAPHARI". Available at https://mpeda.gov.in/wp-content/uploads/2024/09/GUIDELINES_FOR_SHAPHARI_CERTIFICATION_OF_FARMS.pdf, Accessed on 27 August 2026.

50. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Press release on 'India Unveils "National Framework on Traceability in Fisheries and Aquaculture 2025 as the Sector Marks a Major Leap on World Fisheries Day'. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2192602&reg=48&lang=2**,** Accessed on 27 August 2026.

51. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2026, Press release on 'Emphasis on Swadeshi in Blue Revolution under Fisheries Department'. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=2210861&reg=6&lang=1, Accessed on 27 August 2026.

52. Indian Council of Agricultural Research, Department of Agricultural Research and Education, 2023. Significant Achievements (2014–23): Aspiring for a Developed India in the Amrit Kaal. Available at https://eprints.cmfri.org.in/17259/1/DARE-ICAR%20Significant%20Achievements_2014-2023.pdf, Accessed on 27 August 2026.

53. ICAR-Central Institute of Fisheries Aquaculture. 2024. Annual Report 2024. Available at https://cifa.nic.in read/?b= aHR0cHM6Ly9jaWZhLm5pYy5pbi9jaWZhL3dwLWNvbnRlbnQvdXBsb2Fkcy8yMDIzLzA2L0FubnVhbFJlcG9ydF8yMDI0LnBkZg==, Accessed on 27 August 2026.

54. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Annual Report 2024-25. Available at https://www.dof.gov.in/static/uploads/2025/08/4686b6bf87e0a1844293531a7ad72c74.pdf, as accessed on 27 August, 2026.

55. Rajiv Gandhi Centre for Aquaculture, Ministry of Commerce and Industry, The GIFT Tilapia project. Available at https://rgca.co.in/p_tilap.php, Accessed on 27 August 2026.



SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 67 17/11/26 10:55 AM

56. S S Giri, 2024, Sustainable aquaculture practices in South Asia: a comparative analysis of feed formulation and utilization. Animal Frontiers, 14 (4): 6-16. Available at https://academic.oup.com/af/article/14/4/6/7749992, Accessed on 27 August 2026.

57. ICAR-Central Institute of Freshwater Aquaculture. National Feed Testing Laboratory. Available at https://cifa.nic.in/national-feed-testing-lab/, Accessed on 27 August 2026.

58. ICAR-Central Institute of Brackishwater Aquaculture, NABL Accreditation to ICAR-Central Institute of Brackishwater Aquaculture Feed laboratory. Available at https://ciba.res.in/?post_type=edmento_events&p=16478, Accessed on 27 August 2026.

59. TNB Analytical Private Limited, 2025, Animal Feed Testing. Available at https://tnbanalytical.com/animal-feed-testing/, Accessed on 27 August 2026.

60. METS Laboratories India. Available at https://metslab.in/services/, Accessed on 27 August 2026.

61. P Panikar et al., 2019, Black Soldier Fly (Hermetia illucens) pre-pupae meal as a fish meal replacement in diet for Amur carp (Cyprinus carpio). Journal of the Inland Fisheries Society of India. 50(2). Available at https://epubs.icar.org.in/index.php/JIFSI/article/view/91941, Accessed on 27 August 2026.

62. ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA). Fish Nutrition & Physiology. Available at https://cifa.nic.in/fish-nutrition-physiology/, Accessed on 27 August 2026.

63. Department of Fisheries, Government of Andhra Pradesh., 2020, Andhra Pradesh Fish Feed (Quality short title, extent Control) Act, 2020. Available at https://indiankanoon.org/doc/33635103/, Accessed on 27 August 2026.

64. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025, Annual Report 2024-25. Available at https://www.dof.gov.in/static/uploads/2025/08/4686b6bf87e0a1844293531a7ad72c74.pdf, as accessed on 27 August, 2026.

65. P K Namburu et. al., 2014, Impact of probiotics on shrimp culture practices: A case study'. Indian Journal of Fisheries. 61(4): 134-137. Available at https://epubs.icar.org.in/index.php/IJF/article/view/15551/19811, Accessed on 27 August 2026.

66. T C Joseph et al., 2020, Prophylactic health products use in Penaeus vannamei farming in Andhra Pradesh: Perception of shrimp farmers of north, central and south coastal regions. Indian Journal of Fisheries, 8(2): 143-147. Available at https://epubs.icar.org.in/index.php/IJF/article/view/88643/44503, Accessed on 27 August 2026.



SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 68 17/11/26 10:55 AM

67. P Choudhary et al., 2023, Effects of dietary Moringa oleifera leaf extract on growth performance, enzyme activity and non-specific immune parameters in rohu Labeo rohita (Hamilton, 1822). Indian Journal of Fisheries, 71 (4): 78-84. Available at https://epubs.icar.org.in/index.php/IJF/article/view/138381/58889, Accessed on 27 August 2026.

68. P Choudhary et al. 2021, Evaluation of the effect of mono or multi-microbe probiotics on growth, serum enzymes and non-specific immune parameters in rohu Labeo rohita (Hamilton, 1822) fingerlings. Indian Journal of Fisheries, 68(4): 82-92. Available at https://epubs.icar.org.in/index.php/IJF/article/view/92225/45988, Accessed on 27 August 2026.

69. L Priyadarsani et al., 2021, Effects of dietary supplementation of vitamin-E and commercial probiotics on the innate immunity of Labeo rohita against Aeromonas hydrophila infection. Fish and Shellfish Immunology Reports, 2: 100013. Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC9680084/pdf/main.pdf, Accessed on 27 August 2026.

70. N M Sankappa et al., 2024, Novel lytic bacteriophage AhFM11 as an effective therapy against hypervirulent Aeromonas hydrophila. Scientific Reports, 14:16882. Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC11266544/pdf/41598_2024_Article_67768.pdf, Accessed on 27 August 2026.

71. V Nagar et al., 2024, Characterization and genome analyses of the novel phages P2 and vB_AhydM-H1 targeting Aeromonas hydrophila. PHAGE: Therapy, Applications, and Research, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC11447392/, Accessed on 30 August 2026.

72. M S Nithin et al., 2021, Novel lytic bacteriophages (AhFM4 & AhFM5) as bio-control measures against multidrug resistant biofilm producing Aeromonas hydrophila (AhZ1K). Aquaculture, 544: 737106. Available at https://www.sciencedirect.com/science/article/abs/pii/S0044848621007699, Accessed on 30 August 2026.

73. ICAR-Central Institute of Fisheries Aquaculture. 2024 Annual Report 2024. Available at https://cifa.nic.inread/?b= aHR0cHM6Ly9jaWZhLm5pYy5pbi9jaWZhL3dwLWNvbnRlbnQvdXBsb2Fkcy8yMDIzLzA2L0FubnVhbFJlc G9ydF8yMDI0LnBkZg==, Accessed on 27 August 2026.

74. A Abhiram et al., 2025, Development of oral vaccine using calcium phosphate nanoparticles conjugated with outer membrane protein of Aeromonas hydrophila in Oreochromis niloticus (Tilapia). Vaccine, 62: 127508. Available at https://www.sciencedirect.com/science/article/abs/pii/S0264410X25008059?via%3Dihub, Accessed on 27 August 2026.



SUSTAINABLE FRESHWATER AQUACULTURE IN INDIA report.indd 69 17/11/26 10:55 AM

75. R Guha et al. 2026, Efficacy of a novel oral bivalent vaccine with fucoidan as adjuvant against Aeromonas hydrophila and Edwardsiella tarda infections in Nile tilapia aquaculture. Fish & Shellfish Immunology, 169: 111074. Available at https://www.sciencedirect.com/science/article/abs/pii/S1050464825009635?via%3Dihub, Accessed on 27 August 2026.

76. S. Dubey et al., 2016, Aeromonas hydrophila OmpW PLGA nanoparticle oral vaccine shows a dose-dependent protective immunity in rohu (Labeo rohita). Vaccines, 4(2): 21. Available at https://researcher.manipal.edu/en/publications/aeromonas-hydrophila-ompw-plga-nanoparticle-oral-vaccine-shows-a-/, Accessed on 27 August 2026.

77. MSD Animal Health. Aqua – Aquaculture Products. Available at https://www.msd-animal-health.com/products/aqua/, Accessed on 27 August 2026.

78. PHARMAQ, Available at https://pharmaq.com/en/pharmaq/, Accessed on 27 August 2026.

79. G S Rathor and B Swain, 2024, Advancements in Fish Vaccination: Current Innovations and Future Horizons in Aquaculture Health Management. Applied Sciences, 14 (13): 5672. Available at https://www.mdpi.com/2076-3417/14/13/5672, Accessed on 27 August 2026.

80. Government of Andhra Pradesh, Animal Husbandry, Dairy Development and Fisheries Department, 2020, Andhra Pradesh State Aquaculture Development Authority Act, 2020.

81. Department of Health and Family Welfare, Ministry of Health and Family Welfare, 2025, Gazette Notification on ban on antimicrobials. Available at cdsco.gov.in/opencms/opencms/system/modules/CDSCO.WEB/elements/download_file_division.jsp?num_id=MTM0MDk=, Accessed on 27 August, 2026.

82. Department of Commerce, Ministry of Commerce and Industry, 2025, Order of antibiotics prohibited. Available at https://www.legalitysimplified.com/wp-content/uploads/2025/05/Amendment-to-export-Fresh-Frozen-and-Processed-Fish-and-Fishery-Products.pdf, Accessed on 27 August, 2026.

83. Food Safety and Standards Authority of India, 2024, Gazette Notification on Food Safety and Standards (Contaminants, toxins and Residues) First Amendment Regulations, 2024. Available at https://fssai.gov.in/docs/food-law/notice-comment/67178d79690b3antibiotic%20gazette.pdf, Accessed on 10 September, 2026.



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India's freshwater aquaculture sector has a huge potential for growth and livelihoods. Over the last decade, the sector has received considerable attention from the Central government supported by several state initiatives towards a steep growth. While this growth must remain sustainable — securing small-holder livelihoods, ensuring consumer health, and protecting the environment — the sector remains vulnerable to diseases.

It is critical that prevention-based approaches are mainstreamed in the freshwater aquaculture sector. This report presents a 'prevention-led pathway' which includes challenges and possibilities across eight prevention pillars — water quality, biosecurity, disease management, quality seed, improved varieties, quality feed, alternatives and vaccination. The pathway offers sustainable benefits in addition to keeping the antibiotics effective for fish, animals and humans alike.

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