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AQUACULTURE ASIA

Sun-drying marine fish

Transforming catfish aquaculture

Integrating seaweeds

Ornamental loaches

Aquaculture Asia

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

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NACA

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

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Fossil fuels and the food chain

In 2007-2008 the world suffered a global energy shock, with the price of oil rising to US$147, nearly triple its January 2007 low. Food prices rose sharply, with the FAO Food Price Index rising more than 60%. Both poverty and food security were back on the agenda, particularly in food-importing low-income countries.

The reason, as we have now apparently "rediscovered" due to the war in the Strait of Hormuz, is that our agricultural systems have critical dependencies on fossil fuels. The headline that "20% of global oil" passes through the strait misses the fact that this portion is 34% of globally *exported* oil (that which is available for purchase), and that 84% of it is bound for *Asian markets*.

To quote John Anderson, a former Australian agriculture minister, "It's diesel that feeds you". Agricultural machinery and bulk transport all run on diesel. Without diesel farmers can't plant or harvest crops, nor get them to market. Nitrogen fertilisers (urea, ammonia) are also made from fossil fuels, mainly natural gas, of which much of the supply has also been disrupted by various conflicts.

It's not just fuel availability; the price also matters. Food prices tend to lag energy, so a farmer thinking about starting a new crop today has a difficult decision to make: fuel and fertiliser prices are skyrocketing, but the price of their produce hasn't (yet) followed. If they invest in the new crop and prices don't rise, they may well face ruin. Many farmers will decide that's a risk they can't afford to take.

This is also true of the fishing industry. As of April around 40% of the Thai fleet were tied up in dock, with industry sources warning it could reach 80%. Fuel prices hit 70% of vessel operating costs.

Aquaculture is by no means immune either. Feeds, the largest operating cost, are essentially based on both agricultural and fisheries output. Diesel-powered aerators are still common for intensive systems, although I expect a lot of farmers may reconsider that. And electricity costs are also generally rising due to both rising gas and shipping costs.

I have worked on several climate change projects over the years, and I think it is fair to say that such projects tend to focus on *reducing emissions* rather than on *reducing reliance* on fossil fuels in food production. To be honest, the net impact of the former seems to have been quite limited, and perhaps if we'd spent the last 25 years pursuing the latter we'd be in a much better position.

In aquaculture this is at least technically possible. We have in our hands today aquaculture technologies that enable food production with low emissions or in some cases even zero emissions.

They are not new technologies; they are the old ones: Extensive and semi-intensive farming systems based on natural productivity and local feed materials; low-trophic species that are energetically efficient; and ecological approaches to farming such as polyculture, stocking complementary species that occupy different niches and make full use of available feed resources. Yes, the yields are substantially lower, but so are the costs and the risks. Perhaps we should reconsider where such strategies can fit into our farming systems in the modern context.

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Sun-drying marine fish at Junput-Biramput, Purba Medinipur, West Bengal, India

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Sun-dried Bombay duck (right) and ribbonfish.

Sun-dried fish: A promising sector in Purba Medinipur

Purba Medinipur District leads West Bengal in almost all areas of fisheries and inland aquaculture. This includes grow-out aquaculture and production of Indian major carps, brackishwater shrimps, giant freshwater prawn, and marine capture fisheries. Culture-based capture fisheries in reservoirs, beel fishery, and sewage-fed aquaculture are not practised in this district. Canal fishery, aquarium fish farming, and air-breathing fish seed production are carried out by only a few farmers and are not well established. Air-breathing fish culture and the farming of some high-value finfishes are as developed here as in any other district.

Sun-dried marine fish production and trade is another important sector where Purba Medinipur leads West Bengal. Junput-Biramput village, in Contai-1 Community Development (CD) Block, is one of the main sun-dried marine fish ('Shutki machh') production centres in coastal West Bengal. These production sites are known locally as 'Matsya Khoti'. From here, dry fish is transported to markets in north Bengal, Odisha, Assam, Sikkim, Tripura, other north-eastern states, Nepal, Bhutan, and Bangladesh (including Cox's Bazar, Chottogram, Khulna, Barisal, Sylhet, and Chittagong districts). Fresh or frozen marine fish is not available in the cold hill areas of north Bengal and similar regions, so people there rely on sun-dried fish from Purba Medinipur. West Bengal's coast has 59 marine fish landing centres, and Matsya Khotis are located near these.

Fish drying is an age-old practice, adopted to preserve fish that cannot be immediately consumed or sold fresh[1]. In 1958, scientists from ICAR-CMFRI, Mandapam described three drying processes used in the fish curing industry: natural air drying, open sun drying, and mechanical solar drying[2]. Drying is the least expensive method of food preservation. It has great significance for coastal fishing communities, as dried fish sells well both in India and abroad[3]. Drying removes moisture first from the surface and then from the interior of the fish[8]. Sun drying requires minimal equipment, skills, and labour. It is accessible to small-scale processors along India's coastline, and transforms low-value fish into higher-value products[4]. Dried fish is generally kept to a moisture content of no more than 15-18%. Salting and drying under strong sunshine reduces water activity in fish muscle from 0.95-1.00 in fresh fish to 0.60-0.65[6]. Removing moisture from small- and medium-sized fish prevents bacterial and enzymatic decay and stops the growth of spoilage bacteria, salt-tolerant bacteria, fungi, and enzymes. In West Bengal's marine fishery, 78% of the catch is sold raw and fresh without ice, 16% in ice-preserved form, and 6% as sun-dried fish. Along the 158 km coastline of Purba Medinipur and South 24 Parganas, fish drying has grown from a traditional practice into a well-established, flourishing business.

About 200 dry fish producers work directly at Digha Mohona Matsya Khoti, with approximately 5,000 more people indirectly involved in related activities. Today's producers at this Khoti, aged around 30-32, are in their second or third generation in the trade. Dried fish is exported to Bangladesh and Japan from this Khoti. The people who depend on this trade come from coastal villages around Digha Mohona, including Maitrapur, Shankarpur, Purba Mukundapur, Dasondapur, Dahadia, and Alankarpur (Source: News 18 Bangla, 30/8/2025).

More than 50,000 marine and coastal fishermen in the Digha Mohona, Mandarmoni, and Junput regions are directly or indirectly involved in Shutki machh production and trade for their livelihoods. From Mandarmoni Matsya Khoti alone, 40-50 large vehicles loaded with dry fish supply markets across eastern India each year (Source: TV 9 Bangla, 8/3/2025). According to an elderly dry fish producer at Junput-Biramput, there are 32 Matsya Khotis

Spreading fishes to be dried on raised spilt-bamboo platform.

Bombay duck drying on bamboo scaffolds.

Leiognathus sp. dried in the sun.

along the Purba Medinipur coast; published literature cites a slightly higher figure of around 42[7]. At major Khotis, fish is also brought from Paradeep fishing harbour in Odisha for drying. Some 25% of dry fish from Purba Medinipur goes to markets in Siliguri, Darjeeling, and Jalpaiguri districts in north Bengal.

Well-known recipes and a brief history of dried fish in West Bengal

When catches from open marine waters exceed what can be sold fresh - particularly small, low-value fish - the surplus is dried and salted to prevent waste. Small and medium-sized dried marine fish are widely eaten by tribal and non-tribal communities across north Bengal, the Tarai and Dooars regions of Darjeeling, Sikkim, and the north-eastern states. Like recipes using aquatic molluscs, dry fish dishes are no longer just village food for the poor. Every well-known dried fish recipe was developed through the experiments of wise elderly women long ago, a culinary tradition passed down through the generations.

Shutki machh is cooked with seasonal vegetables such as tomato, brinjal, papaya, or squash, as either a dry spicy vegetable dish or a spicy curry. Another preparation combines the innermost core of banana stem with onion, green chilli, and coriander leaves. Dried fish can also simply be roasted with onion, garlic, and chilli, then mashed (The Indian Express, 23/12/2018). A popular thick curry is made from sun-dried Bombay duck with amaranth stems, sweet pumpkin, and jackfruit seeds. Noted Bengali food historian Smt. Pritha Sen notes that Shutki machh in its preserved form - sun-dried and fermented - has long been eaten by people from Sylhet and Chittagong in Bangladesh. Recipes using red chilli powder, garlic, and other spices produce distinctive flavours. Popular dishes include chutneys (made with dry fish, sugar, vinegar, and spices), pickles, and dry fish curries, all considered delicacies.

People in West Bengal did not traditionally eat dried fish. Following the Bangladesh Liberation War of 1971, refugees from East Bengal ('Purbo Bangal') settled in West Bengal, bringing their food habits with them. Their recipes for hot, oily, spicy, garlicky sun-dried Bombay duck were gradually adopted by the local population. Purbo Bangals are Bengalis from the region that is now Bangladesh. Most dry fish recipes use red chilli powder, black cumin seeds, onion, tomato, green chilli, turmeric, salt, and garlic. Many people find the strong smell of raw dried fish unpleasant, but the cooked dishes are considered delicious. Soaking the fish in warm water for 30 minutes before cooking removes the smell.

General activities at a Matsya Khoti

In the coastal community development blocks of the two coastal districts, hundreds of thousands of people living along the coast depend on fish from nearshore, estuarine, and open marine waters for their livelihoods. Sea-going fishermen operate motorised and mechanised trawlers, catching commercially important marine fish within India's Exclusive Economic Zone and delivering them fresh and chilled to landing centres and harbours. Small-scale coastal fishermen use motorised boats to catch pelagic fish in estuarine and

Fish spread out to dry on a cement slab.

O. tardoore drying under the sun.

nearshore waters. They supply much of the surplus low-value catch to Matsya Khotis in raw, fresh condition. At each Khoti, local people involved in the marine fish trade work together to prepare sun-dried fish hygienically on a commercial scale. A group of dry fish producers in one area forms a Matsya Khoti.

Dried fish production and trade involves many steps. Fishermen catch fish, separate the catch from the nets, and transport it to the Matsya Khoti in rectangular plastic crates. There, workers sort the fish by species and size, clean them in freshwater, and remove operculum bones where needed. Fish are then spread evenly on raised split-bamboo platforms in the drying yard and turned regularly to ensure even drying. In winter evenings, workers cover the fish with black polythene sheets to protect them from heavy dew. Where

required, fish are salted in cement tanks before or after drying. Finally, the dried fish is packed into sacks and moved to storage rooms at the producers' homes. The wealthier fish traders at each Khoti hire young men and elderly women from poor coastal households, both nearby and further away. Thousands of marginalised people, both men and women, gain employment and income through this work.

Matsya Khoti at Junput-Biramput

Commercial fish drying at Junput-Biramput Matsya Khoti began about 70-75 years ago. I spoke with several leading dry fish producers here between November 2025 and January 2026, as the Khoti is close to my current workplace and residence. Junput-Biramput village is 10 km from Contai town towards the Bay of Bengal. The Khoti lies 500m inland from the Junput coastline. Other Matsya Khotis in coastal Purba Medinipur are at Soula, Kadua, Petuaghat, Haripur, Junput, Boguran, Digha Mohona, Jaldha, Khorpai, Jalpai, Shankarpur, Dadanpatrabar, Mandarmoni, and Gopalpur - all coastal fishing villages. Dried fish production at Junput-Biramput is most active from late autumn through to spring. Today, 550-600 dry fish producers make up this Khoti, known locally as 'Sowdagori'. Local residents live in earthen huts, while non-residents stay in single-storey pucca houses. Some producers own their own trawlers or fishing boats and catch their own fish at sea[5]. According to published sources, the Khoti operates from the beginning of June to the end of February. Fish is brought here by trawlers from Digha, Digha Mohona, and Shankarpur fish landing centres[9].

Digha Mohona is the largest marine fish landing centre in eastern India. Between October and February, fish of all kinds - from shallow coastal and deeper waters, both commercially important and less so - are available in large quantities. Fishermen travel up to 22-60 km from shore. This abundance benefits dry fish producers at Junput-Biramput, who can buy the species they need in large quantities at fair prices. During this period - from the third week of September to mid-February - large quantities of good-quality sun-dried fish are produced, free from medicines and insecticides. Market prices are strong during this season, and producers earn good profits.

In the 1980s, commercial fish drying at this Khoti ran for only four months - October to February. Today, it runs for ten months, from June-July to mid-March, typically ending on Holi (Dol Purnima). Merchant agents wait at the Digha-Odisha border and the Petrapole-Bangladesh border to collect dry fish from both districts. They also buy at Balighai dry fish wholesale market.

General method of dried fish preparation at Junput-Biramput Matsya Khoti

After the West Bengal Fisheries Department's two-month ban on marine fishing, motorised fishing boats and larger motorised-mechanised trawlers leave from the Purba Medinipur coast from the third week of June. Fishing continues until the end of March the following year. In the early morning, most of the fish bought for drying is brought

Containers for salting and washing fish.

Lutjanus johnii being salted in a cement tank.

from Digha Mohona fish landing centre, 38 km away. Smaller amounts come from the nearby Haripur (2.5 km) and Junput landing centres, where local fishermen work in 0-5 km coastal waters using two-cylinder motorised boats known locally as 'Bhutbhuti'. Fishing boats arrive at Junput landing centre via a canal extending 300-350m inland from the sea, entering on the high tide. The unloaded fish - mostly small-sized and

small shrimps - are washed immediately in clean sea water and taken to the Khoti. In total, 85-90% of the raw fish comes from Digha Mohona and 10-15% from Junput.

In India, fish drying is mainly carried out by open sun drying[2]. A brief 15-20 minute salt treatment before drying is not needed in winter but is required at other times of the year to kill harmful microorganisms. The operculum bones ('Galsa' in local dialect) are removed from some species using a sharp knife:

- Before sun-drying, operculum bones are removed from *Gudusia chapra*, *Anadontostoma chakunda*, and the already-salted *Lutjanus johnii* and *Dendrophysa russelii*.
- Raw *L. johnii* and *D. russelii* are salt-treated in small cement chambers (250 kg fish to 50 kg salt) for 72 hours before operculum bones are removed and drying begins.
- *Pellona ditchela* and *Carangoides malabaricus* are salt-treated in the same way, but operculum bones are not removed.
- *G. chapra* and *A. chakunda* are sun-dried in both salted and unsalted forms, depending on market demand.

After salting *P. ditchela*, 6-8 deep lateral cuts are made with a knife before drying, as preferred by buyers in Meghalaya and Assam. After salting and before drying, fish are rinsed in freshwater. For saltwater treatment (32-40% salt solution), 8-10 kg of common salt is added to every 25 litres of freshwater. The fish (100 kg) are left to soak overnight, then washed in freshwater and dried. At this Khoti, none of the species are gutted - no incisions are made in the abdomen, and viscera and gills are not removed. Table 1 lists the species sun-dried at this Khoti.

Fish are spread on specially built split-bamboo platforms 1.2 m wide and dried in the open air under sunlight. Workers turn them periodically with a lightweight plastic dustpan or flat iron blade to ensure even drying. In winter, black polythene sheets are placed over the fish on each platform as soon as the sun sets. To preserve their natural colour, Bombay duck and ribbonfish are hung on bamboo scaffolds or horizontal wooden poles supported by vertical poles driven into the ground. Bombay duck is sometimes hung in pairs by inter-locking jaws, but at this Khoti, 14-15 fish are hung individually by inserting their lower jaws into a 1m split-bamboo stick called a 'Khanchi'. Ribbonfish are hung in bunches of 6-8 with heads pointing downward. Most small-sized fish are sun-dried for 3-5 continuous days, each species separately. *Harpodon nehereus*, *Lepturocanthus savala*, and *Trichiurus lepturus* require more time (Table 2). Body oil is released from *H. nehereus* during drying. Its high moisture content makes it prone to spoilage, so it is processed as quickly as possible. Currently, almost 90% of landed *H. nehereus* is dried[10].

Sun-dried fish are packed into jute sacks using a spade. These sacks cost INR 28 and INR 60, holding 32-35 kg and 65k g of dry fish respectively. A sack designed for 50 kg of rice holds 35 kg of dry fish. Sri Tapas Jana, Sri Sanjay Giri, Sri Joydeb Jana, and one other person are the four leading 'Aratdars' - local dry fish traders and wholesalers - who own the four large dry fish warehouses at this Khoti. They buy the dried product from producers, store it briefly, then sell and transport it to merchant agents in other states and north

Removing operculum bones.

Lutjanus johnii with operculum removed after salting.

Bengal. The Aratdars have become wealthy despite having little formal education. Large quantities of dry fish are held in their warehouses.

Dried fish transport from Junput-Biramput Matsya Khoti

Dry fish from the Shankarpur, Kadua, Petuaghat, Tamilporia, and Junput-Biramput Khotis is assembled here. 407 pick-up trucks carry up to 6 tonnes per trip over short distances of 30-200 km within and outside the district. Ten- to twelve-wheel vehicles carry 11-16 tonnes, and six-wheel trucks carry 6-8 tonnes directly to distant markets 650-900 km or more

away. Large trucks depart for Bangladesh and Tripura on Mondays and Tuesdays, and for north Bengal and Assam on Wednesdays, Thursdays, and Saturdays. During peak season, 8-12 large trucks leave the Khoti each week, in addition to smaller vehicles. Smaller Mahindra Bolero pick-up trucks carry 2-3 tonnes of dried fish packed in 45-70 kg sacks to Balighai wholesale dry fish market, 30-32 km away by road. Balighai is a major and well-known wholesale market in West Bengal. From loading to destination, road transport takes no more than 24 hours. North Bengal and the north-eastern states are also supplied from Balighai, where merchants from other states buy directly. Sun-dried *H. nehereus*, *Opisthopterus tardoore*, *T. lepturus*, *Trachipterus* sp., *Stolephorus* sp., and *Thryssa* sp. are mainly exported to Bangladesh.

On the wide sandy beaches at Junput and Haripur, I found large pieces of flat nylon netting (similar to mosquito netting) pegged to the ground at the corners. Low-value small marine shrimps are spread evenly on these nets and dried in the sun. Women manage this small-scale operation. The drying shrimps are turned regularly with a steel shovel, swept up after drying, graded by sieving through locally made rectangular galvanised iron strainers with specific mesh sizes, and packed.

Dry fish sacks are weighed before loading.

Truck loaded with dry fishes ready to leave Matsya Khoti.

Sun-dried L. johnii loaded on motor cycle van.

Earnings of women as casual workers at Junput-Biramput Matsya Khoti

Women are paid INR 25-30 to remove the operculum bones and gills from 600-750 fish of *G. chapra* and *A. chakunda*, a task completed in 20-25 minutes. For hanging 15-16 *H. nehereus* per Khanchi across 100 Khanchis, each woman earns INR 60; the task takes about an hour. Women are paid INR 20 to remove the operculum bones from every 15-20 kg of *L. johnii* and *D. russelii*. For hanging every ten groups of ribbonfish *T. lepturus* and *L. savala* (each group of six fish) on bamboo scaffolding after salt treatment, a woman is paid INR 0.40-0.60. For daily tasks - sorting fish by species and size at the landing centre, spreading fish on platforms, turning them for even drying, packing dried fish, and other work - women are paid INR 200 per day including an afternoon meal, or INR 250 without a meal. Women work daily at each production unit from 7am to 5pm.

Use of solar fish dryers

In February 2011, the Department of Fisheries, Government of West Bengal, provided six solar fish dryers to the Junput Mohila Sebika Matsya Samabaay Samity Limited, an active

Worker at a dry fish yard.

Table 1. Features of small- to medium-sized marine fish species sun-dried at Junput-Biramput Matsya Khoti.

Name of fish species	Local name	Raw bought @	Dry sold @	Fresh fish to produce 1 kg dry
Coilia reynaldi *C. ramkarati*	Olua	30 / kg	100-130 / kg	2.5 kg
Harpodon nehereus	Loite / bomla / babla	40-65 / kg (max 90-95 / kg)	300-400 / kg (max 450-500 / kg)	6 kg
Chrysochir aureus	Modhu bhola	50-60 / kg	140-150 / kg	2.0-2.5 kg
Glossogobius giuris *Sillaginopsis panijus*	Somudrer bele / balkura (mostly consumed fresh)	150 / kg	250-300 / kg	3.5 kg
Opisthopterus tardoore	Tel tapri / tapra / lalpata	120 / kg (max)	300-400 / kg (max)	2.5 kg
Coilia dussumieri	Amudi / Ruli	25-30 / kg	60-65 / kg (120 / kg (max)	3.2 kg
Trichiurus lepturus *Trachipterus sp*	Patiya / fitey / fita	40 / kg	140-160 / kg	3.5 kg
Sillago sihama	Shila	70-80 / kg	200 / kg	3-4 kg
Liza sp	Parse / khosla (dried in small quantity)	20-25 / kg	60-70 / kg	2.25 kg
Escualosa thoracata	Gang mourola	30 / kg	150 / kg	2.5-3.0 kg
Pellona ditchela	Choklet / pankha / pankhai	20-25 / kg (max 60 / kg)	50-60 / kg (max 140 / kg)	2 kg
Lutjanus johnii *Dendrophysa russelii* *(15-25 pieces / kg)*	Bhola ("entee" after operculum removed)	38-45 / kg	70-95 / kg	2.5 kg
Cynoglossus sp. *Paraplagusia bilineata*	Kalopata / banspata	30-35 / kg	120-130 / kg	4 kg
Leiognathus sp *Eubleekeria splendens*	Somudrer chanda / koyen	50 / kg	150-200 / kg	2.8 kg
Gudusia chapra *Anadontostoma chakunda*	Chira khoira	28-30 / kg	60-150 / kg	2.7 kg (unsalted) 2.2 kg (salted fish)
Carangoides malabaricus	Para	50-55 / kg	100-110 / kg	2 kg
Odontamblyopus rubicundus *Taeniodae sp* *Pseudapocryptes elongatus*	Lal cheknno / lal chewo	15-20 / kg	25-35 / kg	2.0-2.5 kg
Scatophagus argus	Bhaja chauli	60-150 / kg (limited suppy)	200 / kg	2.5-3.0 kg
Secutor sp	Gang chanda	30-50 / kg	120-140 / kg	2.5 kg
Setipinna sp, Raconda *russeliana, Ilisha filigera*	Phesa	60 / kg	150 / kg	3 kg
Metapenaeus monoceros *Metapenaeus affinis* *White Acetes indicus*	Somudrer kucho chingri / Kori / goghua	20 / kg	80-100 / kg	5 kg
Stolephorus sp	Keripata / chira thikri	60 / kg	120-150 / kg	2 kg
Lepturacanthus savala	Chhuri (small)	35-40 / kg	140 / kg	3.5 kg
	Chhuri (big)	60-80 / kg	200-275 / kg	
Pama pama	Poa bhola / tula bhola	60 / kg	160-180 / kg	3 kg
Corica soborna	Gura / chauli / kagja / Kechki	100 / kg	300 / kg	2.5 kg
Polynemus paradiseus	Topse	100 / kg (limited supply)	200-250 / kg	3.0-3.5 kg
Nemipterus japonicus	Chomchom	30 / kg	120 / kg	3 kg
Kurtus indicus	Bukdhuli	50-80 / kg	250-300 / kg (max 350 / kg)	3.0-3.2 kg
Thryssa sp	Modhu / chorki	25-30 / kg	70-80 / kg	2 kg
Sardinella sp	Chhoyna	28-30 / kg	70-75 / kg	2.5 kg
Dussumieria sp	Doth	32-35 / kg	85-90 / kg	2.3 kg

Table 2. Time required to produce four major sun-dried fishes from raw state at Junput-Biramput Matsya Khoti.

Name of fish species	Time for complete drying one batch of fish
Gudusia chapra, *Anadontostoma chakunda*	3-5 days
Lutjanus johnii and *Dendrophysa russelii* (15-20 pieces /1 kg)	3-5 days
Trichiurus lepturus and *Lepturacanthus savala*	5 days
T. lepturus and *L. savala* (both larger in size)	5 days
Harpodon nehereus	5-7 days

Sun-dried fishes sold in a retail shop.

women-led Primary Fishermen Cooperative Society based at Junput-Biramput. The Society produces sun-dried marine fish and value-added processed products from small marine shrimps. Each dryer has six plate-like fish drawers with a glass cover on top. In 80 m² of open space owned by the Society, a total of 36 kg of marine fish can be dried in each dryer within 24 hours of sunlight. The dryers have instruments to measure moisture content in the fish, and can also use electric heating when sunlight is insufficient. An exhaust fan in each dryer draws out moisture-laden air. When in use, both the glass cover and the internal plates heat up. Each dryer has three solar panels.

End note: the problem of insecticide use

The continental shelf along India's north-east coast, covering West Bengal and Odisha, is less steep than that of the south-west and north-west coasts, and the deep sea is further from shore. As a result, small- and medium-sized lean pelagic fish suitable for drying are more abundant along the north-east coast each year.

In winter, low humidity, dry weather, and cold north winds mean fish dry quickly in strong sunshine. A species that dries in two days in winter may need 3-5 days at other times of the year. Sun-dried fish and shrimps produced at Junput-Biramput Matsya Khoti are free from dirt and sand. Good-quality freshwater is available at every producer's drying yard. Fish are not dried on open sandy beaches. Fish are packed promptly and not left heaped on the ground. Women workers regularly maintain and clean the drying platforms. At this Khoti, fish are not dried on coir matting, bamboo mats, cement platforms, or jute sacks. A few producers have a concreted outdoor area of 40-80 m² adjacent to their homes. Fish meal is not produced here. Heavy monsoon rains disrupt the drying process. At times, demand from distant markets is high and prices are good, but insufficient drying delays supply (Source: News 18 Bangla, 30/8/2025).

Close view of sun-dried ribbonfishes and Bombay duck.

Producers monitor the drying fish to protect them from rodents. Some elderly dry fish producers at Junput-Biramput report that during monsoon and summer months, the blowfly *Lucilia cuprina* infests drying fish and lays eggs in the gill lamellae. The larvae feed on the fish, significantly reducing its quality and texture. Producers admit to using broad-spectrum vegetable crop insecticides at the recommended dose to control infestations of brown plant hoppers, painted bugs, nematodes, and other sucking and chewing insects. Fish treated with these insecticides may pose a slow-acting health risk to consumers within and outside West Bengal. At the same time, producers say they currently have no other effective means to control insect pests. Use of insecticides is kept to a minimum during the peak pre-winter and winter season. From my conversations with producers, I found that many have recognised the problem, reduced their use of insecticides, and are advising others to do the same - aware that insecticide-treated dry fish may become unacceptable in both local and distant markets. Scientific attention to this issue is needed to sustain this long-established industry and tradition.

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Dried fish products for retail sale.

From coast to pond: Integrating seaweed aquaculture with brackishwater farming systems

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Seaweed farming in India is an emerging, sustainable aquaculture activity. It creates livelihoods, enhances coastal ecosystem health, and supplies raw material for food, pharmaceuticals, nutraceuticals, cosmetics, biofertilisers, animal feed, and biofuel production. India's extensive estuaries, coastal lagoons, and brackishwater areas present immense potential for expanding seaweed cultivation beyond traditional marine zones. Historically, seaweed farming in India has been restricted to open coastal waters.

Recent research and innovations are opening new opportunities for growing commercially important seaweed species in brackishwater systems, particularly when integrated with shrimp and crab. This integration improves the ecological sustainability of aquaculture and diversifies income for coastal farmers - marking the start of a promising "Blue-Green Revolution". Indian waters contain 865 documented seaweed taxa: 212 species of Chlorophyta, 211 of Ochrophyta, and 442 of Rhodophyta[1].

Promising species for brackishwater cultivation

The most promising brackishwater seaweed species are in the genus *Gracilaria*, including *G. salicornia*, *G. tenuistipitata*, *G. edulis*, and *G. corticata*, which are widely cultivated because of their superior gel strength. *Ulva lactuca* (sea lettuce) is another fast-growing macroalga of commercial importance. These species suit brackishwater environments because of their high tolerance to salinity fluctuations and efficient absorption of dissolved nutrients, contributing to nutrient remediation and improved water quality.

Method of cultivation and key environmental factors

Site selection is critical for successful seaweed cultivation, as environmental stability directly influences growth, biomass yield, and crop quality. In open coastal waters with greater depth and stable salinity, farmers commonly use raft, long-line, or tube-line methods supported by floats and sinkers to keep seaweed within the photic zone. These systems ensure adequate sunlight while minimising physical stress from wave action.

In shallow coastal environments, farmers widely use pole- or stake-based methods, where tube-lines or long-lines are anchored to the substrate for structural stability under fluctuating tidal conditions. In confined or semi-controlled environments such as brackishwater ponds, lagoons, and

Gracilaria salicornia.

Gracilaria tenuistipitata.

tanks, farmers can efficiently manage culture conditions. In these systems, both tube-line and raft methods work well, allowing control of stocking density, water exchange, and biofouling.

Gracilaria edulis.

Optimal seaweed production requires adequate sunlight, a continuous supply of dissolved inorganic nutrients, and salinity within the species-specific tolerance range. One major advantage of seaweed cultivation is its short culture cycle and minimal inputs. Most commercially important species need no external feed or fertilisers when grown in nutrient-rich waters. This low-input, eco-friendly nature makes seaweed farming an attractive and sustainable livelihood option for coastal and brackishwater farmers.

Rising momentum and innovative farming practices for brackishwater seaweed

Rising industrial demand and a growing need for sustainable, diversified aquaculture are driving the rapid expansion of seaweed farming in brackishwater systems. Although production volume is important, seaweed biomass quality determines market price and industrial applicability, particularly for agar-bearing red seaweeds. In this context, innovative onshore and integrated farming approaches are increasingly recognised as reliable alternatives to conventional offshore cultivation, as they allow better control over environmental conditions and product quality.

Ulva lactuca.

Seaweed quality determines commercial value, especially in agarophytes, where gel strength, purity, colour, and consistency govern suitability for food, pharmaceutical, and biotechnology industries. Open-water cultivation often exposes seaweeds to epiphytic infestation, fouling organisms, sediment deposition, and grazing, which reduce growth and agar quality, ultimately lowering market acceptance and price. In contrast, confined-water systems such as lined ponds, tanks, and brackishwater enclosures offer better control over key environmental parameters, minimise infestation, and enable production of cleaner, more uniform biomass with superior gel characteristics.

Despite these advantages, seaweed monoculture in confined systems often fails to generate sufficient economic returns to cover operational and maintenance costs. To address this, integrating compatible aquaculture species is essential for improving profitability and sustainability. Integrated farming systems enable efficient use of nutrients from fed species, improve water quality through biological nutrient uptake, generate additional income from multiple crops within the same production cycle, and enhance overall resource-use efficiency. Integrating seaweed into brackishwater farming systems also reduces net greenhouse gas emissions, supports climate-resilient and environmentally sustainable aquaculture, and adds value through carbon-efficient biomass production. Integrating seaweed with fish and shellfish farming also improves immunity, disease resistance, and survival because of the diverse bioactive compounds in seaweeds. The success of such integration largely depends on selecting seaweed species that can tolerate the same salinity as the co-cultured animal and reach maximum biomass within the culture duration of the associated species.

1. Integration of seaweed with shrimp culture

Among various integrated approaches, shrimp-seaweed co-culture has emerged as one of the most promising practices for confined brackishwater systems. Penaeid shrimp farmers typically culture shrimp over 90-120 days at an optimal salinity of 20-32 ppt, which suits most *Gracilaria* species. *G. salicornia* is particularly suitable for integration with shrimp because of its short cultivation cycle of 45-55 days, its capacity for a three- to five-fold increase in biomass, and its high tolerance to the salinity fluctuations common in shrimp ponds. These attributes allow two consecutive seaweed harvests within a single shrimp production cycle, generating additional income without extending the culture duration.

In integrated shrimp ponds, farmers grow seaweed using tube net systems installed so they do not interfere with aeration or shrimp movement. Tube nets are tied to ropes and positioned at the right depth to ensure adequate light penetration, optimal water exchange, and uniform seaweed growth both within and outside the net structure. Proper spacing between ropes is critical to avoid self-shading and maximise biomass accumulation. Regular monitoring and cleaning of tube nets prevent fouling and maintain good growth rates.

Commercial shrimp feeds generally contain 30-40% crude protein. Shrimp assimilate only about 20-25% of this, and the remainder accumulates in the pond as organic waste. Seaweeds efficiently absorb dissolved inorganic nutrients released from uneaten feed and shrimp excreta, supporting their growth without additional fertiliser inputs. As a result, ammonia and nitrite concentrations remain low, water quality is stabilised, turbidity stays at levels favourable for light penetration, and dissolved oxygen is sustained through appropriate aeration and water circulation. Tube nets can be reused for multiple production cycles after proper treatment, reducing operational costs.

Field evaluations and experimental studies have consistently shown that shrimp-seaweed co-culture improves feed utilisation efficiency, reduces the feed conversion ratio, and enhances the nutritional and organoleptic qualities of shrimp, including flesh colour and texture, partly because of the natural live feed associated with seaweed biomass. ICAR-CIBA standardised the co-culture technology of *G. salicornia* with *P. vannamei* under different stocking densities, achieving more than a three-fold increase in seaweed biomass, approximately 1.2 t of seaweed from a 0.1 ha lined pond, and shrimp survival exceeding 95% at a harvest size of 45 count. Field demonstrations at Mulapolam, Andhra Pradesh, in collaboration with MoU partner M/s. Uday Aqua Pvt. Ltd., further validated the technology, yielding higher combined

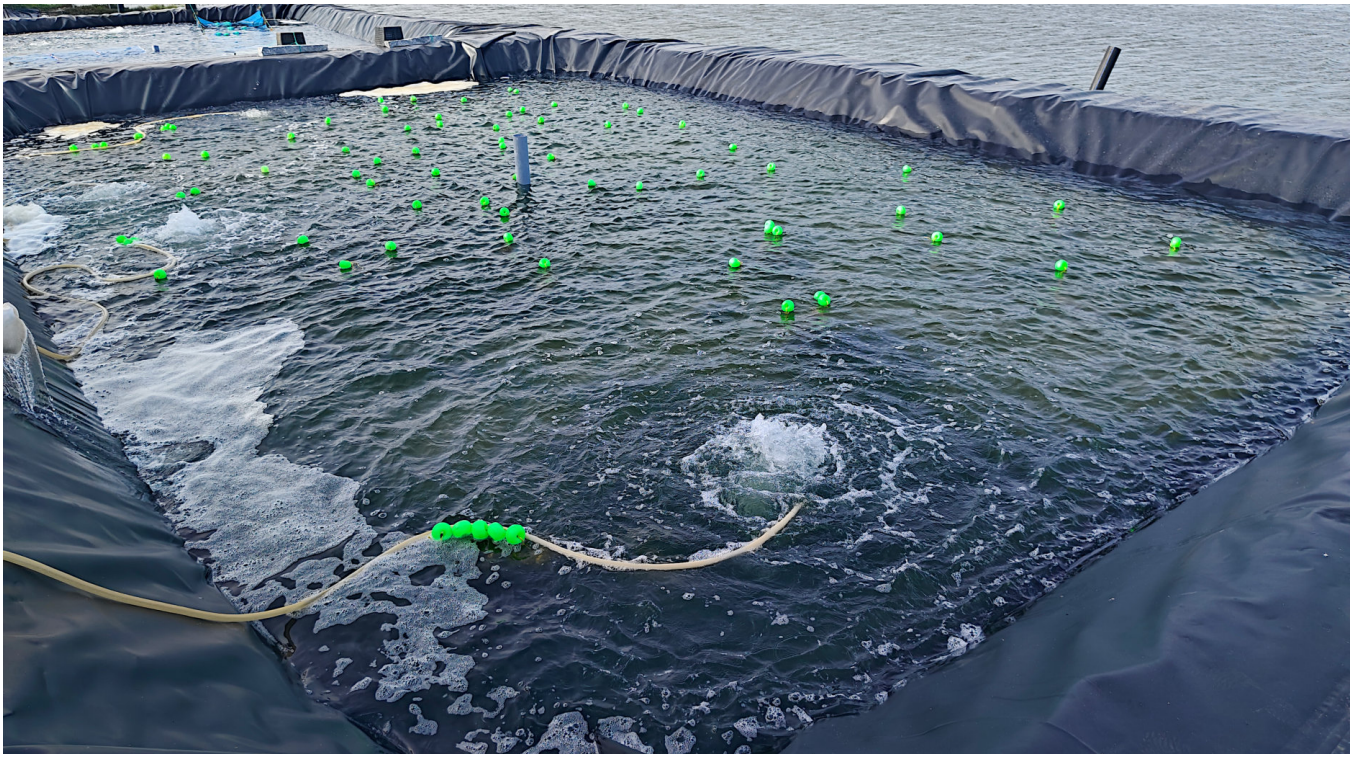
Right, below: Harvested biomass of Gracilaria salicornia from a shrimp pond.

economic returns and a reduced FCR. Retaining a portion of the harvested seaweed as seed material for subsequent crops ensures continuity of production, highlighting the strong potential of this mutually beneficial system for sustainable shrimp farming.

2. Integration of seaweed with mud crab farming

High cannibalism is a major challenge in mud crab farming, from the megalopa stage through grow-out. Adequate shelter is critical for improving survival. Experimental trials at ICAR-CIBA using *G. tenuistipitata* and *G. salicornia* recorded 60-80% survival from megalopa to instar stages, as crab larvae effectively use seaweed thalli as refuge from cannibalism. Before introduction into larval rearing tanks or ponds, seaweeds must be properly treated to remove associated organisms, particularly amphipods and other live feeds. For mid- and grow-out phases, seaweed integration offers both shelter and additional income. Earthen ponds with a water depth of 1.0-1.2 m are ideal for mud crab culture. Farmers can install seaweed tube-nets or place seaweed bunches at strategic locations to act as moulting shelters, reducing predation on soft-shelled crabs. Mud crab grow-out typically lasts 6-8 months at a stocking density of 0.1-0.2 / m², allowing multiple seaweed harvests at 55-day intervals. Harvested seaweed can be marketed fresh or dried. Seaweed also provides shaded microhabitats during periods of high temperature, reducing thermal stress and associated mortality.

Right, harvested biomass of Gracilaria salicornia from a mudcrab pond, below.



3. Integration of seaweed with finfishes

Seaweed can also be integrated with commercially important brackishwater finfishes, where it functions as a nutrient sink and habitat structure. By absorbing excess nutrients, seaweed helps maintain water quality, while fish use the associated natural live feeds, improving the feed conversion ratio (FCR) and growth performance. Suitable species for integrated systems include seabass, mullets, pearlspot, snapper, and milkfish. For herbivorous fish such as milkfish, grazing on seaweed should be prevented by fencing tube nets or culturing seaweed in cages or hapas, depending on fish size and stocking density.

Above, below: Raft cultivation of Gracilaria salicornia in fish pond.

Spatial technologies for managing seaweed resources

Spatial technologies are now available to map, monitor, and manage coastal resources effectively. The rise of temporal and multi-scale satellite data, alongside advances in geographic information systems, has revolutionised how we observe and manage coastal areas, including vital ecosystems such as seaweeds and mangroves. Spectral indices derived from satellite data help identify existing seaweed zones and track their distribution and changes over time. Satellites such as Landsat, Sentinel, MODIS, and WorldView are especially useful for mapping seaweed beds and identifying areas suitable for expanding seaweed and aquaculture. This monitoring is key to promoting the expansion of these vital coastal ecosystems. It supports conservation efforts, informs policy-making, and helps resolve conflicts among multiple users.

Challenges and constraints in brackishwater seaweed farming

Despite its significant potential for sustainable aquaculture diversification, brackishwater seaweed farming in India faces several scientific, technical, and institutional challenges. One primary limitation is the restricted availability of high-quality, disease-free seed stock, largely because of the absence of dedicated large-scale seaweed hatcheries and propagation facilities. As a result, farming operations rely heavily on wild-collected biomass, which requires extensive pre-treatment to eliminate epiphytes, fouling organisms, and potential pathogens, increasing labour inputs and operational costs.

Environmental variability poses another major constraint, particularly in brackishwater systems that are highly susceptible to abrupt salinity fluctuations during monsoon rainfall and freshwater inflow. Such sudden changes affect seaweed physiology, leading to suppressed growth rates and inconsistent biomass yields. Furthermore, more than 95% of seaweed biomass in India is still harvested from wild or open-water sources. This often results in heterogeneous quality, higher contamination levels, and lower market prices compared to biomass produced under controlled farming systems.

In recent years, diseases have become a growing concern in mariculture. Disease outbreaks can significantly reduce the yield and quality of cultivated seaweeds. Major seaweed diseases are caused by pathogenic bacteria, fungi, viruses, and epiphytic algae, as well as environmental stressors such as temperature fluctuations, poor water quality, and nutrient imbalance. Common disease symptoms include bleaching, rotting, tissue softening, and abnormal growth. Effective disease management relies on good farm hygiene, healthy planting material, well-chosen sites with proper water exchange, and regular monitoring to minimise stress and prevent outbreaks.

The absence of standardised price fixation mechanisms for high-quality seaweed produced in confined or integrated systems significantly discourages farmers from adopting improved culture practices. This issue is compounded by the lack of accessible quality assessment and certification facilities. Without these, producers must rely on buyer-driven price determination without objective evaluation of agar yield, gel strength, or purity. Inadequate standardised protocols for harvesting, post-harvest handling, packing, and transportation - particularly regarding optimal moisture content and biomass integrity - result in post-harvest losses and quality deterioration.

Limited awareness and insufficient capacity-building initiatives among coastal and brackishwater farmers also constrain wider adoption of integrated seaweed-based farming models.

Above left, right: Epiphytic growth on seaweed.

Targeted training programmes, extension support, and demonstration of techno-economic viability are essential to overcome these barriers and enable large-scale, sustainable expansion of brackishwater seaweed farming.

Conclusion

Brackishwater seaweed farming, when thoughtfully integrated with shrimp, mud crab, and finfish aquaculture, offers India a sustainable, low-input, high-reward opportunity. By enhancing resource-use efficiency, improving water quality, and generating additional income, integration elevates seaweed farming to the next level. High-quality seaweed biomass commands better market prices and contributes to improved growth, colour, texture, and taste of co-cultured aquatic animals. With growing global demand for seaweed-based products, integrated farming systems can play a crucial role in strengthening the Blue Economy and ensuring the sustainability, resilience, and long-term profitability of brackishwater aquaculture.

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Tiny guardians of hill streams: Exploring the ornamental loaches of the Western Ghats

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Travancoria elongata.

Among the fish of the Western Ghats, loaches (mainly from the families Cobitidae and Nemacheilidae) are a distinctive group of small, bottom-dwelling fish uniquely adapted to fast-flowing hill streams. They have elongated bodies, barbels around the mouth, and cryptic colouring, and play a vital role in stream ecosystems as bottom feeders and indicators of water quality. The region has at least 43 loach species across 12 genera; 39 are endemic, reflecting remarkable evolutionary isolation and habitat specialisation. Species like *Botia striata*, *Bhavania australis*, and *Mesonoemacheilus triangularis* show diverse shapes and behaviours, and some have gained popularity in the global ornamental fish trade. However, these loaches face growing threats from habitat degradation, dam construction, pollution, and unregulated collection. Despite their ecological and commercial value, they receive little conservation attention or legal protection.

Morphological characteristics

Western Ghats loaches are generally small, elongated, bottom-dwelling freshwater fish, highly adapted to life on the streambed. Their body shape ranges from worm-like to spindle-shaped, and they are often scaleless or covered with very small, embedded scales. They have a subterminal mouth fringed with barbels - sensory structures that help them detect food particles in sediment. Many species also have a suborbital spine, a small, retractable spine beneath each eye, used for defence. Their body patterns are often cryptic, with stripes, spots, and blotches that camouflage them among rocks and gravel. For example, *Acanthocobitis mooreh* has bold vertical bands resembling a zipper. By contrast, *Bhavania australis* and *Travancoria elongata* are flattened from top to bottom and have enlarged pectoral fins, which help them cling to rock surfaces in strong currents.

Major endemic ornamental loach species

Many loaches from the Western Ghats are not only endemic but also visually appealing, making them popular in the ornamental fish trade. *Acanthocobitis mooreh*, the Maharashtra zipper loach, is endemic to the northern Ghats. Its zebra-like patterns and agile behaviour make it attractive for display, although it is poorly represented in international trade. *Bhavania australis* is an ancient hill-stream loach confined to the southern Ghats. It has a flattened profile and a body shape adapted for suction. Though less colourful, it is sometimes traded because of its uniqueness. *Lepidocephalichthys thermalis*, locally known as "Ayira Meen" in Tamil Nadu, is widely distributed and often eaten as food. It is also valued for its hardiness and scavenging behaviour in aquaria, and has been prioritised for captive breeding and aquaculture diversification. *Schistura denisonii*, from the Bhavani River basin, is a small, subtly patterned loach named after Sir William Denison. Related species such as *S. sharavathiensis*

Lepidocephalichthys thermalis.

and *S. nilgiriensis* are endangered due to their narrow ranges and habitat degradation. *Botia striata*, the Zebra loach, is perhaps the best-known ornamental loach from India. Its striking black and yellow stripes have made it widely exported. Unfortunately, its limited range and popularity have made it vulnerable to overexploitation. *Mesonoemacheilus triangularis*, the Zodiac Loach, has intricate dark patterns resembling star constellations. It thrives in well-oxygenated streams in Kerala and Tamil Nadu and is a favourite among aquarium hobbyists. It has also been bred in captivity. Genera such as *Indoreonectes*, *Travancoria*, and *Schistura* together represent the region's rich endemic fauna, with both ecological and commercial importance.

Habitat and distribution

Western Ghats loaches are mainly found in fast-flowing, oxygen-rich hill streams. They occur across a range of altitudes, from high mountain torrents to mid- and low-elevation forest streams. They prefer rocky or gravelly streambeds with clear water and moderate to strong current. Species like *Bhavania australis* and *Balitorid* spp. are typical of cold, clear streams, while *Lepidocephalichthys thermalis* is more adaptable, occurring even in lowland and sluggish waters. Many species are micro-endemic, restricted to one or two river basins. For example, *Botia striata* is known only from a few rivers in the Maharashtra-Karnataka region, and *Travancoria elongata* is limited to southern Tamil Nadu and Kerala. Endemism is highest in the southern Western Ghats,

Mesonoemacheilus petrubanarescui.

where rainfall, altitudinal variation, and stream connectivity have produced high species diversity. This makes these loaches especially vulnerable to habitat fragmentation from dams, deforestation, and urban expansion.

Food and feeding

Loaches are bottom feeders, foraging mainly on algae, biofilm, small invertebrates, and detritus. Their barbels help them detect food buried in sand or lodged between rocks. Gut content studies show a diet of diatoms, filamentous algae, insect larvae, and small crustaceans. Species like *M. triangularis* and *S. denisonii* feed mainly on bottom-dwelling algae and organic matter, while *B. striata* has a broader diet, accepting insect larvae, snails, and even commercial pellets in captivity. This opportunistic feeding strategy helps loaches adapt to seasonal changes in food availability, especially during the dry season when insect larvae are scarce.

Behaviour and ecology

Western Ghats loaches show a range of ecological adaptations. Many species, like *B. australis*, are strongly adapted to fast currents. They use their flat undersides and enlarged pectoral fins to cling to rocks. When disturbed, they dive into the substrate or wedge into rock crevices to escape predators. Some species, such as *B. striata*, form shoals and may produce audible clicks during feeding or social interaction. Others, like *Schistura* spp., are territorial - especially males, who defend a specific rock or shelter. Spawning is poorly documented, but rising water levels during the monsoon likely trigger breeding. Juveniles are often seen in late monsoon months, suggesting seasonal reproduction. Loaches play a vital role in nutrient cycling and periphyton control and are important indicators of stream health. Their decline is often one of the first signs of stream degradation.

Aquarium trade demand

Several loach species from the Western Ghats are popular in the global ornamental fish market. *B. striata* is the most commercially exploited, with over 265,000 individuals exported over five years. High demand has raised concerns about over-harvesting during peak breeding seasons. Other species like *M. triangularis* and *L. thermalis* are also collected in smaller numbers. These loaches are valued for their patterns and substrate-cleaning behaviour. Government bodies like the Marine Products Export Development Authority (MPEDA) have tried to promote sustainable wild collection through green certification, though implementation has been patchy. The aquarium trade provides income for local communities, but it must be tightly regulated to ensure species survival. Captive breeding - particularly for *B. striata* - is being explored to reduce pressure on wild populations.

Conservation status

Western Ghats loaches face a range of threats, including habitat loss, pollution, dam construction, and unsustainable harvesting. Species like *B. striata* and *T. elongata* are listed as Endangered by the IUCN. Habitat degradation from deforestation and agricultural runoff reduces oxygen availability and increases sedimentation, destroying spawning and feeding grounds. Dams fragment habitats and disrupt the

Bhavania australis.

flow regimes that loaches need to breed. Conservation efforts include taxonomic research, habitat mapping, and captive breeding initiatives by institutions such as ICAR-NBFGR (2024). The organisation's Peninsular Aquatic Genetic Resource Centre (PAGR) in Kochi has played a vital role in loach documentation and public awareness.

Legal frameworks have not kept pace. Most loaches are not covered under India's Wildlife Protection Act, and there are ongoing efforts to include them under Schedule I or the CITES Appendix to regulate exports. Community engagement, river habitat restoration, and captive propagation are key strategies for the future. With coordinated efforts, Western Ghats loaches can be conserved as integral parts of India's freshwater biodiversity.

Acanthocobitis mooreh.

Mesonoemacheilus triangularis.

Securing the future of the melon barb: Science-based aquaculture for conservation

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The melon barb (Haludaria fasciata) is a freshwater cyprinid endemic to the Western Ghats of India.

A species of endemic beauty and ecological significance

The melon barb (*Haludaria fasciata*) is a freshwater cyprinid endemic to the Western Ghats of India and a living emblem of the region's aquatic biodiversity. Native to the hill streams of Kerala and Tamil Nadu, this vibrant fish has a striking lemon-yellow lateral stripe and gentle schooling behaviour. These qualities have made it a favourite of the global ornamental fish market.

In the wild, melon barbs thrive in cool, well-oxygenated streams with cobble-stone substrates and riparian vegetation. This vegetation stabilises the microclimate, maintains water clarity, and provides food such as insects and plant detritus. Water temperature in these habitats ranges between 22 and 28° C, with a slightly acidic to neutral pH and dissolved oxygen levels consistently above 5 mg/L.

These habitats are increasingly threatened by deforestation, sand mining, urban encroachment, and agricultural runoff, which cause siltation and chemical pollution. These pressures have caused a measurable decline in many native species, including *H. fasciata*. Conservationists now emphasise ex-situ measures such as captive breeding and brood banking as essential complements to habitat protection.

The ecological significance of the melon barb extends beyond its visual appeal. As an omnivore at mid-trophic level, it contributes to nutrient cycling by grazing on algae, detritus, and micro-crustaceans, and it serves as prey for larger native fishes and aquatic birds. Its short generation time, flexible diet, and readiness to breed under controlled conditions make it both a key species for sustainable ornamental aquaculture and a model organism for freshwater ecological studies. Conserving the melon barb is both an economic and ecological necessity, ensuring the continued functioning of Western Ghats stream ecosystems and providing a sustainable resource for the ornamental fish trade.

Breeding success through careful broodstock management

Captive breeding of *H. fasciata* is a science-based success story that combines ecological stewardship with rural livelihood opportunities. The first step is developing robust broodstock. Farmers condition wild-caught or farm-raised adults separately for two to three weeks on a high-protein, carotenoid-enriched diet of live *Artemia*, *Moina*, and carefully formulated micro-pellets. This diet improves gonadal development, intensifies natural coloration, and synchronises spawning readiness.

Farmers gradually raise the water temperature to around 26 °C while maintaining a neutral pH and continuous aeration. This mimics the natural monsoon cues that stimulate breeding in the wild. Sexual dimorphism, though subtle, helps in selecting brooders: males are slimmer and more intensely coloured, especially around the dorsal and caudal fins, while females have a fuller, soft abdomen when gravid.

Farmers typically use spawning tanks of 60 × 30 × 30 cm, equipped with fine-mesh false bottoms and synthetic spawning mops to protect adhesive eggs from predation. They introduce males first, then add females 24 hours later to trigger courtship behaviours such as circling and fin flaring. Covering the tank to maintain darkness completes the environmental simulation.

Within 8 to 12 hours, females scatter several hundred eggs that sink through the mesh and attach to the substrate, safe from adult fish. Fertilisation rates are high, and eggs hatch within 20–26 hours, depending on water temperature. Farmers must remove brooders immediately after spawning to prevent cannibalism and improve hatch rates.

This farmer-friendly protocol requires modest infrastructure and low running costs. Hatcheries across multiple sites have replicated it successfully, providing a reliable supply of seed stock and reducing dependence on wild-caught specimens.

From yolk-sac to juvenile: Rearing the next generation

Larval rearing is the most delicate phase of melon barb culture and demands close attention to nutrition and water quality. Newly hatched larvae, about 2.3 mm long, stay on the bottom and do not feed for their first three days while absorbing yolk sac reserves rich in essential fatty acids. Within 24–48 hours, pigment cells (melanophores) appear along the optic rim and muscle segments (myotomes), fin rays begin forming, and the gas bladder inflates, enabling vertical movement.

Once free-swimming, farmers feed larvae live *Artemia* nauplii at least three times daily for 12–15 days to promote rapid growth and reduce mortality. After this period, they gradually wean larvae onto *Moina* and high-quality micro-diets until the fish accept fine formulated feeds. Consistent feeding sched-

ules, stable water parameters, and gentle aeration are essential. Ammonia and nitrite must remain near zero, and partial water changes every 48 hours maintain ideal conditions.

Many farmers transfer larvae to outdoor FRP tanks or fine-mesh pond hapas, where natural plankton boosts growth. By the end of the first month, juveniles reach 25–30 mm and develop the vertical banding typical of the genus. With optimal feeding and clean, oxygen-rich water, they reach sexual maturity within four to five months. This rapid life cycle allows multiple breeding cycles per year, ensuring a steady supply of ornamental-grade fish for domestic and export markets. These protocols for larval and juvenile rearing provide a model for small-barb aquaculture and show how careful husbandry can convert a vulnerable wild species into a sustainable farmed resource.

Economics and conservation: complementary goals

Melon barb aquaculture is a rare example where conservation and commerce reinforce each other. A starter hatchery unit with 500 L FRP tanks and a few breeding aquaria can be set up for around ₹22,500. From 30 breeding pairs, farmers can harvest 5,400 to 8,400 juveniles within two months. At a conservative farm-gate price of ₹10 per 2-inch fish, gross returns can easily exceed ₹50,000 per cycle, yielding attractive profit margins even after accounting for feed, electricity, and labour. For rural households and small entrepreneurs, especially in biodiversity-rich but economically constrained regions, this represents a reliable supplementary income.

Beyond economics, captive production relieves harvest pressure on wild stocks, which have been declining due to deforestation, agricultural runoff, and unregulated collection for the aquarium trade. By supplying a consistent flow of healthy, farmed fish to domestic and export markets, hatcheries reduce the incentive to capture fish from native streams. The establishment of ex-situ brood banks and genetic resource centres also safeguards against catastrophic losses in the wild and provides material for restocking programmes where natural populations have been depleted.

When combined with catchment reforestation, riparian buffer creation, and pollution control, these hatchery-based measures can play a decisive role in ensuring the long-term survival of *H. fasciata*. The melon barb's commercial success is a compelling case study of how well-designed aquaculture can simultaneously deliver livelihood security and biodiversity conservation.

A sustainable future for an aquatic jewel

The melon barb shows the promise of an integrated approach to ornamental fish farming that unites scientific innovation with environmental ethics. Indian researchers and progressive farmers have shown that careful broodstock conditioning, precise water quality management, and staged larval nutrition can turn a species once threatened by habitat loss into a resilient and profitable aquaculture candidate.

Scaling up through farmer cooperatives and community hatcheries, backed by government extension services and private-sector marketing, will extend economic benefits to a broader rural base while safeguarding natural populations. Consumer awareness is equally important: every aquarist who chooses a certified farmed melon barb instead of a wild-caught specimen supports a supply chain that values ecological sustainability.

Future priorities include molecular tools for genetic monitoring, refinement of live-feed protocols to further reduce early larval mortality, and long-term ecological studies to track remaining wild populations. Internationally, *H. fasciata* can serve as an ambassador for India's unique freshwater heritage, reminding the world that conservation and commerce can work together when managed wisely. The melon barb's success story can inspire similar efforts for other endemic fishes of the Western Ghats and beyond, ensuring that economic development and biodiversity protection advance together for generations to come.

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Quietly transforming catfish aquaculture: ICAR-CIFA's seed production journey in India

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Pangasius pangasius.

Looking back at freshwater aquaculture in India, the story seems straightforward. Carp dominated everything. Farmers designed ponds for carp, hatcheries produced carp seed, training programmes focused on carp polyculture, and most farmers built their livelihoods around these dependable species. Carp culture provided stability and food security, and rightly so.

Yet anyone who has walked through a local fish market knows another truth. Catfishes often disappear from the stalls first. Consumers willingly pay more for them. Their flesh is soft, tasty and lacks interstitial spines. Many regional cuisines prefer catfish. Some species are even regarded as restorative or medicinal foods. In terms of demand and price, catfishes have always had an edge.

So why did catfish farming remain marginal for so many years?

The answer was not demand, not growth potential, and not farmer interest.

It was seed.

For decades, most indigenous catfishes depended almost entirely on wild fry collected from rivers, wetlands and floodplains. Seed availability was seasonal and unpredictable. Some years, farmers obtained enough fry; other years, they got almost none. A pond might be prepared and fertilised, only to remain empty because seed never arrived. Planning became guesswork. Investment felt risky. Naturally, most farmers retreated to carp, where hatchery seed was assured.

In aquaculture, the rule is simple. Without seed, there is no farming.

Many of the indigenous catfishes described in this article are categorised as threatened or vulnerable in parts of their range due to habitat degradation, overfishing and river regulation. Developing reliable captive breeding and hatchery technologies therefore helps both aquaculture diversification and conservation. It reduces pressure on wild stocks and enables stock enhancement programmes.

Over the last three decades, ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA) has steadily and quietly addressed this constraint through systematic research and fieldwork. Instead of treating breeding as a single technical

step, scientists approached catfish culture as a complete biological and production system. They developed broodstock nutrition, induced spawning, hatchery engineering, larval feeding, nursery management and farmer adoption together.

The results did not come overnight. They emerged slowly, species by species. But once dependable hatchery seed became available, everything changed. Hatcheries appeared. Farmers diversified. Local markets stabilised. What had once been an uncertain, capture-dependent activity began to look like a viable aquaculture enterprise.

This transformation is best understood not as a single breakthrough, but as a series of species-specific stories.

Understanding the problem at its roots

Early attempts at catfish breeding showed that the challenge was deeper than simply injecting hormones and waiting for spawning. Many indigenous catfishes evolved to breed under specific environmental cues such as flowing water, temperature shifts, or monsoon flooding. When confined to ponds or tanks, they often refused to spawn or produced poor-quality eggs. Even after hatching, larval survival was inconsistent.

It became clear that induced breeding alone would not solve the problem. Scientists had to manage the entire life cycle carefully.

Researchers began with fundamentals. They conditioned broodstock with balanced, protein-rich diets to improve gonadal maturation. They optimised water quality and space, refined spawning protocols, and standardised egg incubation systems. Researchers provided larvae with appropriate live feeds before gradually transitioning them to formulated diets. They improved nursery practices to reduce stress and mortality.

Gradually, hatchery operations that once depended on luck became predictable. Spawning success improved. Hatching stabilised. Fry survival increased. This shift from uncertainty to reliability laid the foundation for everything that followed.

Induced breeding protocols across species predominantly used synthetic inducing agents such as Ovaprim, Ovatide and Wova-FH, with dosage adjustments based on species and broodstock condition.

Mystus species (small bagrids)

Small bagrid catfishes of the genus *Mystus* were always familiar to rural consumers but largely absent from culture systems. Farmers caught them seasonally from rivers and floodplains and sold them fresh at reasonable prices. Yet farmers hesitated to stock them because seed was unreliable and transport survival poor.

Through careful broodstock conditioning and induced breeding trials, researchers successfully spawned these species in captivity. Refining egg incubation and larval feeding methods significantly improved survival. Once researchers standardised nursery rearing techniques, they could produce robust fingerlings consistently.

These small catfish proved ideally suited for small ponds and low-input farming. Farmers began stocking them alongside carps, often obtaining better returns from the same water area. In several districts of eastern India, small hatcheries now routinely produce Mystus seed. What was once a seasonal catch has become a planned aquaculture crop.

Rita chrysea

Rita chrysea is an indigenous catfish found only in the Mahanadi river system of eastern India. The population is declining due to over-exploitation. Research focused on understanding its reproductive biology and developing captive breeding methods.

Work on brood nutrition, simplified spawning methods, husbandry, and seed rearing management stabilised hatchery production. This research opens the way for both farming and stock enhancement to conserve this native species.

Rita chrysea.

Ompok species (pabda group)

Among the indigenous catfishes, pabda enjoys almost universal consumer preference. Its delicate flesh commands premium prices in markets. Yet for years, pabda culture remained limited because hatchery seed was unavailable.

Initial larval survival was low, and researchers considered the species delicate. However, systematic refinement of spawning, incubation and feeding practices proved otherwise. With improved larval nutrition and careful water management, survival rates increased steadily.

Once dependable seed became available, farmers quickly adopted the species. Hatcheries supplying pabda fry began operating locally, creating entrepreneurship opportunities while reducing pressure on wild populations. The success of pabda demonstrates how targeted hatchery science can unlock the commercial value of a traditionally important fish.

Horabagrus brachysoma (yellow catfish)

This striking yellow catfish from the Western Ghats has both ornamental and food value. However, declining natural populations and limited knowledge of captive breeding restricted its use.

Research showed that the species adapts well to pond conditions when farmers manage broodstock appropriately. Successful hatchery production supported both farming and conservation. Reduced dependence on wild capture helped protect natural stocks, while farmers gained access to a new species.

It stands as a clear example of how aquaculture development and biodiversity conservation can go hand in hand.

Clarias batrachus (magur)

Magur perhaps best illustrates the direct livelihood impact of catfish seed technology. Hardy, air-breathing, and tolerant of low oxygen, it thrives in small ponds, tanks, and backyard systems. For land-poor households, few fish are more suitable.

Yet unreliable seed and poor larval survival long held back expansion.

Horabagrus brachysoma.

Clarias batrachus.

Heteropneustes fossilis.

Improved brood nutrition, simplified breeding methods, and portable FRP hatchery systems made dependable seed production feasible. Equally important, scientists developed formulated feeds to support early life stages.

CIFA developed a larval feed, Starter-M, and a fry feed, CIFAMA, both now commercialised and widely used. These feeds significantly improved survival, uniform growth, and nursery performance, allowing farmers and hatchery operators to raise healthy fingerlings with greater consistency.

To support decentralised seed production, CIFA designed and fabricated low-cost FRP-based modular hatchery units for *Clarias batrachus* (FRP-Magur hatchery) and *Ompok* spp. (FRP-Pabda hatchery). These units have been installed and adopted in multiple states across India, enabling small-scale hatchery operators to produce seed under controlled and hygienic conditions.

Today, in many villages, farmers stock small ponds beside their homes with magur fingerlings. They harvest and sell fish fresh in local markets, often earning

a steady weekly income. For many families, magur culture is no longer experimental. It is dependable.

Heteropneustes fossilis (singhi)

Singhi shares many of magur's strengths: hardiness, high consumer demand, and suitability for small water bodies. Earlier, an inconsistent seed supply limited its culture.

Refinements in brood management, spawning, and larval rearing stabilised hatchery production. Farmers now use singhi as a diversification species, spreading risk across multiple crops and improving overall farm resilience.

Clarias dussumieri

This lesser-known indigenous catfish has a restricted distribution and declining populations. Research focused on understanding its reproductive biology and establishing captive breeding methods.

Although still emerging as a culture species, hatchery production opens possibilities for both farming and stock enhancement. The work highlights the importance of conserving native genetic resources while exploring new aquaculture opportunities.

Pangasius pangasius

Among larger indigenous catfishes, *Pangasius pangasius* offers strong commercial potential because of its fast growth and good feed conversion. However, dependence on riverine seed once restricted expansion.

Standardising breeding, nursery techniques and feeding management enabled dependable hatchery production. To support different growth stages, CIFA also developed stage-specific feeds: Starter Pangas for larvae, Pangas Grow-I for fry and Pangas Grow-II for fingerlings. These feeds improved growth rates, feed efficiency, and survival, enabling more intensive and predictable production. With reliable seed and suitable feeds, farmers could confidently adopt larger-scale culture. The species has now moved from capture-based supply to organised aquaculture.

Clarias dussumieri.

Mystus cavasius.

Wallago attu.

Wallago attu

Wallago attu, a large predatory catfish, posed unique challenges, particularly cannibalism during early larval stages. Hatchery survival was often low.

Research focused on understanding behaviour, feeding strategies and density management. While commercial production remains technically demanding, the knowledge generated provides a scientific base for future advances and demonstrates continued commitment to indigenous species development. Rearing under controlled red-light conditions significantly reduced larval cannibalism and improved survival rates, particularly during the early post-yolk absorption stage.

Timeline of progress

ICAR-Central Institute of Freshwater Aquaculture has developed catfish seed technologies over nearly five decades. Foundational work during 1971–1985 was carried out under the All India Coordinated Project on Air-breathing Fishes and the CIFRI/IDRC Rural Aquaculture Project. This generated essential biological information on the breeding and larval ecology of indigenous and air-breathing catfishes. Building on this

base, the 1990s focused on captive breeding and hatchery standardisation of *C. batrachus* and *H. fossilis*. The 2000s expanded efforts to larger species, such as *W. attu* and *H. brachysoma*, with improvements in brood nutrition, hatchery systems, and nursery management. During the 2010s, researchers consolidated technologies and extended them to *Rita chrysea*, *Mystus* spp., and *P. pangasius*, with support from feed development, demonstrations, and farmer adoption. More recently, the 2020s have emphasised species diversification through hatchery production of *Ompok* spp. and *C. dussumieri*. Together, these decade-by-decade advances mark a steady progression from exploratory research to dependable, farmer-ready seed production systems.

Programme contributions and integrated expertise

The progress described above emerged not from isolated trials but from sustained, coordinated efforts that integrated reproductive biology, hatchery technology and fish nutrition within a single programme framework. Breeding and hatchery standardisation focused on developing reliable protocols for induced spawning, egg incubation and larval rearing, while parallel advances in feed formulation and nutritional management ensured stage-specific support for larvae, fry, fingerlings and broodstock. CIFA developed formulated feeds for all catfish species discussed in this paper, covering

Table 1. Standardised breeding and hatchery parameters of indigenous catfishes developed at ICAR-CIFA.

Species	Ideal weight	Ideal age (years)	Hormone (ml/kg)	Latency	Yolk absorption	Fecundity	Larvae produced
Clarias batrachus	100-150 g	2	1.0-1.5	16-17 h	72 h	4-5K/ 100g ♀	2.5-3K/ 100g ♀
Clarias dussumieri	90-150 g	2	1.0-1.2	11-12 h	72 h	6-7K/ 100g ♀	3-3.5K/ 100g ♀
Heteropneustes fossilis	100-150 g	2	0.8-1.0	9-10 h	72 h	10-15K/ 100-120g ♀	6-7K/ 100g ♀
Mystus cavasius	80-100 g	2	1.0	12-13 h	60 h	10-20K/ 50-80g ♀	7-9K/ 100g ♀
Rita chrysea	80-100 g	2	1.0-1.5	13-15 h	72 h	12-13K/ 90-130 g	8-9K/ 90-130 g
Horabagrus brachysoma	150-180 g	2-3	1.0	12-14 h	72 h	18-19K/ 100g ♀	8-9K/ 100g ♀
Ompok bimaculatus	130-180 g	2	1.0-1.5	10-11 h	65-70 h	14-15K/ 100g♀	6-7K/ 100g ♀
Pangasius pangasius	1.0-1.5 kg	3-4	1.0	13-14 h	55-60 h	150-160K/ 1.2-1.5 kg ♀	80-110K/ 1.2-1.5 kg ♀
Wallago attu	1-2 kg	3	0.5-1.0	10-11 h	50-55 h	30-40K/ 1.1-1.4kg ♀	13-17K/ 1.0-1.5 kg ♀

Table 2. Species-wise feeding regimes and nutritional requirements across life stages of indigenous catfishes. Note: All species fed with mixed plankton, *Artemia* nauplii and tubifex as live feed.

Species	Min. protein brood feed	Min. protein larval feed	Min. protein fingerling feed	First form. feed post-hatch	Larval feed particle size	Fingerling feed pellet size (mm)	Fingerling ration size % body weight	Feeds/ day
Clarias batrachus	35%	40-50%	35%	9-10 days	35-50 µ	0.5-1.5	2-5	2
Clarias dussumieri	35%	40-50%	35%	10-11 days	35-50 µ	0.5-1.5	2-5	2
Heteropneustes fossilis	35%	40-50%	35%	11-12 days	35-50 µ	0.5-1	2-5	2
Mystus cavasius	35%	40-50%	35%	11-12 days	35-50 µ	0.5-1	2-5	2
Rita chrysea	35%	40-50%	35%	13-14 days	35-50 µ	0.5-1	2-5	2
Horabagrus brachysoma	35%	40-50%	35%	10-11 days	35-50 µ	0.5-1	2-5	2
Ompok bimaculatus	35%	40%	35%	12-14 days	35-50 µ	0.5-1	2-5	2
Pangasius pangasius	32%	40%	35%	12-13 days	35-50 µ	1-3	2-5	2-3
Wallago attu	40-50% (offal/live)	50-60%	40-50%	Animal protein day 4+	Crushed liver/ form. feed	1-5	1-5	3-4

broodstock, larval, fry, fingerling and grow-out stages. This ensured nutritional continuity throughout the production cycle and minimised dependence on inconsistent live feeds. This close coupling of reproduction and nutrition research led to complete, field-validated technology packages rather than fragmented solutions. Such an integrated approach proved central to achieving consistent seed production and to the widespread adoption of catfish hatchery technologies by farmers and private hatchery operators across the region.

Conclusion

The transformation of catfish aquaculture in India did not happen through a single dramatic breakthrough. It came through steady, patient, species-wise progress. Broodstock management improved. Hatcheries became simpler and more reliable. Researchers developed larval feeds. Nursery survival increased. Researchers trained farmers and adapted technologies to field realities.

By solving the most fundamental constraint - dependable seed supply - ICAR-Central Institute of Freshwater Aquaculture helped indigenous catfishes move from rivers and wetlands into ponds and hatcheries.

Today, farmers stock magur, pabda, *Mystus*, or *Pangasius* fingerlings with confidence. Hatcheries operate locally. Feed technologies support every life stage. Livelihoods have strengthened. Natural stocks face less pressure.

It may appear quiet from the outside, but across thousands of ponds, this steady, science-driven progress has reshaped freshwater aquaculture in lasting ways.

In every sense, it has been a silent revolution, one that began with seed and continues to grow with every harvest. Together, these advances have firmly positioned indigenous catfishes as a significant and sustainable component of India's freshwater aquaculture sector.

About the Authors

Dr. Sangram Ketan Sahoo is a senior fish reproductive biologist with over three decades of experience in breeding and hatchery standardisation of indigenous catfishes and other freshwater species.

Dr. Shiba Shankar Giri is a fish nutrition scientist with more than 30 years of experience in feed formulation and nutritional programming for freshwater aquaculture.

Together, their integrated work in reproduction and nutrition has contributed significantly to the development and dissemination of catfish seed and feed technologies across India.

ICAR-CIFA promoting Kalong-Kapili for opening new avenues to strengthen aquaculture in Northeast region of India

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Aquaculture production has increased steadily across India, driven by the adoption of diversified systems that raise yields per unit area. Continuous expansion has been possible through extension services that transfer technologies to farmers, promoting aquaculture as an accessible and sustainable farming practice. These services ensure that aquaculture remains viable by providing technical support and demonstrating practical methods. Aquaculture supplies aquatic protein, supports rural livelihoods, and generates income in villages across the region. ICAR-CIFA (Indian Council of Agricultural Research-Central Institute of Freshwater Aquaculture) has contributed substantially to transforming fishing communities from subsistence farming to vibrant local economies. Non-governmental organisations (NGOs) play a vital role in this transformation, reaching rural communities and promoting sustainable livelihoods through diverse activities. This article describes the role of Kalong-Kapili, an NGO in Assam, in developing aquaculture across the north-eastern regions of India. With support from CIFA, Kalong-Kapili has worked to make aquaculture a viable tool for reducing poverty and malnutrition.

Kalong-Kapili - playing a key role in strengthening rural aquaculture

Kalong-Kapili began operations in 2007 at Bagibari village in Kamrup Metropolitan district of Assam, India, with the goal of creating sustainable livelihood opportunities among villagers. Mr Jyotish Talukdar, the organisation's Director, recognised that Assam possesses diverse water bodies including large

Farmer holding a chitala.

wetlands, beels, jheels, rivers, ponds, canals and lakes, most of which are perennial or annual, with some seasonal. These water bodies represented untapped resources that could be used for fish production. Assam's population traditionally eats fish and has knowledge of fishing and fish farming. India's aquaculture sector has grown substantially in recent years to meet increasing fish demand. Population growth and rising demand for fish have led to intensification of production. CIFA has promoted aquaculture to meet demand for aquatic protein as wild fisheries resources have declined due to unsustainable exploitation. At this juncture, CIFA encouraged Mr Talukdar and his colleagues to pursue aquaculture for rural development through sustainable livelihood programmes. Supported by CIFA, Kalong-Kapili has worked to utilise water resources for aquaculture with technical support and capacity building.

Capacity building - an initial step to train human resources

Kalong-Kapili established a 'field laboratory' at Bagibari village. The field laboratory was designed as a one-stop knowledge centre to disseminate information among stakeholders. Facilities developed for acquiring aquaculture knowledge include diverse programmes coordinated through structured systems, which include:

Aquaculture support system:

- Solar panels for electricity supply.
- Solar systems for grow-out culture ponds.
- Breeding facilities including breeding pools and hatching pools.
- Rearing facilities comprising spawn rearing tanks, fry and fingerling rearing nursery ponds.
- Culture facilities with ponds of different sizes for grow-out culture from table-sized fish to marketable size.
- Ornamental fish breeding unit.

Feeding support system

- Feed mill.
- Pellet feed production capacity of 100 kg daily.
- Operational guidance manual for farmers and entrepreneurs.

Pond management system:

- Guidelines displayed on signboards in local language for step-by-step learning.
- Application of raw cow dung in appropriate amounts.
- Fertiliser application rates per unit area.
- Timing of fertiliser application per unit area.
- Pond water management for plankton production.

Advanced aquaculture facility system:

- Recirculatory aquaculture system (RAS).

Solar system operated in grow-out culture pond

- Specialised RAS for larval rearing.
- Biofloc.
- Aquaponics setup.
- Live food preparation unit.
- Solar fish dryer.
- Fish library.
- Fish museum.

Provision of learning system:

- Training hall (area, classroom, computer system, etc.).
- Conference hall/
- Training hostel (accommodation, washrooms, pantry, etc.).
- Dining hall.
- Computer centre with internet connection.
- Laboratory for soil and water analyses.
- Disease diagnostic unit.

Learning programmes: needs based and problem focused

Aquaculture has evolved from simple pond culture to sophisticated systems as technology has advanced. Recognising the limitations of traditional pond-based farming, practitioners have equipped existing water bodies with modern facilities for optimal resource use. Many smallholder farmers meet their food, nutrition and income requirements using backyard water bodies. Some integrate fisheries with other farming systems, planting vegetables, horticultural crops and keeping poultry on pond dykes. Proportionate resource allocation leads to sustainable pond management, which requires careful stewardship of natural resources including air, water, soils and biodiversity. With technical support from CIFA, Kalong-Kapili provides practical methods for sustainable crop and farm management to stakeholders through the following activities:

- Improved farming practices: Farmers receive training in scientific fish farming. Guidance on sustainable and climate-resilient aquaculture is provided to increase productivity.
- Climate resilience: Farmers receive training on climate-resilient aquaculture to assess vulnerability to climate change and adopt practices that mitigate adverse impacts.
- Disease management: Farmers learn to identify fish diseases caused by different pathogens and manage them effectively.
- Access to resources: Information on technological advances for scientific fish farming practices is provided.

Solar panel for electricity supply.

Breeding pool.

Feed mill.

- Empowerment: Farmers are equipped with skills that build confidence for decision-making in improved aquaculture practices.
- Income generation: Farmers improve livelihoods and increase income by adopting sustainable and effective scientific aquaculture practices.

Aquaculture Field School (AFS) at Bagibari

The AFS is a school without walls. It is an innovative, farmer-centred aquaculture extension approach that emphasises technology transfer, training provision and promotion of good practices in technical areas of aquaculture. It guides farmers on site selection, breeding and seed production, feeding, pond water management and fish health. Effective extension services play a role in increasing aquaculture production for economic development of rural fish farmers. The concept of extension service has broadened beyond simple 'transfer of technology' to encompass human resource development that focuses on learning and empowering farmers. ICAR-CIFA supports Kalong-Kapili to promote farmer-to-farmer learning, thereby advancing horizontal extension. The curriculum integrates scientific methods of aquaculture including site selection, fish culture practices and marketing. It covers various farmer levels and disseminates technologies for seed production of carp, catfish, air-breathing fish and ornamental fish. An 'Aquaculture Technological Park' with live displays of various enterprises is being established to provide more focused and practical learning at a one-stop aquaculture facility.

Benefits of AFS: learning together

AFS benefits farmers in several ways, including knowledge sharing, skill development in scientific fish farming techniques, experience sharing and acquisition of practical experience through training.

- Improved productivity: Farmers can increase fish production and productivity per unit area by learning best management practices.
- Promote sustainability: Farmers can learn sustainable practices that provide stable production without harming the pond environment for future generations.
- Enhanced livelihood: Farmers can learn and adopt scientific farming methods to improve their standard of living.
- Increased income: Farmers can increase income by adopting scientific aquaculture.
- Knowledge sharing: Farmers can exchange experiences and learn from each other to develop knowledge-based information that may be tested at field level.
- Best management practices (BMPs): Farmers can share information to adopt best management practices for improving yields.

Managing pond water for plankton production.

- Eco-friendly approaches: Farmers are encouraged to develop eco-friendly approaches to aquaculture by reducing environmental impacts.

Role of Kalong-Kapili: disseminating knowledge from farmer to farmer

ICAR-CIFA established the first Aquaculture Field School (AFS) in the North East Region at Bagibari in association with Kalong-Kapili. The primary aim of AFS is to empower fish farmers in the region through comprehensive learning, knowledge sharing and technical guidance. The school's campus is well equipped with all essential facilities, providing an ideal learning environment. Participants are encouraged to freely express their opinions and engage in discussions. Kalong-Kapili has highly qualified resource persons who consider each trainee's expectations, attitudes and experiences during training, and deliver training through individualised modules. AFS is a unique facility with residential training capabilities established under one roof. Over time, AFS has conducted various training programmes, including residential sessions, exposure visits and day-long programmes for fish farmers. AFS emphasises training of farmers following structured criteria and guidelines for Community Resource Person (CRP) training. These initiatives have been made possible with support from ICAR-CIFA; the Department of Fisheries, Government of Assam; GIZ; and NABARD.

Specialised RAS for larval rearing.

A bio-floc system.

Aquaponics setup operated with solar system.

Facilities and services of AFS

- Advanced and innovative programmes on sustainable aquaculture and natural farming following agro-ecological principles.
- Database-integrated aquaculture programmes providing access to trainee farmers.
- Breeding unit under network hatchery recognised by NFDB (National Fishery Development Board).
- Demonstration unit for sustainable aquaculture and natural farming.
- Laboratory and internet facilities for trainees and visitors.
- Qualified and experienced resource persons.
- Aqua-tourism.
- Infrastructure: Training hall equipped with modern learning techniques, separate dormitories for male and female participants, hygienic kitchen with dining hall, medical unit, baby care unit, washrooms, etc.

Extension services of Kalong-Kapili: helping farmers realise their goals

Kalong-Kapili takes initiatives towards social responsibility by providing reasonable remuneration for labour in aquaculture. It has developed value chain initiatives for overall efficiency and profitability. The organisation encourages local participation in aquaculture development so that community engagement serves as a tool for knowledge sharing. It provides farmers with market linkages that enable them to sell products with profitable margins. It has worked to involve more women to ensure that women's empowerment drives inclusive development. For successful execution of extension programmes, Kalong-Kapili has adopted the following measures.

- Meetings: Regular meetings among farmers to share experiences, information, skills and knowledge.
- Farmers' groups: Formation of farmers' groups to facilitate learning, information sharing and decision-making.
- Community events: Organisation of community events, workshops and training sessions to bring farmers together.

Live food preparation unit.

Solar fish dryer.

A view of soil and water analysis.

Soil and water analysis for female trainees.

- Decision-making process: Allowing farmers to participate in decision-making processes and share information with others.
- Social media: Engagement on various social media platforms to connect farmers and share information.
- Online forums: Creation of online forums or groups for discussion, knowledge sharing and collaboration.
- Stakeholder engagement: Collaboration with other agencies to provide farmers with access to resources and expertise.
- Networking: Building partnerships with organisations and networks to expand reach.
- Mentorship: Sharing knowledge from experienced farmers to new farmers through various programmes for technical guidance.
- Collaboration: Collaboration with farmers' organisations with different farming practices to promote collaborative activities.
- Farmer-to-farmer exchange: Promotion of peer-to-peer learning by facilitating knowledge sharing and exchanges.

Support services of Kalong-Kapili: from near to far

Kalong-Kapili extends its services across the entire north-eastern region, including Assam, Meghalaya, Manipur and Arunachal Pradesh, India. Integrated aquaculture, including fish-cum-pig, fish-cum-poultry, fish-cum-duck and fish-cum-rice farming, along with horticultural crop plantation - is common in the north-eastern region.

Borbeel cluster, Assam

The tribal population of Borbeel was poorly developed. People possess potential water bodies that were not utilised. Kalong-Kapili has changed their lives through continuous intervention. The integrated approach to aquaculture, horticulture and agriculture has benefitted 400 families. Fish farming was introduced for the first time in that remote area and has changed the living standards of beneficiaries. Many tangible changes have transformed their lives through provision of modern facilities including approach roads, marketing outlets for aquaculture products and horticultural crops, and support for farmers to travel from home to markets. For long-term benefit, areca nut plantations, pig sties and piglets have been supplied.

Lohit cluster, Arunachal Pradesh

An integrated tribal development project was introduced in Lohit district to support 200 families through integrated and sustainable aquaculture practices. The project includes aquaculture, kitchen gardens on the dykes of backyard ponds and horticultural crop plantations. Women's participation is prominent, ensuring women's empowerment through skill development. Additionally, nine village planning committees were developed, leading to creation of the Lohit Integrated Tribal Development Cluster Committee. This programme provides environmental, social and economic benefits.

Lower Siang cluster, Arunachal Pradesh

Kalong-Kapili replicated the Lohit cluster programme to support 200 families in Lower Siang, Arunachal Pradesh. Beneficiaries have applied scientific knowledge under the project to develop orchards, kitchen gardens, backyard pond farming, piggery and other allied activities. Crops are chosen carefully to ensure a steady flow of income in a sustainable manner for short-term, intermediate and long-term benefits. Beneficiaries have learnt to utilise resources through an integrated farming approach.

Women's empowerment

Kalong-Kapili empowers women through a range of aquaculture development initiatives. It forms self-help groups (SHGs) among women to provide gainful employment and empowerment. The Umbrella Programme for Natural Resource Management (UPNRM) was introduced to motivate women to participate in climate-smart fisheries programmes. Kalong-Kapili adapted NABARD's (National Bank for Agriculture and Rural Development) 'Grand model' to a 'Business model' through the replacement of bottom-dwelling fish with freshwater prawns. Under this programme, 200 fish ponds around Bagibari were developed through landscape changes with participation of village women. Active involvement of enthusiastic women in aquaculture has provided access to economic benefits, which has begun to reflect in qualitative improvements in their livelihood standards.

Impact of Kalong-Kapili: human resource generation

Kalong-Kapili has trained 10,000 people comprising both youth and women throughout Assam and the north-eastern region as part of aquaculture skill

Aquaculture Technological Park.

development. It provides two residential training courses: three-day and ten-day programmes on sustainable aquaculture practices, with a focus on 'learning by doing' designed to emphasise practical and field-oriented classes alongside theoretical discussion on site. In addition, non-residential programmes on scientific aquaculture are conducted as day-long sessions for local farmers. Kalong-Kapili organises workshops, exposure visits, special lectures, interaction meetings and knowledge-exchange programmes by invited speakers for the benefit of stakeholders, including undergraduate and postgraduate students, entrepreneurs, hatchery owners, progressive farmers and smallholder farmers. Kalong-Kapili has trained more than 30,000 stakeholders and indirectly reached more than 100,000 people.

Trainees learn both sustainable aquaculture and climate resilient farming.

Learning through aquaculture field school for women participants.

Learning through aquaculture field school for participants sponsored by NABARD.

Integrated tribal development project.

Empowering women through three days residential training.

Empowering women through training.

Truck loaded fish feed supplied by CIFA to distribute fish farmers.

CIFA distributed fish feed to farmers.

Learning through aquaculture field school for student participants.

Aquaculture resource generation: potential impact of Kalong-Kapili

Kalong-Kapili owns 20 hectares of water area used for fish cultivation. In 2024, it produced fish seeds comprising 1.32 billion spawn, 630 million fry and 530 million fingerlings. With its guidance, farmers practise cultivation of high-yielding varieties including Jayanti rohu, rohu, improved catla, freshwater prawn, pabda, chital and amur carp with Indian major carps (IMC). It is also promoting single stocking with multiple harvesting, multiple stocking with multiple harvesting, and multiple stocking with cycling harvesting. It has extended support to flood-prone and drought-affected areas. It has advised farmers to stock seed at 8,000-10,000 per hectare for cultivation periods of 8-10 months. IMC is harvested when individual fish reach 1.0 kg, which costs Rs 300 (US$3.65). Farmers harvest on average 5,000 kg per hectare, which is economically beneficial.

CIFA's aquaculture outreach programme through Kalong-Kapili

CIFA began implementing a government of India scheme for developing aquaculture and improving livelihoods of people in poverty. Activities include identifying beneficiaries, providing skill training and supplying critical inputs such as fish seed, fish feed and other materials to under-privileged people in unreached areas to demonstrate the benefits of scientific fish culture. With help from Kalong-Kapili, CIFA selected 200 farmers for this programme who own water bodies in West Karbi Anglong, Assam. Previously, people in that area were forest-dependent dwellers who did not practise agriculture. They collected forest resources including non-timber forest products to sustain their livelihoods. Kalong-Kapili trained them in aquaculture practice and CIFA provided key aquaculture inputs. Each beneficiary received 1,000 IMC fingerlings and 100 kg of fish feed. Final harvest is awaited. Karbi Anglong possesses potential water resources for aquaculture as a community practice, guided by Kalong-Kapili. The demonstration of scientific practices is expected to generate interest among other people in the region and boost fish production.

Conclusion

The adoption of innovative and improved fish farming approaches supports sustainable livelihoods among people in the north-eastern region of India. This is essential for mitigating environmental threats posed by intensification and commercialisation of aquaculture. Sustainable aquaculture is gaining attention and is regarded as a means of providing aquatic protein, balanced nutrition and livelihoods for small-scale farmers in India. Sustainable aquaculture ensures ecological balance and environmental conservation. Addition of more fish to household diets promotes nutritional security and improves dietary quality. Aquaculture serves as a central focus for consistent income generation through community-driven sustainable practices, as demonstrated in the north-eastern region by Kalong-Kapili. With technical support from CIFA, Kalong-Kapili guides farmers in adopting polyculture and composite fish farming integrated with plant crops and animal husbandry that recycles farm resources as fertiliser inputs from multiple crops. Since its inception, Kalong-Kapili has championed the causes of people in poverty. By joining forces with this organisation, CIFA has expanded its aquaculture outreach efforts considerably. Newer approaches to aquaculture, tailored to the north-east region, are finding greater acceptance by people and, as a consequence, bringing positive changes to their livelihoods.

Acknowledgements

The authors thank the Indian Council of Agricultural Research, Department of Agricultural Research and Education, Government of India for support of this programme. The authors acknowledge the Director, ICAR-CIFA for encouragement to write the article. The authors thank Mr Jyotish Talukdar, Director, Kalong-Kapili, for providing information and images, and Mr P. P. Chakrabarti, former Principal Scientist, ICAR-CIFA, for information.

ICAR-CIFA distributing fish seed to farmers.

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AquaInnovate 2: Scaling nature-based solutions and regional synergy in Bangkok

AquaInnovate participants.

The momentum for aquaculture transformation continued in Bangkok as AquaInnovate 2 convened from 23–27 March 2026. Building on the success of the inaugural event, this second iteration brought together a fresh cohort of entrepreneurs, scientists, and industry leaders in Bangkok to accelerate nature-based solutions and climate innovation across the Asia-Pacific. Organised by NACA and FutureFish, with support from Canada's IDRC, the week served as a high-intensity bridge between scientific breakthrough and commercial viability.

A Global Stage for Regional Talent

The week opened with a series of high-impact pitch presentations by 12 startups and entrepreneurs:

- Thailand's Innovation Hub: Presentations were by Karnchana Karnchanamayoon (Siam Farm Services Co., Ltd), Patipond Tiyapunjanit (AQUAWISE), and Tuchakorn Lertwanakarn (Kasetsart University).
- Biotech & Microbiology: Scientific breakthroughs were pitched by Patai Charoonnart (BIOTEC, Thailand), Warangkhana Songsungthong (BIOTEC, Thailand), and Trinh Thanh Trung (Institute of Microbiology and Biotechnology, Vietnam).
- Regional Scaling: International perspectives were brought by Vijaya Molli (Aquavida Tech, India), Nguyen Van Nguyen (APOTEC-RIA2, Vietnam), and Jiosese Tale (Kerry Farms Fiji Ltd).
- Social & Community Enterprise: Solutions focused on impact were presented by Hector Abes (Kaizen Aquaventure Inc., Philippines), Hilarie P. Orario (De La Salle University, Philippines), and Jonathan Brenes (Yunus Thailand)

Deep Dives and Expert Coaching

The second day shifted focus toward the "AquaLead" curriculum, where industry veterans led sessions on four critical pillars:

- Nature-Based & Climate Innovation: Led by Rebecca McMillan (IDRC) and Edward Allison (WorldFish).

- Social Impact & Community Engagement: Interactive sessions led by Sizwile Khoza (SEI) and Callum Mackenzie (Yunus Thailand Foundation).
- Business Fundamentals: Operational strategies presented by Chris Aurand (Space-F).
- Investing for Impact: Insights into attracting mission-aligned capital from Patti Chu (Mana Impact) and Chris Justice (Tathva).

The afternoon featured Expert Coaching Circles, where participants rotated through small-group sessions to receive bespoke advice on their specific business models and technical challenges.

From Lab to Farm: Practical Immersion

Theory met practice on the third day during field visits to two innovative Thai aquaculture sites:

- Manit Farms: Participants explored large-scale operations and received an introduction to modern farm management and innovation adoption.
- Family farm visit: A dedicated session on seaweed cultivation and its role in sustainable coastal livelihoods.

Into the Shark Tank

The immersive experience continued at The Food School on Day 4, where the program's focus shifted from operational theory to market reality. In a high-stakes "Shark Tank" session, the innovators pitched their refined value propositions to a panel of established business leaders and investors. This exercise forced participants to defend their commercial viability and impact strategies in a professional incubator environment.

Following the pitches, the focus moved from the boardroom to the kitchen for a "Thai fish demonstration and cooking event". Moderated by Thanisorn "Orb" Chanthaphan, a renowned specialist in sustainable seafood, this session underscored the critical link between sustainable production methods and the exacting standards of the culinary industry.

The day's activities highlighted a core truth for aquaculture startups: technical innovation alone is rarely enough for market penetration. By engaging directly with culinary experts, the innovators learned that a product's success often depends on the endorsement of influential buyers, such as leading chefs, whose selection of a brand not only validates its quality but serves as the ultimate catalyst for consumer recognition and premium market positioning.

Looking Ahead: The AquaHub Vision

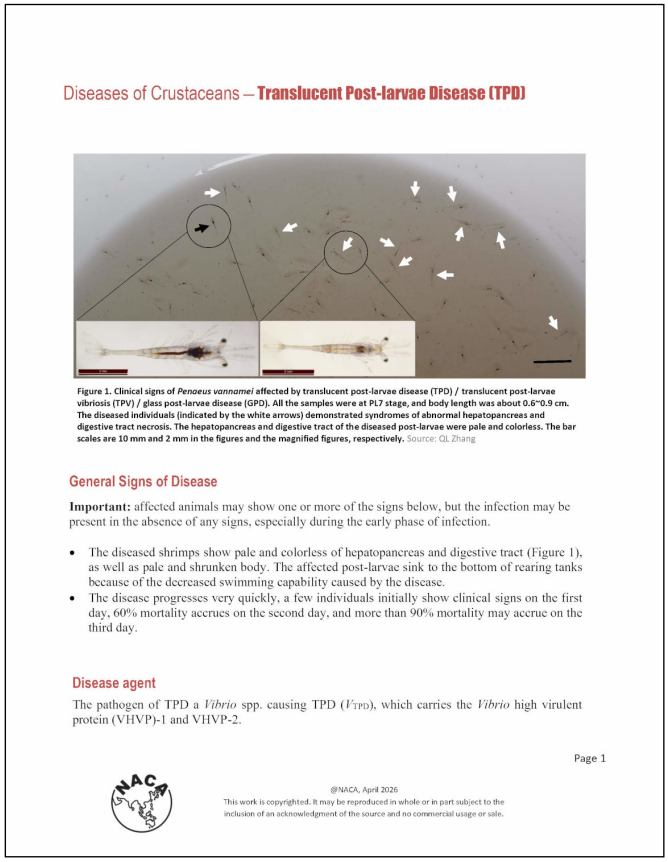
The workshop concluded with a "Lessons Learnt Journey," where participants drafted action plans and critical priorities for their ventures. Regional reflections from the Pacific and Thailand emphasized the need for continued cross-border collaboration.

The final session unveiled the AquaHub Vision for 2026 and Beyond. This roadmap outlines a permanent support process and a digital platform designed to ensure that the innovations sparked during the week grow into a resilient, pan-regional ecosystem for sustainable aquaculture.

Videos will be available shortly

Videos of the workshop presentations from the workshop are in preparation and will be available on the NACA website and YouTube channel.

Translucent post-larvae disease (TPD): Disease card



Diseases of Crustaceans – **Translucent Post-larvae Disease (TPD)**

Figure 1. Clinical signs of *Penaeus vannamei* affected by translucent post-larvae disease (TPD) / translucent post-larvae vibriosis (TPV) / glass post-larvae disease (GPD). All the samples were at PL7 stage, and body length was about 0.6~0.9 cm. The diseased individuals (indicated by the white arrows) demonstrated syndromes of abnormal hepatopancreas and digestive tract necrosis. The hepatopancreas and digestive tract of the diseased post-larvae were pale and colorless. The bar scales are 10 mm and 2 mm in the figures and the magnified figures, respectively. Source: QL Zhang

General Signs of Disease

Important: affected animals may show one or more of the signs below, but the infection may be present in the absence of any signs, especially during the early phase of infection.

- The diseased shrimps show pale and colorless of hepatopancreas and digestive tract (Figure 1), as well as pale and shrunken body. The affected post-larvae sink to the bottom of rearing tanks because of the decreased swimming capability caused by the disease.
- The disease progresses very quickly, a few individuals initially show clinical signs on the first day, 60% mortality accrues on the second day, and more than 90% mortality may accrue on the third day.

Disease agent

The pathogen of TPD a *Vibrio* spp. causing TPD (V_{TPD}), which carries the *Vibrio* high virulent protein (VHVP)-1 and VHVP-2.

Page 1

This disease card provides an overview of translucent post-larvae disease (TPD), a highly infectious and lethal disease known (thus far) to infect *Penaeus vannamei*, *P. chinensis* and *P. japonicus* mainly in post-larvae of four to seven days age (PL2~PL7). TPD can cause morbidity of up to 60% in 24 hours after clinical signs and up to 90-100% mortality in severe cases on the second to third day.

This card details the causative agent (a *Vibrio* spp. carrying the *Vibrio* high virulent protein VHP-1 and VHVP-2), host range, geographical distribution, epidemiology, prevention and control measures, histopathology, molecular diagnostics, expert contact and references.

- Download the disease card

Strengthening the partnership: NACA welcomes new Director General of Thai DOF

Dr Thitiporn Laoprasert (right), Director General of the Thailand Department of Fisheries, and NACA DG Dr Eduardo Leaño

NACA paid a courtesy visit to Dr. Thitiporn Laoprasert, the newly appointed Director General of Thailand's Department of Fisheries (DOF), to chart a course for enhanced regional cooperation. This high-level meeting served as both an official welcome for the new Director General, although she has contributed to NACA activities for many years, and a strategic session to align regional goals with Thailand's national fisheries expertise.

Decades of foundational support

During the visit, Dr. Eduardo Leano, Director General of NACA, extended his appreciation for Thailand's unwavering commitment to the organisation. For over thirty-five years, Thailand has played a pivotal role as the host nation for the NACA Secretariat, providing the essential infrastructure and administrative support that allows the network to function as a hub for aquaculture innovation across the Asia-Pacific.

Addressing modern challenges

Dr. Laoprasert outlined a forward-thinking agenda centered on driving innovation and efficiency of the aquaculture industry for regional food security. Recognising the economic pressures facing producers, she called for a collaborative push in R&D to drive down costs for producers.

Priority areas for collaboration

The discussion identified four pillars for cooperation:

- Climate resilience: Developing strategies to protect the aquaculture sector against the increasing unpredictability of climate change.
- Social equity: Actively promoting gender equality and inclusive practices within the industry workforce.
- Nature-based solutions: Integrating ecological health with economic output.
- Knowledge brokering: Expanding the "Aquaculture Innovation and Investment Hub" to streamline how new technologies reach local farmers.

Looking ahead: The AquaHub hub

The partnership is already yielding tangible results through the documentation of nature-based solutions. The Thai DOF team is currently identifying indigenous innovations that will contribute to a new AquaHub initiative, a regional aquaculture innovation and investment hub, ensuring that Thai expertise continues to shape the transformation of aquaculture throughout Asia-Pacific.

Turning Guidance into Action Insights from the FAO Expert Workshop on Sustainable Aquaculture

NACA recently participated in the FAO Expert Workshop, "Turning guidance into action: regional insights for implementing the Guidelines for Sustainable Aquaculture," held from 24-25 February 2026, in Rome, Italy. As a partner of the Food and Agriculture Organization of the United Nations (FAO), we are pleased to share the outcomes of this event and highlight the path forward for our sector.

A Vision for the Future of Aquaculture

The Guidelines for Sustainable Aquaculture (GSA) represent a major milestone in promoting best practices. Developed through consultations between FAO and its Members, they contain a set of shared and agreed principles, practices and recommendations designed to promote a sustainable aquaculture sector worldwide.

The vision underpinning the GSA is an aquaculture sector that contributes significantly to a world free from hunger and leads to the equitable improvement of the living standards of all actors in its value chains, including the poorest.

To achieve this, the main body of the GSA provides concrete recommendations across four critical areas for the economic, social and environmental sustainability of aquaculture:

- Governance and planning.
- Sustainable resource use, ecosystem and farm management.
- Social responsibility, decent work and gender equality.
- Value chains, market access and trade.

Moving from "What" to "How"

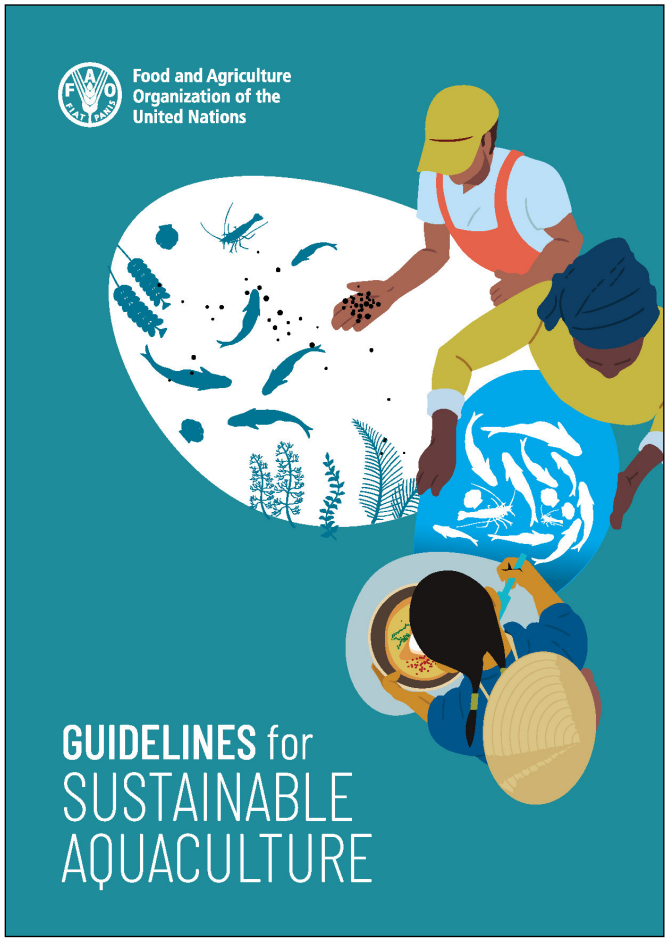
While the GSA clearly articulate what needs to be done to make aquaculture sustainable, the critical next step is supporting stakeholders in understanding how to put these recommendations into practice. This was the driving force behind the Rome workshop.

Building on the momentum of five EU-funded Regional Workshops held across the globe in 2025, the expert gathering aimed to translate regional insights into practical, country-adaptable implementation guidance.

Creating an Enabling Environment

Implementing the GSA requires robust institutional support, coordinated efforts, and effective resource mobilization. The GSA emphasises four main areas to create a favorable environment for policy change:

- Funding and Financing: Expanding access to public and private investments, blended finance, and insurance schemes to support infrastructure and small-scale farmers.



- Research and Innovation: Investing in advanced technologies for climate-resilient systems and incorporating traditional knowledge to improve efficiency and reduce environmental impacts.
- Communication: Utilising effective tools to support informed decision-making and build credibility among stakeholders.
- Capacity Building: Strengthening the skills of all stakeholders through inclusive, long-term participatory interventions, educational opportunities, and financial literacy training.

Developing Practical Tools for Implementation

Translating the GSA from voluntary guidelines into national policies requires practical, on-the-ground resources. To address this, the workshop focused on three core areas to support member states:

The Decision-Support Tool: A major focus of the group work was identifying and preparing elements for a new decision-support tool. This tool will provide a roadmap and a monitoring and evaluation methodology with measurable indicators to help countries adapt the GSA to their specific contexts.

Communication and Outreach: Effective communication is essential for building consensus and countering misinformation about the sector. Participants reviewed the new GSA Communication Handbook and Toolkit, discussing actionable ways to use and share these resources within their own regional networks.

Regional Case Studies: To ensure future implementation is grounded in real-world realities, the workshop gathered expert guidance on developing GSA case studies. These studies will showcase successful approaches and transferable lessons from diverse regions, highlighting what sustainable aquaculture looks like in practice.

The Way Forward

While the GSA are voluntary, they serve as a critical reference for policy and decision-making. NACA encourages policymakers, private enterprises, and community stakeholders to implement and integrate the GSA into their governance frameworks.

The guidelines provide a clear and actionable roadmap. By adapting these principles to our diverse regional and national contexts, we can maximize the sector's contributions to global food security and nutrition, poverty reduction and environmental conservation, ensuring a resilient, equitable and sustainable future for all.

You can download the Guidelines on Sustainable Aquaculture from FAO, along with a fact sheet, policy brief, and communications toolkit at the links below:

- Guidelines for Sustainable Aquaculture
- The Guidelines for Sustainable Aquaculture at a glance (fact sheet)
- Translating the Guidelines for Sustainable Aquaculture into Action (policy brief)
- Guidelines for Sustainable Aquaculture: Communications handbook and toolkit

Advancing global collaboration for sustainable aquaculture

Participants in the FAO Roundtable on the Global Sustainable Aquaculture Advancement Partnership.

in Fuzhou, China

NACA joined international leaders in Fuzhou, China, in March 2026 for two major back-to-back events focused on advancing sustainable aquaculture. Convened by the Food and Agriculture Organization of the United Nations (FAO), the meetings brought together policymakers, researchers, industry stakeholders and development institutions to strengthen collaboration and accelerate implementation of global sustainability frameworks.

The FAO Roundtable on the Global Sustainable Aquaculture Advancement Partnership (GSAAP) and the First FAO-China Fisheries Association (CFA) Joint International Conference on

Sustainable Aquaculture underscored the urgency of coordinated action as the sector continues to expand rapidly while facing mounting environmental and structural challenges.

FAO Roundtable on Upgrading the Global Sustainable Aquaculture Advancement Partnership (GSAAP)

The FAO Roundtable on GSAAP, held 17 March, focused on strengthening the partnership as a key mechanism for implementing the FAO Guidelines for Sustainable Aquaculture and advancing the Blue Transformation agenda.

With global aquaculture production continuing to grow, participants highlighted the need to address persistent constraints, including environmental impacts, disease risks, governance gaps and limited access to technical expertise. Discussions emphasised that scaling sustainable aquaculture will require stronger alignment between policy, science, investment and capacity development.

The roundtable opened with a technical matchmaking session, where countries presented priority needs and GSAAP partners identified opportunities to provide targeted support. This practical exchange demonstrated the Partnership's role in mobilizing expertise and connecting demand with available resources.

In the afternoon, the GSAAP Annual Meeting convened in a roundtable format to examine the Partnership's future direction. Participants engaged in focused discussions on strategic priorities, institutional strengthening and approaches to scaling impact beyond pilot initiatives.

The meeting concluded with agreement on key priority areas for collaboration and a renewed commitment to strengthening GSAAP as a global platform for coordinated action. Participants also underscored the importance of delivering measurable outcomes through stronger partnerships and more effective implementation mechanisms.

First FAO-CFA Joint International Conference on Sustainable Aquaculture, 18–20 March 2026

Building on the momentum of the Roundtable, the First FAO-CFA Joint International Conference on Sustainable Aquaculture brought together a global audience to examine practical solutions for advancing sustainability across the sector.

With aquaculture now accounting for more than half of global aquatic animal production, and Asia contributing the vast majority, participants stressed the sector's central role in food security, nutrition and livelihoods, alongside the increasing pressure to improve sustainability and resilience.

Over three days, the conference featured keynote presentations, technical sessions and panel discussions covering key thematic areas, including sustainable feed systems, seed supply chains, aquatic animal health and innovation. Discussions focused on translating policy commitments into practical action, supported by investment, technology transfer and stronger institutional frameworks.

Regional perspectives and country case studies, including experiences from major aquaculture-producing nations, provided insight into both progress and ongoing challenges. Participants highlighted the importance of integrated approaches that connect research, industry and policy to enable scalable and inclusive solutions.

The conference concluded with a field visit to a local aquaculture facility, offering participants direct exposure to emerging technologies and operational practices supporting sustainable production.

Sustaining Momentum Through Partnership

Together, the two events reinforced the importance of global and regional cooperation in shaping the future of aquaculture. The back-to-back format enabled participants to link strategic discussions on partnership development with technical exchanges on implementation and innovation.

For NACA, engagement in these meetings reaffirmed its role in facilitating regional collaboration and knowledge exchange across Asia-Pacific. The outcomes highlighted a shared commitment among stakeholders to move from dialogue to action, with stronger partnerships positioned as a key driver of sustainable aquaculture transformation.

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the Third and Fourth Quarters of 2025

Reports received in 2025 only came from Australia, Chinese Taipei, Hong Kong SAR, India, Indonesia, Malaysia, Myanmar, the Philippines and Saudi Arabia. Listed below are the reported aquatic animal diseases covering the third and fourth quarters of 2025 (with first and second quarter reports from Chinese Taipei). The original and updated reports can be accessed at the Quarterly Aquatic Animal Disease Report page.

Finfish Diseases

- **Viral encephalopathy and retinopathy (VER):** Australia in farmed seabass (*Lates calcarifer*) and giant grouper (*Epinephelus lanceolatus*); Chinese Taipei in hybrid grouper (*E. fuscoguttatus* x *E. lanceolatus*) and *L. calcarifer*; Indonesia in *L. calcarifer*, humpback grouper (*Cromileptes altivelis*), tiger grouper (*E. fuscoguttatus*), and hybrid grouper; and, the Philippines in roundscad (*Decapterus macrosoma*), pompano larvae (*Trachinotus blochii*), siganid (*Siganus guttatus*), milkfish (*Chanos chanos*), L. calcarifer larvae, and herring (*Sardinella lemura*).
- **Infection with Koi herpesvirus (KHV):** Chinese Taipei in Amur carp (*Cyprinus rubrofuscus*); Indonesia in common carp and Koi carp (*Cyprinus carpio*); and, Malaysia in *C. carpio*.

- **Infection with Megalocytivirus pagrus 1** (incl. RSIV, ISKNV and TRBIV): Chinese Taipei in *L. calcarifer* and largemouth bass (*Micropterus salmoides*) (reported in the first two quarters of 2025); Hong Kong SAR in *E. lanceolatus*; and, Indonesia in hybrid grouper tilapia and pompano (*T. blochii*) (RSIV).
- **Infection with Tilapia lake virus (TiLV):** Indonesia in tilapia (*Oreochromis niloticus*) and gouramy (*Osphronemus gourami*); Indonesia in tilapia (*O. niloticus*); and, Malaysia in tilapia (*Oreochromis* spp.).
- **Grouper iridoviral disease (GIV):** Chinese Taipei in orange-spotted grouper (*E. coioides*), *E. lanceolatus*, and hybrid grouper.
- **Enteric septicaemia of catfish:** Indonesia in *Pangasius* sp. and catfish.

Crustacean diseases

- **Infection with white spot syndrome virus (WSSV):** Chinese Taipei, India, and Malaysia in whiteleg shrimp (*Penaeus vannamei*); Indonesia in *P. vannamei* and black tiger shrimp (*P. monodon*); and, the Philippines in *P. vannamei* and *P. monodon* (PL and grow-out), freshwater prawn (*Macrobrachium rosenbergii*), and mudcrab (*Scylla serrata* and *S. olivacea*).
- **Infection with Infectious hypodermal and haematopoietic necrosis virus (IHHNV):** Australia in farmed postlarvae of in *P. monodon*; and, the Philippines in *P. monodon* (grow-out) and *P. vannamei* (PL, grow-out and broodstock).
- **Infection with infectious myonecrosis virus:** Indonesia in *P. vannamei*; and, Malaysia in *P. monodon*.
- **Infection with infectious myonecrosis virus (IMNV):** Indonesia in *P. vannamei*.
- **Acute Hepatopancreatic necrosis disease (AHPND):** The Philippines in *P. vannamei* (grow-out) and *P. monodon* (PI and grow-out).
- **Hepatopancreatic Microsporidiosis caused by *Enterocytozoon hepatopenaei* (HPM-EHP):** Chinese Taipei in *P. vannamei* (reported in the first two quarters of 2025); India and Indonesia in *P. vannamei*; Malaysia in *P. vannamei* and *P. monodon*; and, the Philippines in *P. vannamei* (grow-out) and *P. monodon* (PL and grow-out).

Molluscan diseases

- **Infection with *Perkinsus olseni*:** Australia in farmed broodstock of green lip abalone (*Haliotis laevigata*).

Amphibian diseases

- **Infection with *Batrachochytrium dendrobatidis*:** Australia in wild white lipped tree frog (*Litoria caerulea*).

Other diseases

- India reported Infection with ***Tilapia parvovirus*** in *O. niloticus*.

Prepared by: Eduardo Leaño, Director General and Senior Programme Officer (Health and Biosecurity)

Scholarships for Master's Degree in Aquaculture and Fisheries, China 2026

The Freshwater Fisheries Research Center (FFRC), NACA's Regional Lead Centre in China, has opened applications for its 2026 Master's Degree Program at Wuxi Fisheries College, Nanjing Agricultural University.

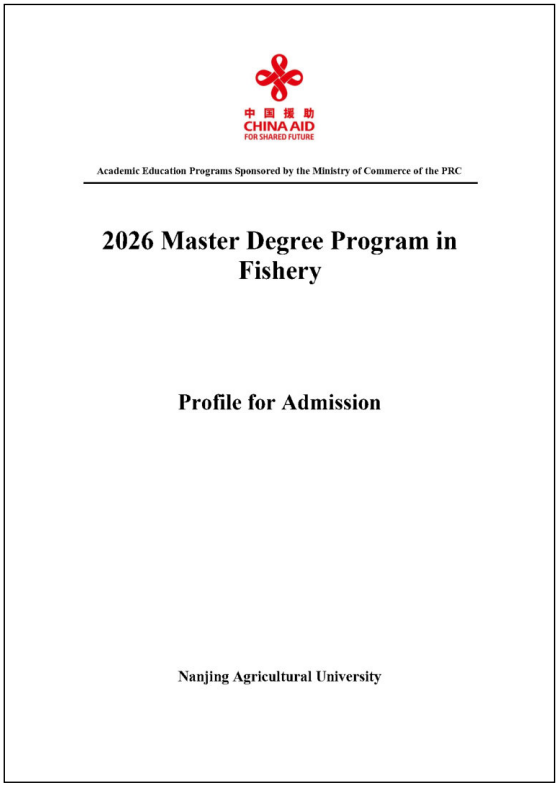
This two-year program is fully funded by the Chinese Government Scholarship and offers comprehensive support to allow students to focus entirely on their studies:

- Full tuition waiver and accommodation
- Living stipend for the entire duration of stay in China
- International airfare covering two round-trip tickets (for enrolment/graduation and home leave/internship)

The program aims to build capacity in aquaculture and fisheries across the region. The application deadline is **6 June 2026**.

For specific admission requirements, curriculum details, and application procedures download the enrollment guide or visit the NACA website at:

- https://enaca.org/?id=1479



Report of the 24th Meeting of the Asia Regional Advisory Group on Aquatic Animal Health

This report summarises the proceedings of the 24th meeting of the Regional Advisory Group on Aquatic Animal Health, held 24-25 November 2025 by video conference. Originally attended by only AG members, co-opted members and few observers, the meeting was again participated by NACA member country representatives, as in the last five years. NACA member countries and territories represented include Australia, Bangladesh, Cambodia, Hong Kong SAR China, India, Malaysia, Maldives, Myanmar, the Philippines, Thailand, and Vietnam

The role of the group is to review trends in disease and emerging threats in the region, identify developments in global disease issues and standards, to evaluate the Quarterly Aquatic Animal Disease Reporting Program and to provide guidance on regional strategies to improve aquatic animal health management.

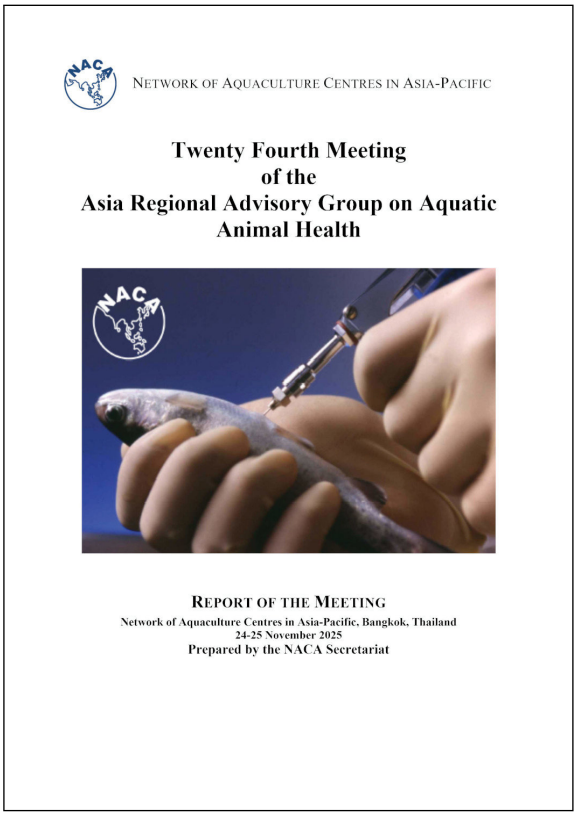
The meeting discussed:

- Progress on NACA's Asia Regional Aquatic Animal Health Programme.
- Updates from the WOAH Aquatic Animal Health Standards Commission.
- Updates from the SEAFDEC Aquaculture Department.
- Aquaculture Biosecurity:
- The hidden highways of death: Critical biosecurity insights for shrimp production.
- Use of environmental DNA (eDNA).
- Advancing the biosurveillance of emerging aquatic pathogens in Singapore with eDNA.
- eDNA for disease detection and to support surveillance program of crayfish plague.
- Updates on Regional Disease Reporting and Disease List.
- Regional aquatic animal disease reporting.
- Proposal for new regional aquatic animal disease reporting system.
- Translucent post-larva disease (TPD): Disease card and endorsement for listing in the regional aquatic animal disease reporting system.

The Advisory Group was established by the Governing Council of the Network of Aquaculture Centres in AsiaPacific (NACA) in 2001 to provide advice to NACA members in the Asia-Pacific region on aquatic animal health management

Members of the Advisory Group presented include invited aquatic animal disease experts in the region, representatives of the World Organisation for Animal Health (WOAH) and the Food and Agricultural Organization of the United Nations (FAO), collaborating regional organisations such as SEAFDEC Aquaculture Department (SEAFDEC AQD) and WOAH-Regional Representation in Asia and the Pacific (WOAH-RRAP), and the private sector.

- Download the report from the NACA website.



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