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AQUACULTURE ASIA

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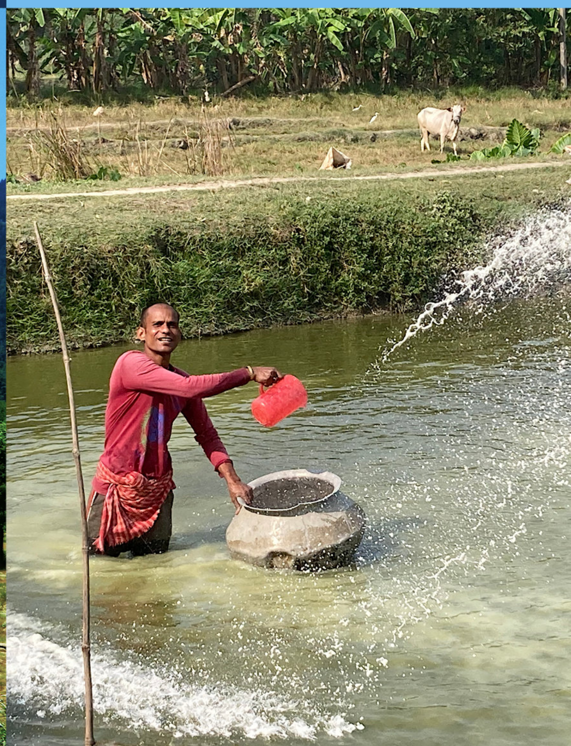
Science-based aquaculture



AQUACULTURE ASIA

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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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Decolonising rural development

In my opinion one of the most common shortcomings of international development agencies is the adoption of a dogmatic approach to development: Rigid or ideological adherence to internal values, priorities, or development models that are allowed to take precedence over the needs and aspirations of the communities they aim to serve.

Although done with the best of intentions, promoting one's own values in communities in other parts of the world without critically assessing their applicability to the local context is an inherently colonial approach to development.

It is at odds with the foundational principle of development assistance: Consultation with local people and communities. To plan an effective intervention, you need to have an (if inevitably, inadequate) understanding of *their* needs, values and aspirations. You need to go there and talk to people and find out how the place works. It is not optional.

The 'why' should be obvious, but I will state it here: Every community is a unique and complicated circumstance of people with competing needs, values, aspirations, interests, alliances, opinions and access to resources. As an outsider, making assumptions about how the place works and what the problems and solutions are isn't going to fly. A 'one size fits all' approach does not work.

Making assumptions about what is needed or wanted leads to misguided interventions that are not appropriate or effective, and that are dropped by communities as soon as funding support is withdrawn. Worse, it also results in misallocation of scarce funding resources that are desperately needed elsewhere.

One of the reasons this happens is the massive power imbalance between funding agencies and poor rural communities. Most cannot afford to say no. They also have a not entirely unreasonable fear of losing out if they offer criticism or seek to deviate from the stated interests of funding agencies.

Even among high-ranking government officials, nobody wants to be the person that scared the donor out of town, because that would be a 'career limiting move' at best, and possibly much worse. Development agencies need to recognise these issues, be sensitive to them, provide avenues for honest and critical feedback, and be mindful that people may not be comfortable - or able - to provide such in a public setting.

The beauty of genuine consultative processes, both formal and informal, is that they are self-correcting: Issues that are legitimately a problem *in the local context* will be raised, and issues that are not, won't. Yes, there will be local power imbalances, veiled interests and marginalised groups or individuals within the community, but the solution to that is to broaden the consultation base.

Approaches to rural development need to be flexible, practical, and grounded in discussion with the communities that will be implementing and benefiting from them. Everyone wants better development projects. The first step is to ask the locals.

Simon Wilkinson

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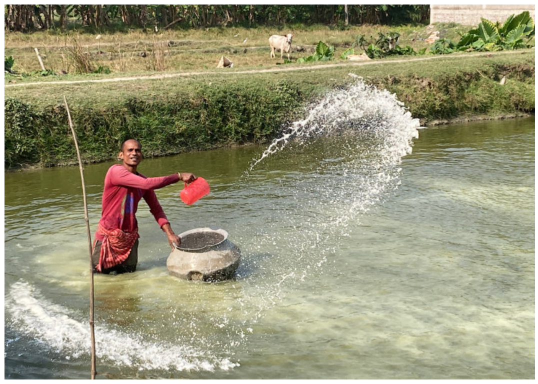

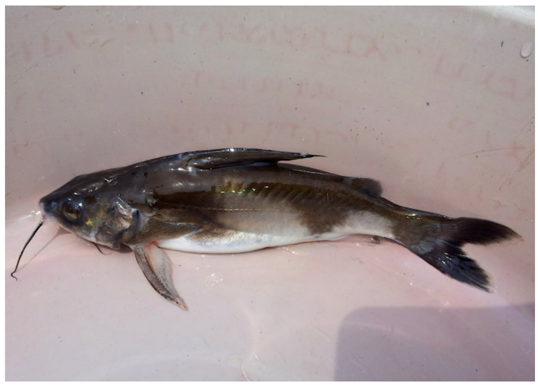

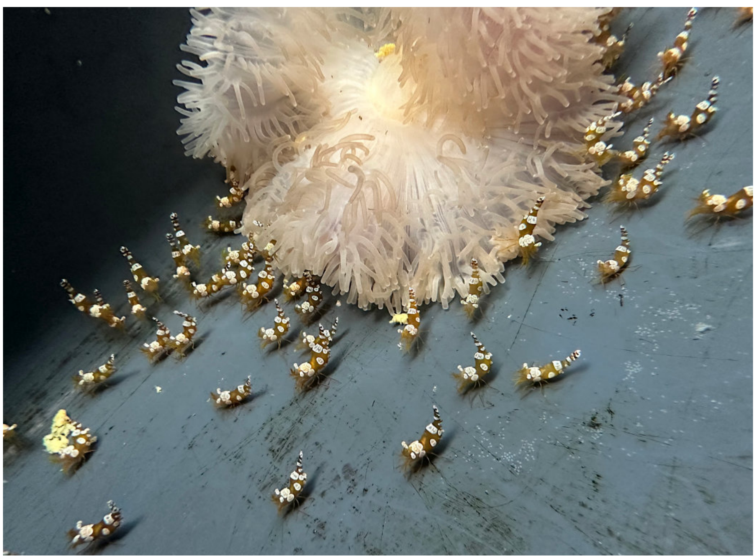

Scientific aquaculture to promote better livelihoods for Scheduled Caste farmers

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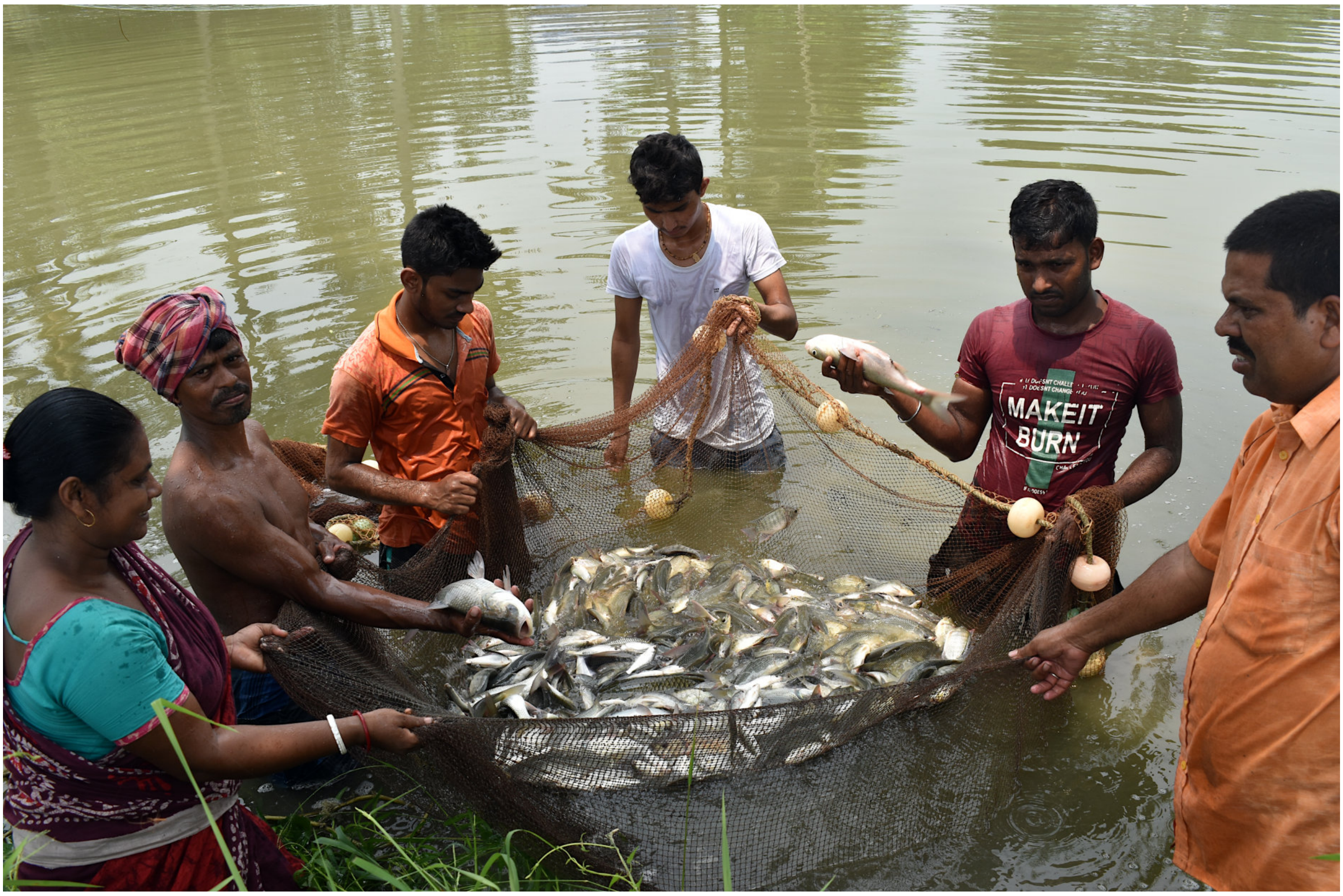
Aquaculture, following technological advancements in traditional practices, has yielded desirable fish crops by increasing productivity per unit of water area. Consequently, it plays a crucial role in sustaining livelihoods for a significant portion of the impoverished population, particularly among Scheduled Caste communities (officially designated as the most disadvantaged socio-economic groups in India).

The Indian Council of Agricultural Research (ICAR), under the Ministry of Agriculture and Farmers' Welfare, Government of India, allocates funds through the Scheduled Caste Sub Plan (SCSP) project. This initiative aims to enhance income generation among marginalised individuals who can be trained and skilled to leverage available resources for crop production. The Central Institute of Freshwater Aquaculture (ICAR-CIFA), a premier research institute in aquaculture, utilises these funds to provide support such as fish seeds, fish feed, lime, and manure to Scheduled Caste farmers. The goal is to enable them to utilise untapped resources, such as available water areas, for fish production.

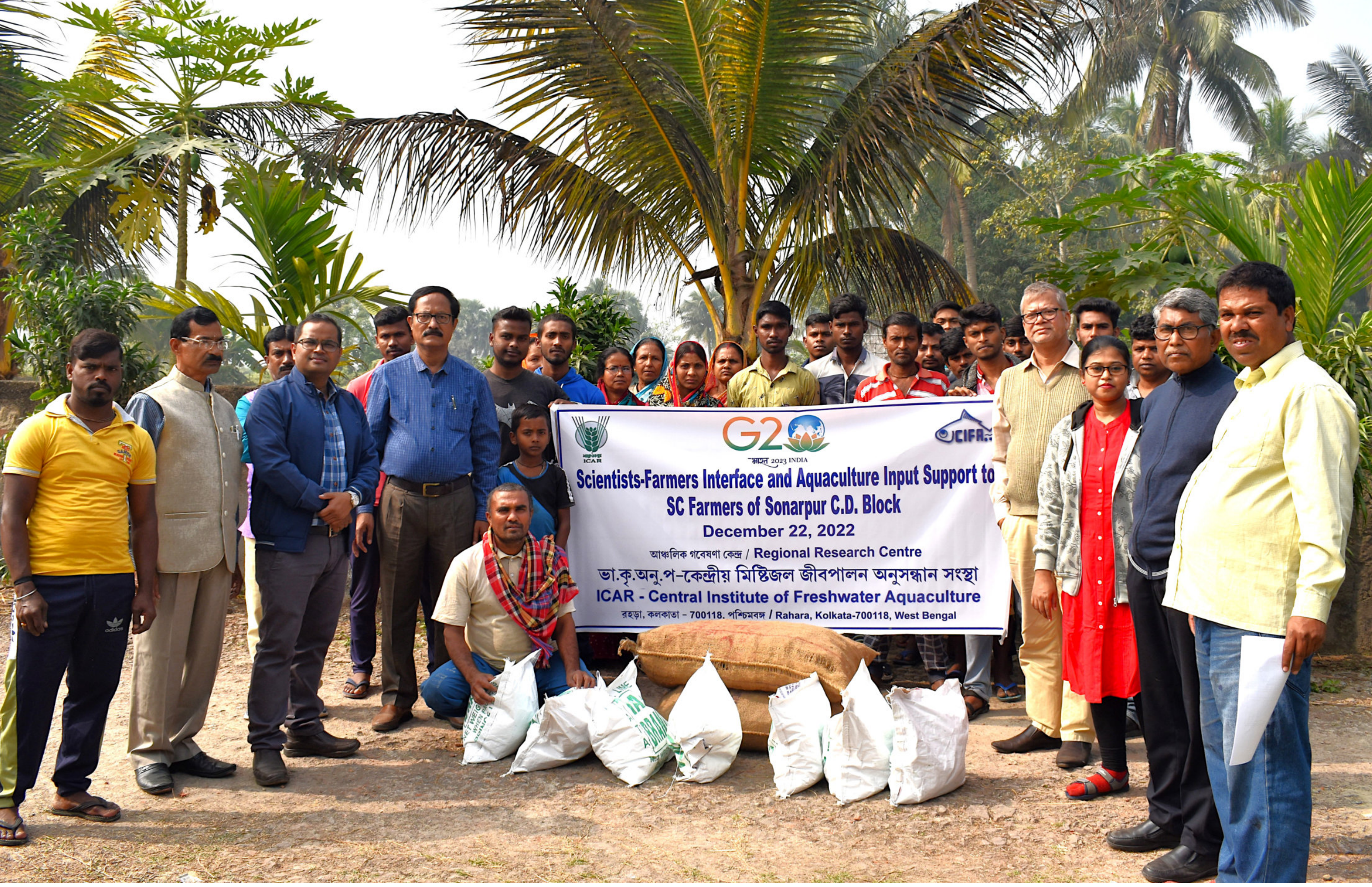
This support in aquaculture inputs has resulted in increased fish production, heightened income, the creation of employment opportunities, the development of skilled labourers and workforces, and a significant contribution to the national income. Marginal fish farmers have consistently generated revenue through these efforts.

Furthermore, aquaculture serves as a source of protein-rich food, contributing to nutritional security. It directly provides poor communities with essential nutrients through fish consumption, promoting health nourishment. Indirectly, it aids in increasing immunity to combat hidden hunger prevalent among impoverished individuals due to a lack of sufficient nutritious foods.

Fish is analysed as a rich source of minerals, vitamins, health-supportive fish oils, and easily digestible bio-available proteins for the human body. The agro-ecological conditions in West Bengal are conducive to fish culture, with farmers traditionally familiar with producing such crops.



The harvest.



Distribution of inputs among fish farmers.

Traditional aquaculture versus scientific aquaculture

Traditional aquaculture involves the production of fish from any available water bodies, relying on knowledge passed down through generations. In contrast, scientific aquaculture requires essential management practices. These include measuring the water area of a pond, draining the pond, removing weeds and predator fishes, fertilising the pond, stocking fish seeds based on water resources, selecting fish species according to niche, determining the ratio of different fish species, producing natural food resources, providing supplementary feeding, monitoring the health of reared fish regularly, and harvesting fish at regular intervals. These activities are conducted using scientific methods, hence the term "scientific aquaculture."

Scientific aquaculture encompasses various approaches depending on the combination of different fish species and their culture practices. Examples include composite fish culture, polyculture, intensive culture, extensive culture, and semi-intensive cultures. Regardless of the specific practice, scientific intervention is crucial to optimise natural resources and achieve a desirable crop yield. There exists a significant disparity between traditional aquaculture and scientific aquaculture in terms of unit area production. Scientific aquaculture has the potential to yield many times more crops than traditional methods, both in terms of total fish yields and unit area production.

Location of scientific aquaculture activities

Our project, titled 'Economic Empowerment and Capacity Building of Rural SC Farm Families in West Bengal through Technological Intervention in Fish Farming,' was implemented in the Kheadah-I Gram Panchayat of the Sonarpur Community Development Block in West Bengal. Kheadah-I Gram Panchayat was chosen due to its significant population of Scheduled Caste residents and the presence of untapped water resources suitable for aquaculture.

Before commencing the project, we conducted a baseline study, gathering data through a structured questionnaire to understand the prevailing aquaculture practices in the community. The questionnaire, prepared in the local language, comprised four sections:

Household information:

- Demographics
- Principal occupation
- Alternative livelihood
- Aadhar number
- SC certificate/identity
- Status of ration card

Resources:

- Water bodies
- Area
- Water holding capacity
- Ownership

Methodology of fish farming:

- Time of pond preparation
- Method of pond preparation
- Pond fertilisation
- Ingredients used for fertilisation
- Production of plankton through pond management

Fish cultivation:

- Fish stocking
- Choice of fish species
- Size of fish species released
- Ratio of different species stocked
- Farming practices
- Supplementary feeding production
- Disease prevalence and monitoring
- Fish growth and development

Harvest

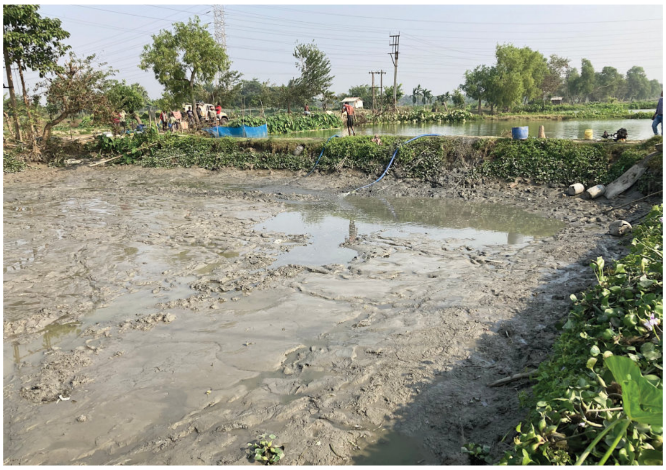
This comprehensive survey aimed to provide a thorough understanding of the existing practices and resources, laying the foundation for effective intervention and improvements in the community's fish farming practices.

Strategy formulation based on collected data

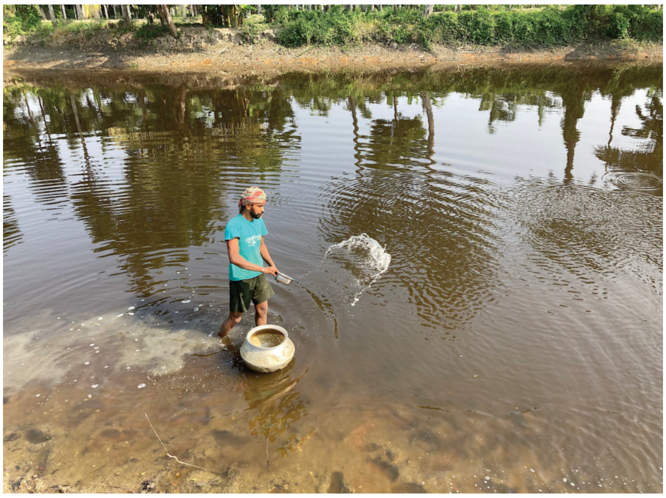
The information gathered through the questionnaire was crucial for understanding the status of stakeholders targeted for the project. It provided insights into their resourcefulness, identified gaps, and discerned whether the challenges stemmed from a scarcity of resources, lack of knowledge, or a combination of both. The following strategies were devised based on the identified gaps to implement scientific aquaculture under the project in the area.

Strategy 1: Pond renovation

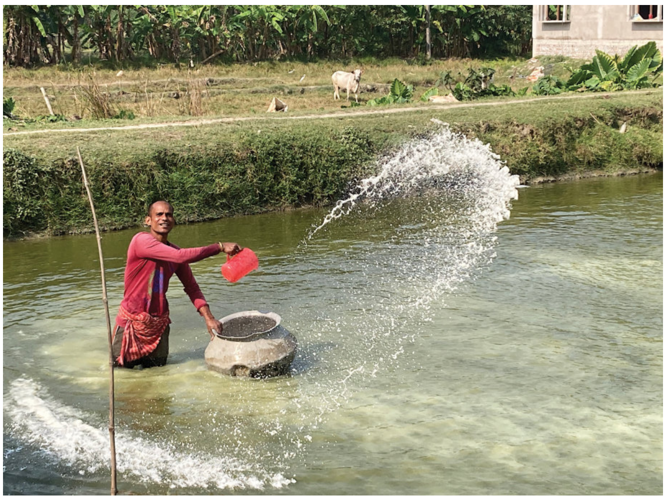
Approximately 80% of the ponds underwent renovation, involving the removal of plants from both the surface and interior. This process improved light penetration and nutrient availability for plankton growth, resulting in a greenish water body due to increased phytoplankton production, followed by zooplankton. The dynamic pond ecology facilitated nutrient recycling, enhancing dissolved oxygen (DO), gross primary productivity (GPP), and the exchange of foods in different trophic levels.



Dewatering of pond prior to scientific aquaculture.



One farmer processing alum for its use in pond water.



Application of lime to maintain pH.

Strategy 2: Analysis of water samples

Water samples were analysed to understand the hydro-biological features of the pond. Physical parameters such as pH, temperature, alkalinity, hardness, DO, and GPP, along with biological parameters like phytoplankton, zooplankton, benthos, and other biotic organisms essential for aquaculture, were examined.

Strategy 3: Fertilisation of pond

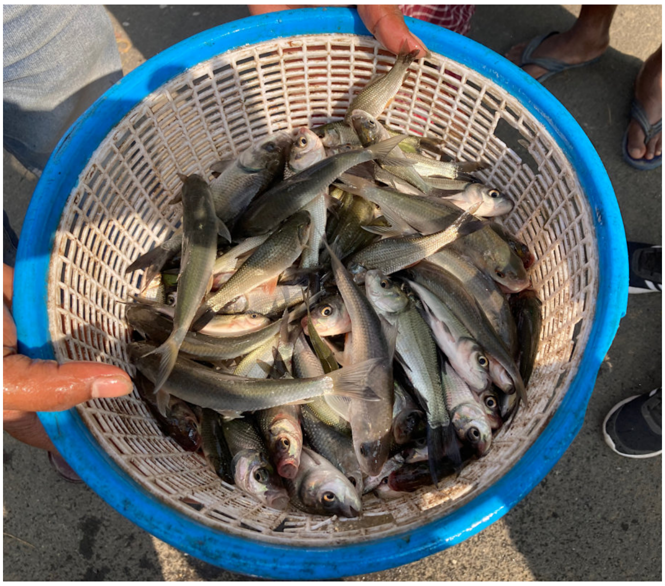
Analysis of water samples identified fertilisation gaps in specific ponds. Accordingly, each pond was fertilised with appropriate amounts of manure, including cattle dung, single super phosphate (SSP), urea, and organic juice. Lime was applied at prescribed frequencies to maintain the pond water pH, with the use of alum when the water was alkaline. These practices aimed at ensuring the sustainable health of the pond through environmental management, supporting plankton growth, and increasing water productivity.

Strategy 4: Fish farming

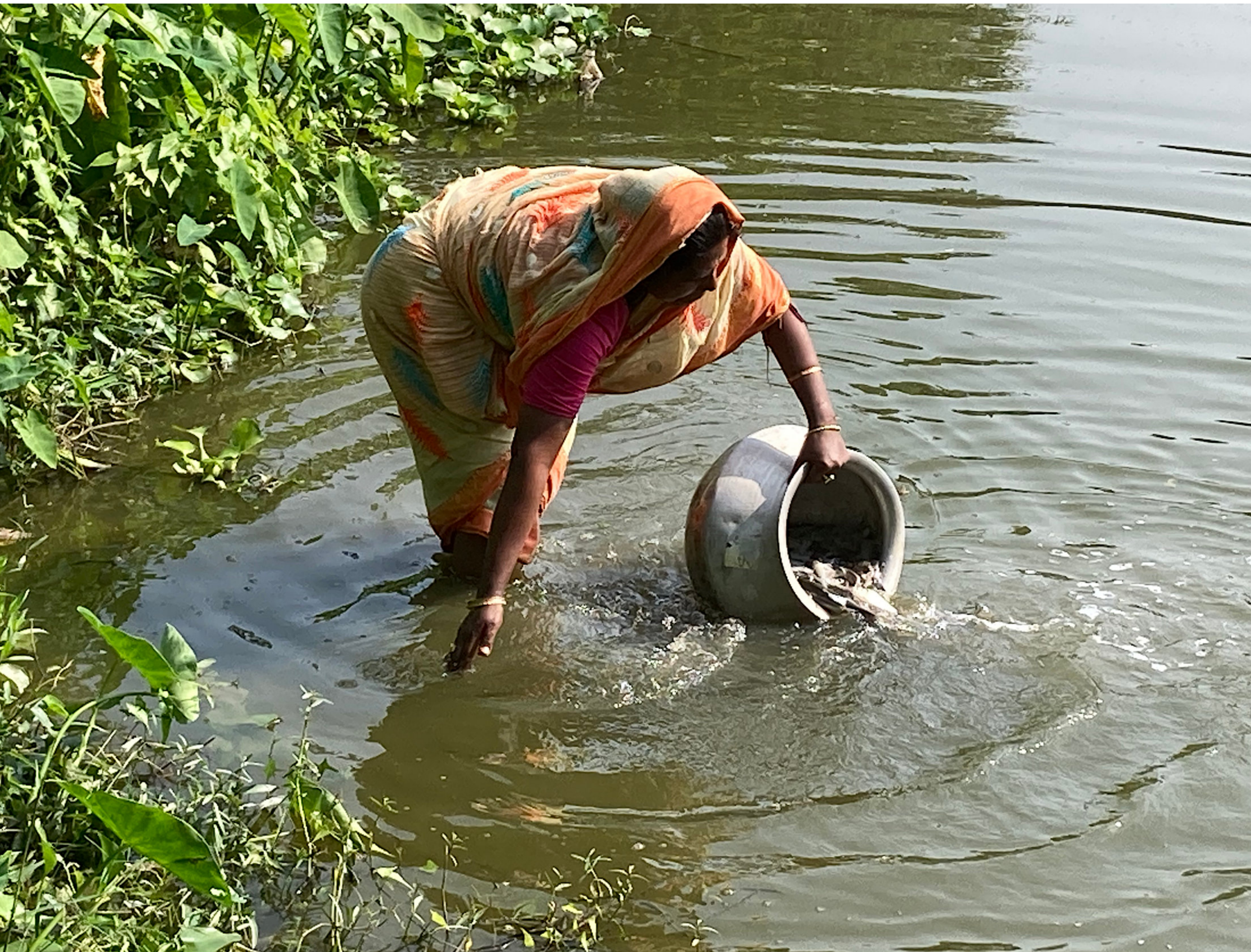
Three species of Indian major carp catla (*Catla catla*), rohu (*Labeo rohita*), and mrigal (*Cirrhinus mrigala*) - were typically chosen for culture. The stocking density was set at 10,000/ha, with an average release of 500 advanced fingerlings in 0.05 ha ponds. The ratio of catla, rohu, and mrigal was maintained at 40:30:30. However, farmers had flexibility in adjusting stocking density and species ratio based on their preferences and pond conditions.

Strategy 5: Management

After fish release, operational management played a critical role. Farmers were actively involved in ‘hands-on training’ through demonstrations, including feeding fish at 3% of their body weight, maintaining live plankton populations, monitoring water quality, and surveillance of fish diseases. Regular



Fish seed supplied as an input support.



Beneficiary releasing fish seed in her pond.

fortnight sampling was conducted for growth measurement, contributing to farmers' education on scientific aquaculture practices.

Strategy 6: Benefits for encouragement

The project demonstrated significant benefits, with fish growth and yields surpassing farmers' expectations from traditional aquaculture. Successful farming led to nutritional security, enhanced skills in scientific aquaculture through demonstrations, a clear understanding of the differences between scientific and traditional practices, enthusiasm for adopting this culture as a livelihood, and assured earnings. The successful farming model was transferable for replication among others.

Culture practice in earthen ponds

The culture practice in earthen ponds relies on natural fish food production through pond manuring and fertilisation, supplemented by additional feeding. Three key management practices—pre-stocking, stocking, and post-stocking—were adopted to optimise fish production.

Pre-stocking management

Pond preparation

Selected ponds underwent preparation through dewatering, desilting, manual removal of aquatic weeds (floating, submerged, or emergent), and elimination of unwanted and predatory fishes. Mahua oil cake was applied at the rate of 2,500 kg/ha/meter depth water (250 ppm) as a fish toxicant in the pond bed.

Vegetation management

Long trees on pond dykes were trimmed to allow sunlight into the pond water, enhancing primary productivity.

Water source and filling

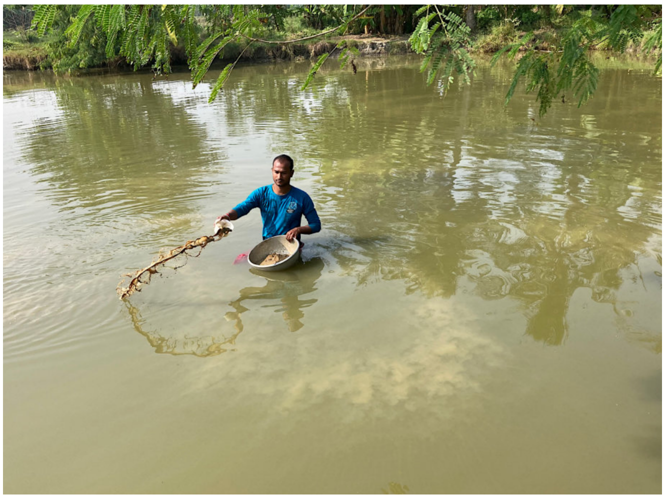
In the absence of inlets and outlets, ponds were filled with water sourced from nearby canals, the primary water source for aquaculture in the region. The water level was maintained at 1.5 - 1.8 meters.

Liming

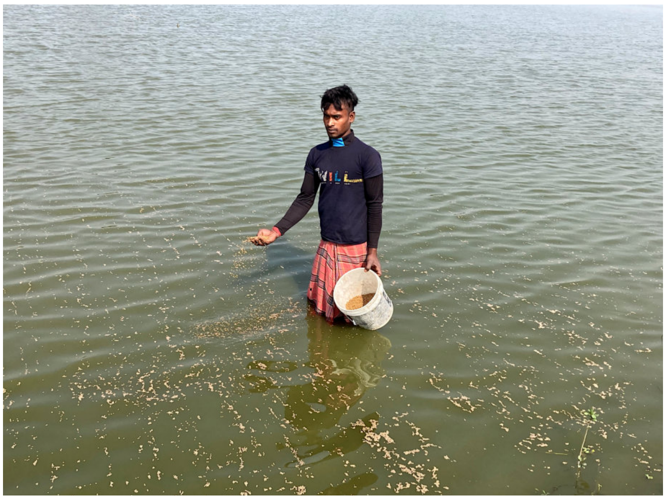
Liming was carried out at a rate of 200 kg/ha^{-1} to maintain standard pH and pond water hygiene. Liming reduced water turbidity, promoting photosynthesis of phytoplankton, and enhancing dissolved oxygen (DO) and gross primary productivity (GPP).

Alum application (for alkaline water)

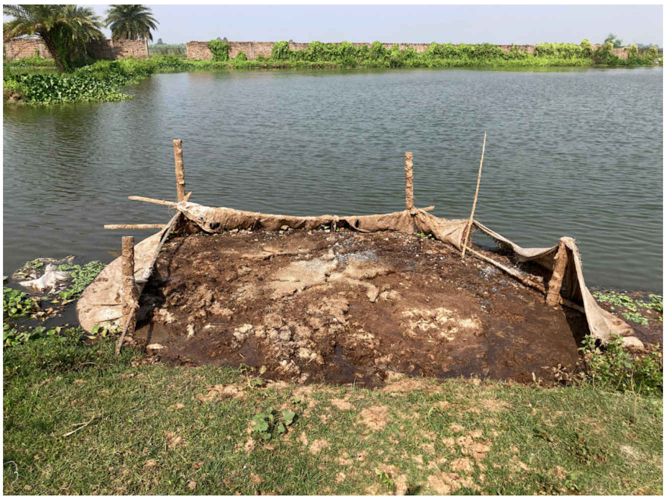
In cases of alkaline water, alum was applied to manage excess nutrient loads and turbidity.



Application of mustard oil cake to fertilise pond.



Broadcasting pellet feed.



Cattle dung along with single super phosphate and urea mixture kept in one place for slow release of nutrients into pond water for plankton production.

Manuring

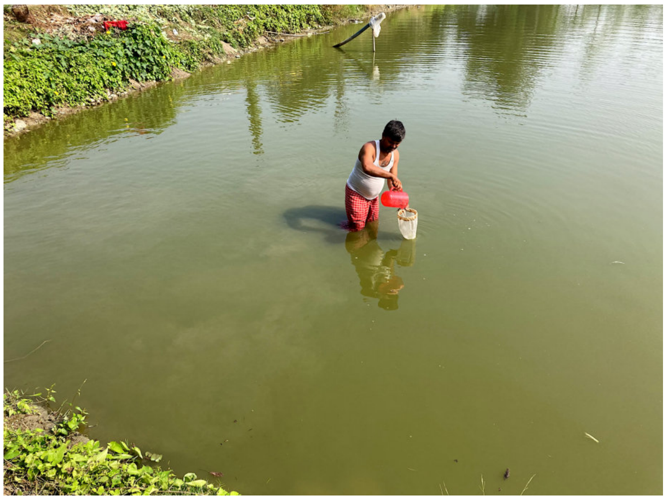
Depending on soil and water quality, ponds were manured with a combination of organic and inorganic fertilisers. Cow dung was applied at 2,000 kg/ha as a basal dose about one week after liming. Inorganic fertilisation with single super-phosphate followed two weeks after organic manuring.

Stocking of seed

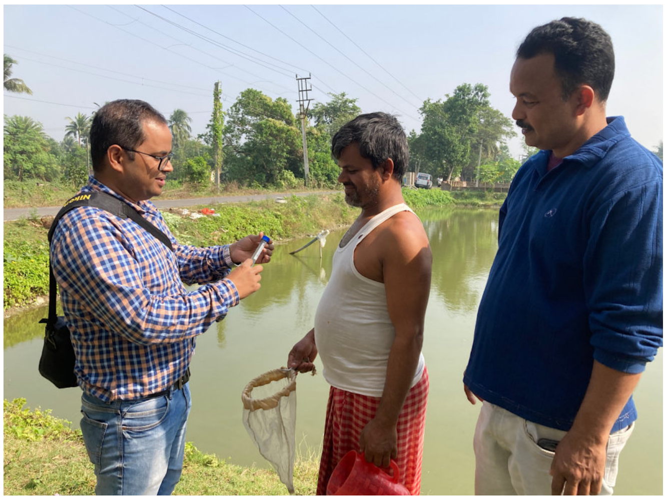
Stocking of fish took place one week after the application of organic manure. This timeframe allowed for the neutralisation of organic acids released during the decomposition of organic manure. Fingerlings of catla, rohu, and mrigal, each weighing approximately 40 g, 25 g, and 25 g, respectively, underwent a dip treatment with 3% potassium permanganate or 2 to 3% common salt solution before being released. The stocking density was set at 10,000 fish per hectare for one minute. Fish seed was reared for 6-8 months using a single stocking and multiple harvesting method in a three-species (catla, rohu, and mrigal with a ratio of 4:3:3) polyculture system, considering their popularity and acceptance.

Post-stocking management

A daily feed mixture of wheat bran and mustard oil cake in equal quantities (1:1 ratio) was applied to feed the fishes, with occasional supplementary feeding using pellet feed. The feed mixture was applied at a rate of 2.5-3% of the fish body weight in perforated bags or trays fixed on bamboo poles, while pellet feed was broadcast in the pond. Cow dung was applied in monthly batches at 1 tonne/ha, kept in one place surrounded by jute cloth to continuously supply nutrients into the pond water, promoting plankton growth. Depending on pond productivity, organic fermented juice (rice bran and molasses in a 3:1 ratio, with 10g yeast powder) and single super phosphate (SSP) were applied at monthly intervals, alternating with cow dung, to regulate plankton production. Periodical netting was conducted monthly to monitor the growth and health status of the cultured fish. Occasional bottom raking, using a rope fixed with several bricks dragged from one end to the other, was performed to remove toxic gases from the pond bottom and improve its environment.



Farmer measuring plankton in his culture pond.



Arabinda Das, Scientist, guides farmers on how to quantify plankton.

Fish growth, production, and economy

After three months of rearing, the mean total length of the fish increased to 21.8 cm ± 10.1 from the initial length of 12.5 cm ± 2.0, and the mean weight increased to 124.8 g ± 46.7 from the initial weight of 22.7 g ± 10.1. Approximately 30-40% of the stock, with a mean weight of 150g fish, was harvested through repeated nettings after 4 months of culture. A partial harvest of 1,323 kg fish was conducted from a total water area of 2.45 ha. The mean body weights of catla, rohu, and mrigal after six months of culture were 426 g, 320 g, and 257 g, respectively, with an overall mean size of 345 g. Following the final harvest (4,564 kg), the total fish production reached 5,887 kg during the 6-7 months of culture. The mean productivity (kg/ha/year) was 3,604 in the scientific culture compared to 2,125 in the traditional system, resulting in a mean increase of 1,479 kg higher production (including an average consumption of 3-7 kg fish per month) due to scientific aquaculture. The calculated net profit was Rs. 216,997.

Conclusion

Scientific aquaculture has significantly increased fish yields in a sustainable manner. The adoption of the improved method of composite fish culture by the untapped resource-rich Scheduled Caste fish farmers have positively impacted the economy of their farming system, providing them with a better livelihood. The benefit-cost ratio was calculated as 1:20. Such farming approaches can contribute to climate-resilient aquaculture and robust fish production systems, ensuring food security, environmental preservation, women's empowerment, and increased control for peasants over their lands. This approach may serve as a model for replication in areas where untapped water resources are underutilised, ponds lack systematic fertilisation, and human resources require appropriate training on adopting scientific aquaculture for optimal resource utilisation. Scientific aquaculture, requiring not only substantial input support but also the judicious use of available resources, timely monitoring, and the creation of an enthusiastic environment to skill human resources for adopting such farming practices.

Acknowledgment

The authors express their gratitude to Dr. P.K. Sahoo, Director of ICAR-CIFA, for granting permission to conduct this project under the SCSP. Special appreciation is extended to Mr. Pabitra Sarkar and Mr. Kundal Pal, Research Scholars, for their valuable assistance and contribution to the success of this project.

Rainbow trout in Jammu and Kashmir: Present status and strategies for expansion

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Jammu and Kashmir, often referred to as "heaven on Earth," owes its distinct soil and vegetation to its unique climate. With abundant green forests and high-altitude terrain, it boasts valuable natural resources such as Himalayan glaciers and rivers.

Among these resources are fast-flowing cold-water streams, unspoiled lakes, winding rivers, natural springs, and high-altitude lakes. At the heart of this ecosystem is the Jhelum River, originating within the valley itself and formed by the contributions of its various tributaries. These include the Sindh, Liddar, Vishav, Dudhganga, Shaliganga, Pohru, Erin, and Madhumati rivers. The Jhelum River is deeply intertwined with the valley's landscape and plays a central role in its ecology.

The region has a total of 30,000 hectares of inland water bodies, consisting of 27,781 km of rivers and canals, 70,000 hectares of reservoirs, 17,000 hectares of tanks and ponds, and 6,000 hectares of floodplain lakes/derelict waters (Ayyappan et al., 2011). These aquatic environments create a favourable climate for a wide variety of plants and animals to thrive, supporting diverse fish species, including both warm-water and cold-water varieties. Predominantly, fish species from families such as Salmonidae, Cyprinodontidae, Sisoridae, Siluridae, Cyprinidae, and Cobitidae are found in the water bodies of Kashmir (Mir et al., 2020).

In the Kashmir region, there are approximately 447 kilometers of streams, 486 kilometers of rivers, and around 157 square kilometers of lakes (Sodhi et al., 2013). In the upper headwaters of the Jhelum drainage, there are robust populations of

A picturesque view of the Lidder catchment, Kashmir.

Trout fish farming project, Kokernag.

both native and non-native coldwater fish species. Among the non-native species, brown trout and rainbow trout have not only adapted to this environment but are also being bred and raised in captivity.

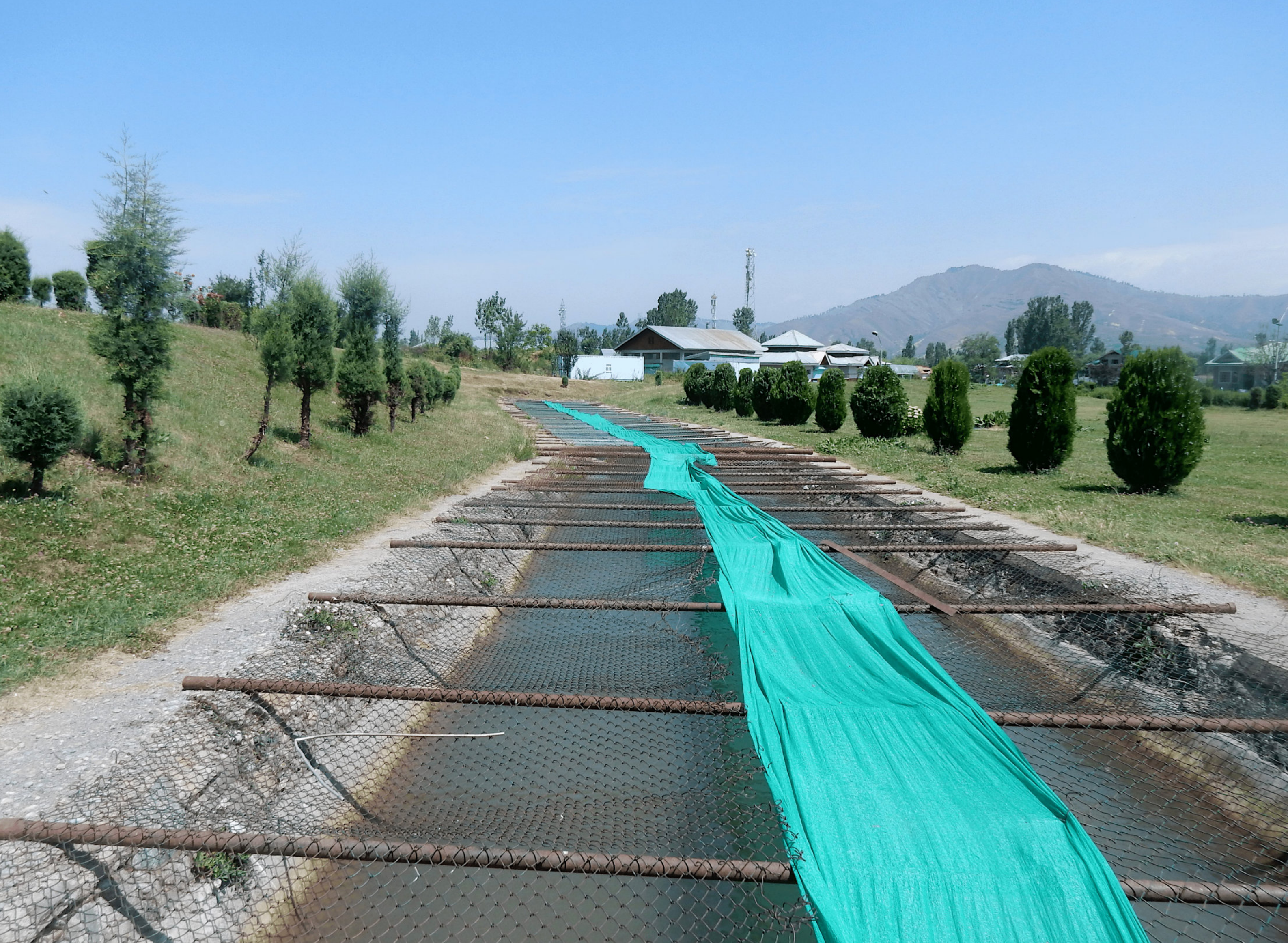
Rainbow trout originally hail from the rivers and lakes that drain into the Pacific on the west coast of North America, with their habitat ranging from Mexico in the south to Alaska in the north (MacCrimmon, 1971). Since the 1880s, rainbow trout have been cultivated and introduced into rivers and lakes outside of their native range, most notably through farming at the McLeod River and San Leandro hatcheries in California. These two hatcheries are the primary sources of artificially bred rainbow trout found across the globe. Rainbows have also been introduced to numerous other countries, where they often establish self-sustaining, wild populations. Today, rainbow trout can be found on every continent except, of course, Antarctica.

Rainbow trout, scientifically known as *Oncorhynchus mykiss*, was initially classified by Walbaum in East Asia (Kamchatka) in 1792. However, over time, various other Latin names were attributed to rainbow trout by different researchers. In 1988, the American Fisheries Society officially recognised rainbow trout as a species, adding the original name *mykiss*.

Rainbow trout is a promising cultivable fish species in cold water and holds significant potential for expansion. As a high-value commodity with relatively low production volume, trout offers opportunities for both domestic consumption and foreign export. However, the development and scaling of trout farming in the region has not yet been realised on a large scale. Trout culture demands more input resources compared to other fish species for survival and growth. The feasibility of achieving desired production levels hinges on several factors, including seed quality, feed availability, health management, and environmental considerations. To succeed in trout production, it is imperative to significantly improve management practices.

Rainbow trout introduction to Kashmir valley

The history of trout fisheries in Kashmir traces back to 1898 when Mr. Frank Mitchel, a Scotsman, with the assistance of Pandit Sodhama Miskeen and Khwaja Gafarjoo, introduced trout to the region. Operating a carpet factory in Srinagar during the late 19th century, Mr. Mitchel was inspired by Kashmir's serene and unspoiled water resources to introduce trout to its aquatic ecosystem. His motivation was to attract more tourists to the area by enhancing its natural appeal.



A typical raceway in Kokernag trout farm, Anantnag.

The initial batch of 10,000 trout eggs arrived from the U.K. in 1899, courtesy of the Duke of Bedford. This gift came after the Kashmir Maharaja had presented a magnificent Kashmir Stag trophy to the Duke through Sir Adelbert Talbot, the British Resident at Srinagar. Mr. Mitchel's first attempt at trout culture took place near his factory at Bagh-e-dilwar Khan in Srinagar, where he collaborated with a local, Sodhama Miskeen. Unfortunately, half of the trout eggs perished during transit due to the absence of airplanes at that time, necessitating transportation by sea route. The journey involved rail travel to Rawalpindi from Bombay and then a bus ride to Srinagar, with frequent water changes that led to the loss of half the stock during transit. Despite the initial setback, a subsequent attempt in 1900 proved successful.

The second shipment of trout eggs arrived from Scotland in December 1900, in excellent condition, thanks to Mr. J.S. Macdonall. This shipment included 1,800 fry, with 1,000 of them being transferred to Panzagam Dachigam (Harwan), approximately 24 km from Srinagar, and the remaining 800 fry being reared at a private carpet factory owned by Mr. Mitchel in Baghi Dilawar Khan, located in the heart of the city near Khank-i-Moulla. This marked the inception of trout culture in the valley. However, in 1903, a devastating flood hit Kashmir, resulting in the loss of all trout at the Harwan hatchery. Disheartened by this setback, Mitchel and Sodhama temporarily discontinued their efforts.

One day, Mr. Mitchel noticed brown trout in Ferozpur Nallah near Tangmarg actively leaping out of the water to feed on insects. Encouraged by this success, Mr. Mitchel resumed his work at Harwan. He successfully persuaded Maharaja Pratap Singh to establish a Fisheries Department in Jamu and Kashmir and became its first Director. He appointed Mr. Sodhama as the first inspector and Mr. Gaffarjoo as the first guard. By 1908, brown trout (*Salmo trutta*) was firmly established in the valley, with several fishing areas created in the streams for angling enthusiasts.

In 1908, a hatchery was constructed in Achabal within the Anantnag District. Subsequently, in 1912, they acquired eyed ova of Rainbow trout, then known as *Salmo gairdneri*, from Bristol Water Works. At the Achabal hatchery, nearly one thousand alevins (advanced fry) were hatched. Eyed ova of brown trout were also obtained from Achabal hatchery and distributed throughout Kashmir. Following the successful introduction of both Brown and Rainbow trout, the Fisheries Department of Jammu and Kashmir attempted to import eyed-ova (seed) of Eastern brook trout (*Savelinus fontinalis*) from Canada, land-locked salmon (*Salmo salar*) from the USA, and Splake trout, a hybrid of brook trout and lake trout from Canada. Unfortunately, these efforts did not lead to the establishment of these fish species in Kashmir waters. Over time, the department procured shipments of eyed ova from various European countries to enhance the existing fish stock within the state. However, due to a lack of adequate infrastructure and the necessary expertise in stock management, the desired outcomes could not be achieved. The summarised introduction of trout in Kashmir waters is mentioned in Table 1.

Distribution

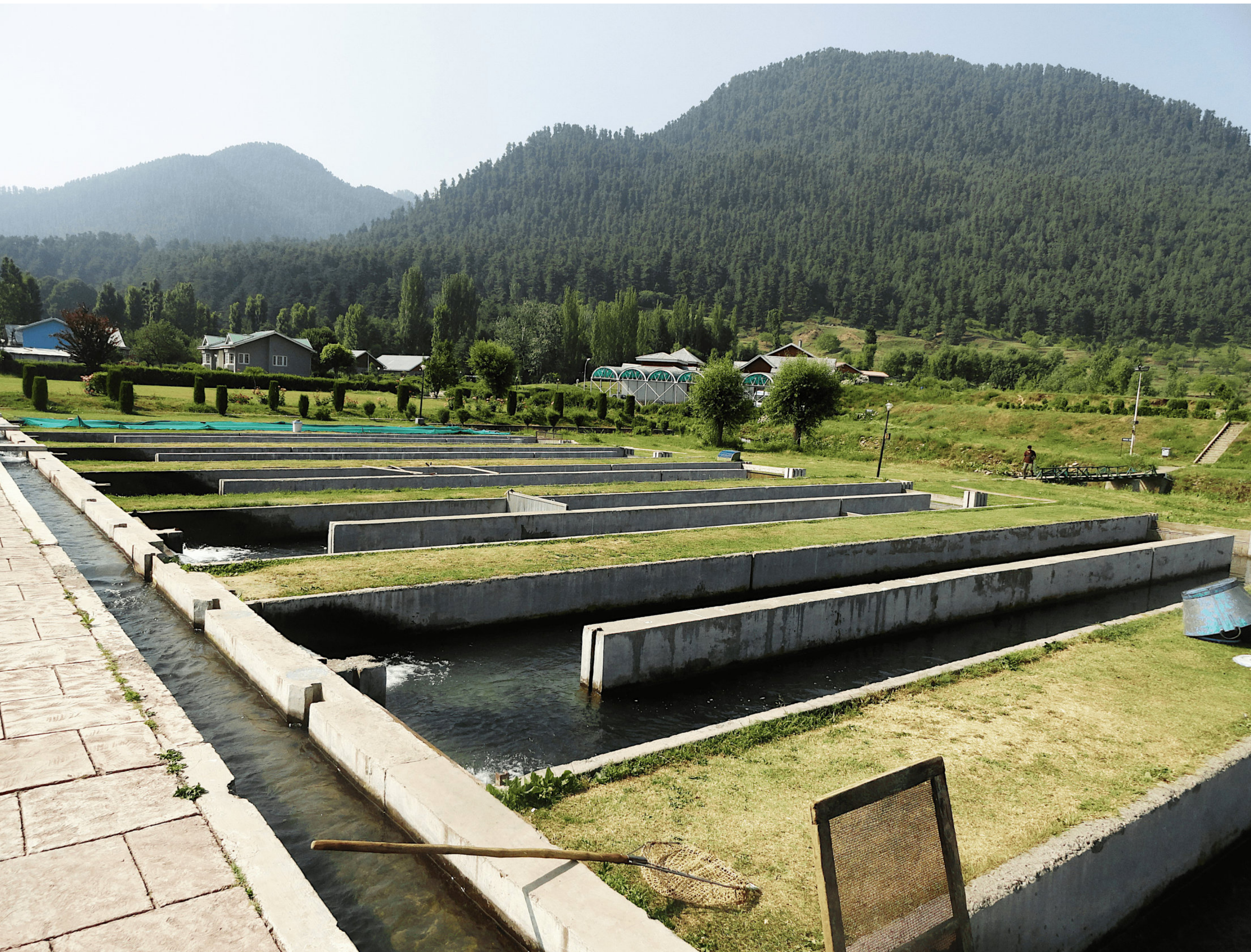
Once it became clear that trout could thrive in the Kashmir Valley, the potential for trout breeding in numerous local water bodies became evident. In response to this opportunity, the ambitious rout Fish Farming Project was initiated at Kokernag in collaboration with the European Economic Community. This collaborative effort led to the establishment of the Kokernag trout farm in 1984, which has since become the primary source for producing high-quality rainbow trout and brown trout seed in the region.

Before this development, the Maharaja of Kashmir received numerous requests from other princely states seeking both trout seed and expertise to introduce the fish into their fast-flowing streams, which were essential for the trout to flourish. Consequently, Pt. Sodhama undertook journeys to various locations such as Nilgiris in the South, Himachal (then part of Punjab), Uttarakhand (then part of Uttar Pradesh), and Muree (now in Pakistan) to facilitate the introduction of trout in those areas.

Trout are known to thrive in cold, clear streams and lakes characterised by high oxygen levels and minimal vegetation. These conditions are abundant in the Himalayas and other southern mountain ranges, making it an ideal setting for trout culture. As a result, many water bodies in the valley were stocked with trout, including snowfed streams like Bringhi, Lidder, and Sindh, which are tributaries of the Jhelum River, as well as spring-fed streams like Verinag, Kokernag, and Achhabal. Furthermore, trout were introduced into high-altitude lakes such as Gangabal, Vishensar, Kisenar, Satsar, Gadsar, Sheshnag, and Kounsarnag. Consequently, all these water bodies now boast well-established trout populations.

The introduction and stocking of trout were not limited to the water bodies of the Kashmir Valley alone but extended to the coldwater streams of the Jammu division as well. This initiative aimed to capitalise on the abundant coldwater resources available in the region and attract tourists. Significant water bodies in the Jammu division, including Dhaggar Nallah in Kathua District, Kirchi Stream in Daddu-Basantgarh of Udhampur District, Thanala in the upper reaches of Neeru Nallah in Doda District, Fember Nallah, Keshwan Nallah, Singhpura Nallah, and Marwah-Wardwan Nallah in Kishtwar District, Budhal in Rajouri District, Bhadora Stream, and Sui-Devta Nallah in Reasi District, as well as Mohu-Mangat and Kheet streams in Ramban District, were stocked with trout.

A typical representation of American style raceways in Kokernag.



An inlet feeding channel to the Asia's Largest trout fish farm, Kokernag.

In recent times, due to the rapid expansion of rainbow trout farming, which includes both the production of trout eggs and table-sized trout, Kashmir has emerged as a potential supplier to meet the demand for trout eyed ova from neighboring countries like Myanmar and Bhutan. Additionally, various hilly states within India, including Himachal Pradesh, Sikkim, Uttarakhand, and Arunachal Pradesh, have shown interest in acquiring trout from Kashmir. These regions possess favorable climatic conditions for trout cultivation. The goal is to assist them in building their trout stocks and achieving self-sufficiency in trout farming and production.

Trout farming infrastructure in Jammu and Kashmir

In Jammu and Kashmir, there are currently nine operational hatcheries that serve as both seed producers and breeding projects. Among these, seven are in the Kashmir region, specifically at Laribal (Srinagar), Kokernag (Anantnag), Shookababa (Baramulla), Mammer (Gandarbal), Khag (Budgam), Tchancer (Kulgam), and Panzeth (Anantnag). The remaining two hatcheries are situated in the Jammu division, with one in Rajouri District and the other in Doda District at Phailini and Bheja, respectively. These hatcheries play a vital role in meeting the seed requirements for trout rearing units, both public and private. Notably, the Kokernag and Laribal trout hatcheries have a combined production capacity exceeding 15 million eyed ova per year. The breeding and seed production at these facilities adhere to modern scientific practices to ensure the well-being and survival of the brood-stock and young trout.

Over the past decade, the trout farming industry in Jammu and Kashmir has undergone a significant transformation, particularly with the government's decision to permit private sector involvement. In the 2019-20 fiscal year, just before the COVID-19 pandemic, 534 farmers collaborated to produce a total of 650 tonnes of trout. Fast forward to 2022-23, and the industry has witnessed substantial growth, with the active participation of 1,144 farmers. This remarkable expansion represents an impressive increase of over 200%, resulting in a total production of 1,990 tonnes of trout.

Most of these trout farming units are located in the Kashmir region, mainly due to its favorable climate, pristine cold water resources, and suitable topography—a prerequisite for successful trout farming. Trout farming primarily relies on cemented tanks known as raceways, and artificial feeding is crucial to meet the dietary needs of cultured fish. Therefore, ensuring the availability of nutritionally balanced feed is paramount for the growth and survival of the fish. To address the feed requirements of both public and private trout farmers, Jammu and Kashmir has established three trout feed mills in key locations within the Kashmir region. Among them,

Table: 1. Dates of trout introduction to Kashmir.

Fish species	Place	Introduction	Source	Present status
Brown trout, *Salmo trutta fario*	Kashmir	1899-1900	UK, Howeiton, Scotland	Established
Rainbow trout, *Onchorhynchus mykiss*	Kashmir	1912	England	Established
Brook trout, *Salvelinus fontinalis*	Kashmir	1960	Canada	Disease incidence lead to the total loss of stock
Splake trout (cross between the lake trout *Salmo trutta lacustris* and eastern brook trout)	Kashmir	1960	Canada	
Land-locked salmon, *Salmo salar*	Kashmir	1960	USA	Poor results from breeding and ultimately lead to loss
Rainbow trout, *Onchorhynchus mykiss*	Kashmir	1984	Isle of Man, England	Established but mixing with previous stocks
Rainbow trout, *O. mykiss*	Kashmir	1985	Isle of Man, England	
Rainbow trout, *O. mykiss*	Kashmir	1986	Isle of Man, England	
Rainbow trout, *O. mykiss*	Kashmir	1989	Denmark	
Rainbow trout, *O. mykiss*, genetically modified	Kashmir	2019	Aquasearch, Billud, Denmark	Established

the Kokernag and Laribal feed mills operate conventionally, while the Manasbal feed mill has been fully modernised. The modernisation of the Manasbal feed mill was made possible through an import from Holland, with support from the National Fisheries Development Board (NFDB). This advanced facility boasts a production capacity of 1 tonne per hour.

The establishment of the modern Manasbal feed mill has played a pivotal role in enhancing the department's ability to produce high-quality trout feed. This development has not only led to improved feed conversion rates but has also contributed to the production of healthier and more marketable trout. Additionally, the trout feeds, namely PerforMAX-S and PerforMAX-G, developed and formulated by ICAR-DCFR, Bhimtal, have played a significant role in strengthening the sector. These feeds have demonstrated favorable outcomes in trout nutrition, leading to improved egg quantity, size, and uniformity, ultimately resulting in higher survival rates in hatcheries. This progress underscores a strong commitment to enhancing the efficiency and sustainability of the trout farming industry in the region. Through collaborative efforts involving the fisheries department, government bodies, research institutions, and public-private partnerships (PPP), Jammu and Kashmir is making substantial strides in advancing trout farming in the country.

Holistic development of agriculture and allied sectors: Key objectives for strengthening the fisheries industry

In 2022, a programme was initiated to enhance the fisheries and aquaculture sector in Jammu and Kashmir. This programme, known as the "Holistic Development of Agriculture and Allied Sectors," is designed to bring about a comprehensive transformation in the fish farming industry in the region. The overarching goal of this ambitious endeavour is to achieve multiple key objectives, which include significantly boosting trout and carp production, generating employment opportunities, and fostering economic development.

One of the primary goals of this project is to revolutionise fish farming by increasing annual trout production from the current 1,990 tonnes to an impressive 4,000 tonnes, effectively tripling the output. Additionally, the programme seeks to incorporate an extra 1,200 tonnes of carp production each year. This strategic approach is designed to shift the dynamics of the local fish market significantly, reducing reliance on importing approximately 5,000 tonnes of fish from other regions. By achieving these production targets, the programme anticipates a significant surge in local commerce. The project also envisages the creation of 6,050 jobs and the establishment of 150 new enterprises. This significant boost in employment opportunities and entrepreneurial ventures is poised to have a profound impact on the socio-economic landscape of the UT J&K. The fisheries sector will emerge as a key contributor to employment generation and overall economic development.

A particularly ambitious aspect of the program is its aspiration to elevate the growth rate of the fish sector from the current 3.28% to an astonishing 40%. This unprecedented rate of growth, if realised, would position the fisheries sector as a dynamic engine of economic progress in the region. Achieving such rapid expansion would undoubtedly require meticulous planning, investments, and innovation, but the additional revenue generated can be reinvested in further enhancing the infrastructure of the fisheries sector, modernisation, and sustainability efforts, ensuring long-term growth and resilience.

It is of utmost importance for this initiative to prioritise sustainable practices and environmental considerations. Responsible and eco-friendly approaches to fish farming will be crucial to prevent any adverse effects on local ecosystems and water bodies. This way, the program can ensure not only economic growth but also the preservation of the environment. To achieve its goals, the program must focus on developing critical infrastructure, including fish farms, hatcheries, processing facilities, and efficient transportation networks. Embracing modern technology and adhering to best practices in the industry will be instrumental in achieving the ambitious targets set forth in the program.

Furthermore, market development and robust distribution channels will be vital to absorb the increased fish production and ensure it meets consumer demand. Building and maintaining a sound regulatory framework is equally essential to govern the sector effectively, addressing issues related to quality control, hygiene, and sustainability.

Conclusion and expansion strategies

The valley of Kashmir offers an ideal environment for culturing rainbow trout. However, when compared to other forms of aquaculture in the region, trout farming is relatively elemental. Despite its potential as a sustainable means of utilising the valley's abundant cold water resources, there is a need to enhance trout farming by adopting modern and sustainable approaches to expand and develop the industry. Numerous challenges are associated with trout farming, including limited access to seasonal water resources, adverse environmental conditions due to global warming (such as high summer temperatures), insufficient availability of fish seed and feed, expensive transportation costs, restricted financial support, and growing competition for resources like land and water due to urbanisation. Consequently, a comprehensive approach is required to encourage both horizontal and vertical growth in trout production across the region. Key priorities include enhancing the productivity of existing operations through the application of scientific advancements in trout farming and marketing:

- Selecting suitable locations for trout farming by utilising remote sensing and GIS-based tools, while also taking into account the historical context of the area, to ensure efficient utilisation of water resources.

- Modernising existing trout farms by incorporating contemporary information and digital technologies, such as sensors and digital monitoring systems, coupled with AI and IoT to enhance operational efficiency, data-driven decision-making, and resource management.

- Adapting farming techniques to harmonise with the unique attributes of the surrounding environment and prevailing conditions in the area. This involves adopting a finely tuned and site-specific approach that considers factors like water availability and quality, temperature, precipitation, elevation, and the availability of market infrastructure. The goal is to implement farming practices that are efficient and environmentally sustainable.

- Engaging in scientific investigations and experiments aimed at enhancing genetic traits in trout, formulating advanced and nutritious feeds, and refining methodologies for more efficient trout production. The aim is to continuously improve the quality and sustainability of fish farming practices, leading to better yields and healthier trout.

- Creating a vertically integrated production system that engages private stakeholders. This involves setting up a comprehensive production system where various stages of the trout farming process, from seed production and culture to processing and distribution, are interconnected and managed with the involvement of private sector participation.

- Applying scientifically robust methods and techniques for precise disease identification, thorough understanding, and effective treatment within the rainbow trout population. Additionally, the development of specific disease-resistant and disease-free rainbow trout varieties is imperative to proactively mitigate or minimise losses attributed to diseases. Achieving this goal requires the concurrent establishment of disease-free environments to prevent outbreaks and financial losses in rainbow trout farming.

- Adoption of cluster farming models to encourage collaboration among farmers. It represents a strategic initiative to stimulate greater cooperation and synergy among trout growers, fostering collaboration within farming communities to enhance productivity and sustainability. This approach brings farmers together, encouraging joint efforts in areas such as resource sharing, knowledge exchange, and collective decision-making. Through this approach, the collective potential of farmers can be harnessed, leading to improved yields, efficient resource utilisation, and the development of trout growing communities.

- Creating the necessary infrastructure to facilitate efficient supply chains and add value to products. This involves establishing the physical and logistical framework required to streamline the production, distribution, and processing of goods, ultimately enhancing the overall value and competitiveness of products.

- Harnessing information and communication technologies to disseminate technical knowledge and provide farmers with valuable market insights and expertise. This involves utilising digital tools and platforms like mobile apps, online platforms, and data analytics systems to facilitate the exchange of knowledge on best practices, innovative techniques, and up-to-date market information. Ultimately, this empowers farmers to make informed decisions, enhance productivity, and adapt to changing market conditions.

- Enacting policy reforms specifically designed to offer financial support to trout growers through means such as loans, subsidies, and price regulation. These changes in government policies and regulations aim to create a more conducive environment for trout farmers, ensuring their access to affordable credit, financial aid, and mechanisms to stabilise trout prices.

- Readiness to adjust to the challenges posed by climate change and respond effectively to natural disasters. This involves developing strategies and implementing measures that enable individuals, communities, and organisations to cope with the evolving impacts of climate change and effectively manage the aftermath of natural disasters. For instance, in the context of trout farming, preparedness for climate change involves specific steps. These include adopting resilient farming practices such as establishing alternative water sources, reinforcing the structural integrity of raceways, and creating auxiliary water channels. Additionally, diversifying farming methods through integration with livestock, horticultural crops, and different fish species contributes to adaptability. The implementation of water conservation techniques, like constructing recharge pits and utilising traditional rainwater harvesting structures known as “chal khals,” further helps mitigate the impacts of shifting weather patterns.

Moreover, being prepared for natural disasters entails comprehensive disaster response plans. These plans encompass securing essential equipment such as water motors, oxygen cylinders, and maintaining vehicles for swift response during emergencies. Backup power sources also play a crucial role in ensuring continuous operation. Early warning systems are another vital component, including the deployment of water level sensors in the inlet stream, geotechnical and seismic sensors in and around the farm, as well as automatic weather stations. These systems are complemented by well-organised response teams and mobile alert notifications.

Furthermore, community training initiatives are fundamental in enhancing resilience and reducing the consequences of events like flash floods, landslides, and earthquakes. Educating the local community about disaster response and preparedness fosters collective efforts and ensures everyone is well-prepared to face unexpected challenges.

Acknowledgement

The authors extend their heartfelt gratitude to the Director, ICAR-DCFR, Bhimtal, for generously providing the essential resources required for the documentation of this study. Furthermore, the authors wish to express their profound appreciation to the dedicated trout growers, as well as the officials of the Fisheries Department, Jammu and Kashmir. It is their invaluable cooperation and willingness to share vital information that have been instrumental in the successful completion of this work. Their contributions have greatly enriched and enhanced the quality of this research, and for that, the authors are truly thankful.

References

Ayyappan, S., Jena, J.K., Gopalakrishnan, A. and Pandey, A.K. 2011. Handbook of Fisheries and Aquaculture. Indian Council of Agricultural Research, New Delhi.

Sodhi, A.S., Saroch, J.D. and Verma, J. 2013. Fisheries Resources of Kashmir: A case study of river Jhelum. Journal of Chemical, Biological and Physical Sciences, 3(2): 11941200.

Mir, S.A., Gul, S., Mir, I.N., Qayoom, U and Mushtaq, Z. 2020. Trout culture in Kashmir: An economical venture for young entrepreneurs. Aquastar. (Accessed on 14.08.23).

MacCrimmon, H.R. 1971. World Distribution of Rainbow Trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada, 28(5), 663–704. doi:10.1139/f71-098.

Community participation in marine ornamental aquaculture: An integral approach on livelihood empowerment of islander women and conservation of reef ecosystems at the Lakshadweep Islands, India

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Promoting and encouraging community participation in marine ornamental aquaculture presents an alternative approach to enhancing the economic status of marginalised individuals, particularly women, in the Lakshadweep islands, India. Additionally, it aids in curbing the wild capture of marine ornamental organisms, thereby relieving pressure on natural resources. This initiative is spearheaded by the ICAR-National Bureau of Fish Genetic Resources as part of a socio-economic endeavour aimed at offering nature-based solutions for conserving and managing wild ornamental organisms. The coral reef ecosystem, the largest living marine repository, harbours an incredibly diverse range of species, crucial for sustenance, income, and cultural identity. Nevertheless, this intricate and productive ecosystem faces threats from both natural occurrences and human activities, prompting concerns regarding its sustainability and resource management (Dammannagoda, 2018).

The article examines the strategy of community-based marine ornamental aquaculture and its significance in bolstering the economy of islanders, particularly women, in the Lakshadweep Sea. It seeks to investigate effective approaches to promote the sustainability of the coral reef ecosystem in the region. The initiative is guided by the following objectives: (a) conservation of marine biodiversity, (b) sustainable utilisation of biodiversity, and (c) equitable sharing of benefits arising from this initiative.

High-value marine ornamental organisms, such as fishes and shrimps, are cultivated in community aquaculture units using simplified technology. These organisms are supplied to aquarists and hobbyists, thus supplementing the income of local women islanders.

Community aquaculture unit with beneficaries.

An overview of the marine ornamental fish trade

The marine ornamental fish trade industry has generated an estimated 5.4 billion USD, with a projected compound annual growth rate (CAGR) of 8.5% from 2022 to 2023 (Market Analysis Report, 2022-2030). Globally, approximately 46 million individuals, representing 25,000 species/varieties, are traded, raising concerns about the disruptive and reckless exploitation of ornamental organisms from sensitive coral reef ecosystems for the aquarium industry (Wabnitz et al., 2003).

Marine ornamental organisms are valued at US$1,000 per kg, significantly higher than the average price of US$13 for food fish. The value chain for ornamentals is also shorter compared to food fishes (Cato and Brown, 2003). However, the exploitation of 20-30 million reef fishes annually for commercialisation has sparked significant concerns about their conservation status (Baquero, 1999; Wabnitz et al., 2003; Rhyne et al., 2012; Leal et al., 2015). This exploitation not only diminishes their population density to endangered levels but also damages the entire ecosystem.

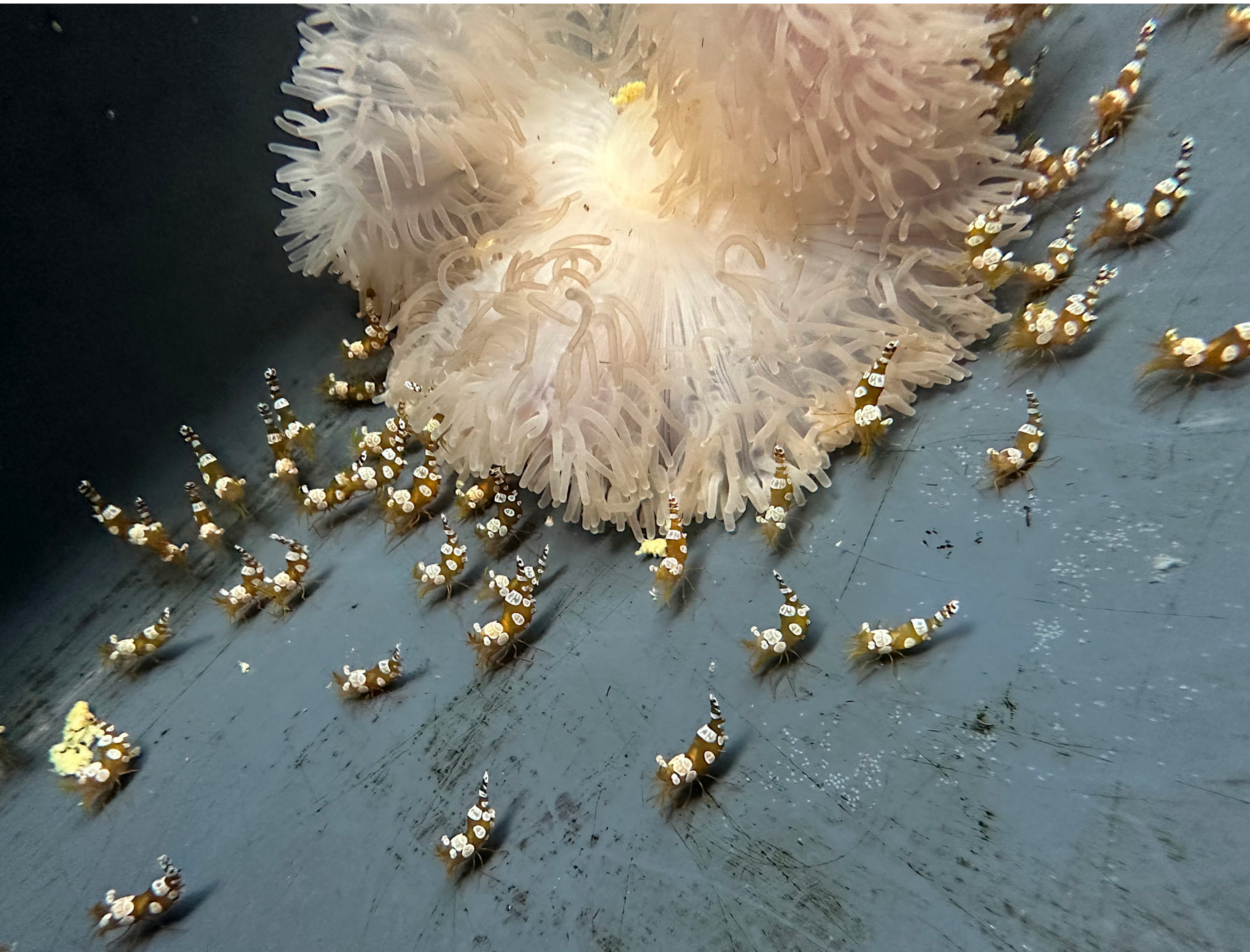
Currently, approximately 50 countries participate in marine ornamental fish trading, yielding significant financial returns. For many, this trade serves as a major economic driver.

Beneficaries atatending the animals in community aquaculture unit.

Indonesia leads the pack, contributing 34.4% of all shipments, averaging 1,727,940 organisms annually, while Sri Lanka follows as the second leading exporter, accounting for 15.1% of shipments and 599,072 specimens. The Philippines trails behind with 12% of shipments and 309,350 specimens.

The number of species traded has seen a notable increase from 2014 to 2017, rising by 61.1% (from 47,136 specimens) to 78% (from 32,5091 specimens). However, data spanning 2014 to 2017 indicates a declining trend in the top 20 traded species, primarily due to habitat destruction (Biondo & Rainer, 2019).

Thor hainanensis.



Biotope and socio-economic status of Lakshadweep

Lakshadweep is renowned for its atoll-based islands, situated within the Laccadive-Chagos ridge, an area characterised by a transition between oceanic crust to the west and continental crust to the east. This ridge comprises shoals, banks, and coral reefs stretching approximately 2,500 km, with a depth of around 1,500 m. Positioned at 8°-13" North latitude and 71°-74° East longitude in the Arabian Sea of the western Indian Ocean, Lakshadweep is located about 220-440 km off the coast of Kerala, India.

The region boasts a total lagoon area of approximately 4,200 km², territorial waters spanning around 20,000 km², and an Exclusive Economic Zone covering 400,000 km². Lakshadweep consists of 36 small islands scattered across the Arabian Sea, covering a total area of about 32 km². Among these islands, ten are inhabited, seventeen are uninhabited, and three are submerged. The capital of this Union Territory is Kavaratti, with other inhabited islands including Agatti, Andrott, Kiltan, Chetlat, Amini, Bitra, Kadamat, Kalpeni, and Minicoy. Uninhabited islands include Bangaram, Viringili, Cheriyam, Kodithala, Thilakkam (1), Thilakkam (2), Thilakkam- (3), Pitti- (1), Pitti (2), Thinnnakara, Parali, (1), Parali-(2), Parali -3, Kalpetti, Suheli, Valiyakkkara, and Cheriyakkara (Jose et al., 2021).

The Lakshadweep islands boast a rich diversity of species, including 114 species of seaweeds, 7 species of seagrasses, 91 species of sponges, 148 species of corals, 170 species of crustaceans, 768 species of molluscs, 78 species of echinoderms, 296 species of ornamental fishes, 603 species of fishes, 4 species of sea turtles, 80 species of birds, 12 species of cetaceans, and 3 species of mangroves (Jose et al., 2021).

Islanders primarily rely on fishing, particularly tuna, for their livelihoods. The production of value-added products from tuna fishes (MASMIN) is a major occupation. Additionally, revenue is generated through the production of coconut oil, coconut powder, vinegar, jaggery, and crafting handicrafts from dead shells.

Women in community aquaculture

Women are receiving training to set up aquaculture units, mainly focusing on ornamental species, to improve their social and economic status (Allison, 2011; Beveridge et al., 2013; Ajith Kumar et al., 2020). Marine ornamental aquaculture has the potential to attract determined women to engage successfully in blue ventures (Pandey & Mandal, 2017). By making the most of blue bio-resources, women's economic status can be improved, especially as the rearing unit is often considered a 'work from home' model. As a result, women on the islands are actively involved in various ornamental aquaculture activities, including breeding, rearing, value addition, and marketing. The trade in marine ornamentals offers a valuable opportunity to promote gender equality and boost household income, providing a wide range of employment opportunities for women through self-help groups (SHGs) and cooperatives.

The promotion of technology for breeding and rearing marine ornamentals has been actively encouraged among coastal communities (Ajith Kumar et al., 2020). Selecting the Lakshadweep islands as the site for this venture is highly suitable due to several factors: (a) easy accessibility to a variety of colourful ornamental organisms, (b) availability of quality seawater, (c) provision of favourable conditions consistently, and (d) availability of live feeds. Cultivating marine ornamentals in the Lakshadweep islands is both feasible and effective, and it can be planned in a coherent manner to safeguard natural marine ornamental resources.

Ancylocaris brevicarpalis.

Additionally, efforts are underway to maintain genetic diversity, which is crucial for the thriving variety of marine ornamentals to adapt to captivity, develop resistance, and remain attractive. Consequently, the development of the marine aquarium trade enhances the living standards of island communities.

In aquariums, marine ornamental crustaceans have gained prominence due to their symbiotic behaviour with fish and other invertebrates (Calado, 2008). The symbiotic relationship of ornamental shrimps with other organisms simplifies rearing, especially in small "nano-tanks". The propagation of marine ornamental shrimps is facilitated by the ICAR - NBFGR, focusing on two species, namely, *Thor hainanensis* and *Ancylocaris brevicarpalis*, which are provided to women islanders for further rearing in community aquaculture units (ICAR - NBFGR, 2020).

Supply and value chain for sustainability: A successful model

The loss of coral reef inhabitants due to unstructured collection and harvesting of living jewels is disrupting the habitat balance, as each individual plays a unique role in their environment, essential for biosphere sustainability. To mitigate this pressure on the ecosystem, promoting marine ornamental aquaculture is crucial, as it can contribute to sustainable aquarium trade and encourage environmentally friendly practices.

In this context, the establishment of a live germplasm resource centre on Agatti Island, Lakshadweep by the ICAR-NBFGR is noteworthy. This centre disseminates rearing technology and supplies captive propagated animals (F2 generation of shrimps and fishes) to women islanders for further rearing in community aquaculture units, which are constructed using locally available indigenous materials. This eco-friendly approach enables the production of high-quality marine ornamentals, mainly pathogen-free, fetching attractive prices for the beneficiaries.

The demand for small-sized species suitable for nano-tanks is increasing, as they are easy to transport and maintain, satisfying hobbyists (Olivotto et al., 2011). A significant advantage of marine ornamental aquaculture is that it can be conducted year-round, even during the off-season period when the Arabian Sea is rough. Moreover, cultured ornamentals often fetch market prices equal to or even higher than those of food fishes, providing an added advantage to this venture.

Opportunities

The potential of ocean resources is vast and needs to be brought to the forefront. It is crucial to raise awareness among people and educate them about the benefits and drawbacks. The success of our mission lies in convincing people to seize the opportunities and reap the real benefits. The ICAR-NBFGR is effectively achieving this by harnessing the potential resources of the Lakshadweep Sea through new initiatives.

This goal is being realised through community-based aquaculture for marine ornamentals, utilising locally available facilities. Currently, women on Agatti Island are actively involved and have begun establishing community aquaculture units to breed and supply marine ornamentals for sustainable aquarium trade.

In conclusion, our vision to explore native marine ornamentals suitable for community-based aquaculture has been successfully realised, aiming to improve the economic status of marginalised people in Lakshadweep. The island community, particularly women, has been convinced and trained to

Inner view of the germplasm centre.

establish backyard aquaculture units using available facilities. This approach allows for the amicable and effective utilisation of native bio-resources from the coral reef ecosystem, adopting a “work from home” model.

As a result, women actively participate in various community-based aquaculture activities, including breeding, raising, value addition, and marketing. The initiatives led by ICAR-NBFGR in Lakshadweep have been embraced by women islanders and have garnered appreciation from the scientific community for their dual role in promoting this rearing technology among islanders and conserving biodiversity meticulously.

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References

Ajith Kumar, T.T., Charan, R., Jayakumar, T., Tyagi, L.K., Saravanane, N., Mohindra, V., Jaffer Hisham, T. and Lal Kuldeep, K. 2020. Framework of participatory linkage for marine ornamentals germplasm conservation to livelihood: is community aquaculture an inclusive option? Aquaculture Asia 24(4): 1-9.

Allison, E. H. 2011. Aquaculture, fisheries, poverty and food security. Working paper 2011-65. Commissioned for OECD. Worldfish Centre, Penang, Malaysia. pp. 62.

Baquero, J. 1999. Marine Ornamentals Trade Quality and Sustainability for the Pacific Region. South Pacific Forum Secretariat Trade and Investment Division.Suva,Fiji.pp.50 http://www.aquariumcouncil.org/docs/final%20 marine%20ornamentals%20Rpt-ver%20june%204.htm.,50pp.

Beveridge, M. C. M, S. H., Thilsted, M. J., Phillips, M., Meti, M. Troel., and S. J. Hall. 2013. Meeting the food and nutrition needs of the poor: the role of fish and the opportunities and challenges emerging from the rise of aquaculture. Journal of Fish Biology 83:1067-10.

Biondo M.V. and Rainer B. 2019. Monitoring the trade in marine ornamental fishes through the European trade control and expert system TRACES: Challenges and possibilities. Marine policy 108:8, pp.103-620.

Calado, R. 2008 Marine ornamental shrimp biology, aquaculture and conservation. Wiley-Blackwell publishing Oxford, UK. p 286, 15-22.

Cato, J.C., and C.L. Brown. 2003. Marine Ornamental Species: Collection, Culture and Conservation. Ames, IA: Iowa State Press. A Blackwell Publishing Company, First edition, pp. 442 17-21

Dammannagoda, S.T. 2018. Sustainable Fishing Methods in Asia Pacific Region. In: Hai FI, Visvanathan C, Boopathy R (Eds.) Sustainable Aquaculture, Applied Environmental Science and Engineering for a Sustainable Future, pp. 95-122. Springer, Cham, Switzerland.

ICAR-NBFGR, 2020. Annual Report 2020, ICAR-National Bureau of Fish Genetic Resources, Lucknow-226002 (U.P), India. 185pp.

Leal, M.C., Vaz, M.C., Puga, J., Rocha, R.J., Brown, C., Rosa, R., Calado, R. 2015. Marine ornamental fish imports in the European Union: an economic perspective. Fish Fish 17: 459-468. doi.org/10.1111/faf.12120.

Market Analysis Report. 2022. Ornamental Fish Market Size & Trends Analysis Report by Product (Tropical Freshwater, Temperate, Marine). By Application (commercial, Household), By Region, And Segment Forecasts, 2022-2030. Report I: GVR-3-68038-567-0. https://www.grandviewresearch.com/industryanalysis/ornamental-fish-market.

Pandey, Pramod, K., and Mandal, S.C. 2017. Present status, challenges, and scope of ornamental trade in India, In: conference Aqua Aquaria India at Mangalore. PP. 157-165.

Rhyne, A. L., and Tlusty, M. F. 2012. Trends in the marine aquarium trade: the influence of global economics and technology. Aquaculture 5, pp. 99-102.

Jose, S., Rejani, C., Saravanane, N., Jafer Hussain, T., Ajith Kumar, T.T., Kuldeep Kumar Lal. 2021. Marine biodiversity and opportunities for livelihood at Lakshadweep. (ICAR- National Bureau of Fish Genetic Resources). pp.44

Wabnitz, C., Taylor, M., Green, E., Razak, T. 2003. From Ocean to Aquarium, UNEP-WCMC, Cambridge, UK. PP.68. http://www.unep-wcmc.org/resources/publications/UNEP_WCMC_bio_series/17.htm

Training programmes organised by West Bengal Fisheries Department in South 24 Parganas in the beginning of 2024

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Fisheries and aquaculture in rural development

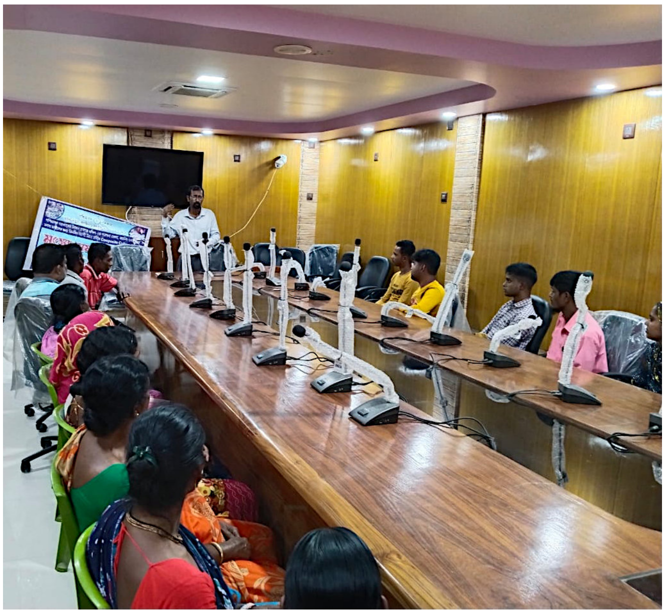
I attended the National Conference on 'Aquaculture and Steps to Maintain High Production' for the first time on January 21-22, 2000, and later, a National Workshop on 'Bridging Gaps for Attaining Self-Sufficiency in Inland Fish Production at the Dawn of the New Millennium' a few months later on June 22, 2000, both held in Kolkata. Over the past 23 years, I have come to conceptualise that fisheries and aquaculture, in particular, are crucial sources and contributors of nutrient-rich food, income, and livelihoods for many people in West Bengal and across India, creating valuable rural employment opportunities and fostering integrated rural development. These themes were extensively discussed at the International Symposium on 'Fish for Nutritional Security in the 21st Century' held during December 4-6, 2001, at ICAR-CIFE, Mumbai, in which I actively participated.

Eminent fishery scientists, the late Dr. Nihar Ranjan Chatterjee and the late Dr. Punyabrata Das, played pivotal roles in organising the first two programs, respectively, and dedicatedly worked towards realising rural development through various dimensions of fishery and aquaculture. In this context, I fondly remember and deeply respect the notable contributions of distinguished scientists and fishery experts, the late Dr. Radheyshyam and the late Dr. Satyendra Datt Tripathi, in this field.

Importance of training and extension

Fish production in West Bengal has increased from 1,472,000 tonnes in 2011-2012 to 1,842,000 tonnes during 2021-2022. This state ranks second in India only after Andhra Pradesh in annual table fish production and possesses open freshwater (warm water and cold water), brackish water, and marine water resources well suited for fishery and aquaculture. In order to keep up the high level of fish production, strengthen livelihoods, and uphold this means of income generation, the West Bengal Fisheries Department has introduced some developmental schemes for fish farmers, fishers, fish vendors by profession, and rural youths interested in adopting fish farming all throughout the state. Training of fish farmers and unemployed fishers is one of the schemes, among others, under the State Plan of the Department of Fisheries, Government of West Bengal.

Efforts are being made by the Fisheries Department to disseminate scientific knowledge about improved techniques of fish culture to fish farmers (progressive farmers, small and marginal farmers) by imparting hands-on training to them. The aim is to increase fish production through various means like bringing more water bodies under scientific fish culture



Training at Canning-1 CD Block.

and ensuring access to nutritionally balanced fish feed and high-quality fry and fingerling-stage fish for fish farmers. Training serves as an important mechanism for the transfer of technology and improving human skills regarding the developmental process[1].

Recently, short-term training programs for fish farmers were organised in almost all districts of the state, including South 24 Parganas. This initiative was the brainchild of Sri Biplab Roy Chowdhury, Hon'ble Minister of State, Department of Fisheries, Government of West Bengal. Notably, this marked the first such initiative in almost four years since the COVID-19 induced lockdown period began in India on March 16, 2020.

Over the years, numerous research and development activities in fisheries and aquaculture have led to the emergence of new ideas and technologies. However, it is essential for these innovations to reach fish farmers to enhance production sustainably. Fisheries and aquaculture extension plays a crucial role in convincing and assisting fish farmers and fishers communities to improve their quality of life and raise their standard of living through better farming practices and production techniques. This approach not only increases fish production and income but also maintains their good socio-economic condition.

Extension personnel are primarily responsible for transmitting technology among users after receiving it from universities and research institutes. Therefore, extension officers must stay updated with the latest technological developments[2].

Training serves as a useful and widely adopted system for disseminating new technology, starting from the trainers and ending with the users[3].

Fisheries and aquaculture in South 24 Parganas District

In finfish and shellfish production by aquaculture, South 24 Parganas district holds high potential and prospect. It is the largest district in West Bengal in terms of area and ranks second highest in annual table fish production in the state, amounting to 262,000 tonnes in 2021-2022, only after Purba Medinipur district. South 24 Parganas is unique in West Bengal as it is the only district out of 23 in the state which has five kinds of well-established sectors: freshwater aquaculture, brackishwater aquaculture, marine fishery, domestic sewage-fed aquaculture, and aquarium fish culture in its rural and suburban regions. Out of the 29 Community Development Blocks in this district, all of them are freshwater Blocks, 14 are designated as brackishwater Blocks in addition to freshwater, and 17 are marine Blocks in addition to freshwater and brackishwater. The unique location of this district within the active deltaic zone of the Ganga river basin is a favorable factor for the development of both freshwater and brackishwater aquaculture activities, based on aquatic resources in different regions of this district. Being in close proximity to the metropolitan city Kolkata, fish farmers have easy access to transportation routes for their farm produce, including aquarium fishes, shrimps, freshwater prawns, Indian major carps, and other inland finfishes, to big wholesale fish markets both within and outside West Bengal.

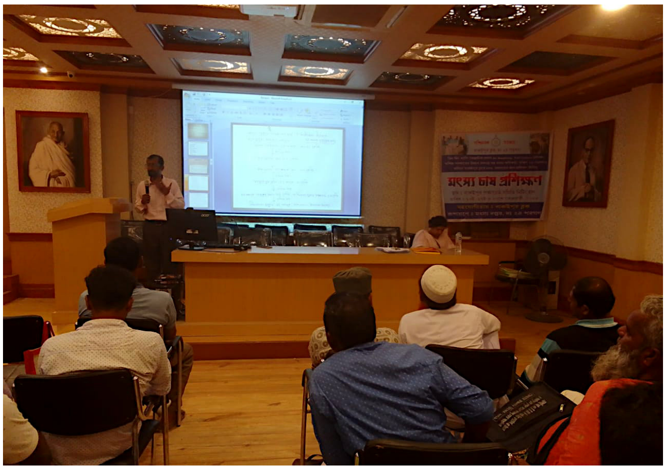
Topic of training courses in South 24 Parganas

During the entire month of February and early March 2024, which is towards the end of the financial year 2023-2024, five types of training programs were organised for fish farmers in almost all blocks of this district concurrently, each lasting for three days. These were:

- Training program on scientific fish culture of different fish species with special reference to composite fish culture, where individual fish farmer beneficiaries selected for the scheme ‘Composite fish culture with supply of quality fish seed and feed’ and ‘Jal Bharo Jal Dharo’ at the Block level participated as trainees.

- Training program on scientific fish culture of different fish species with special reference to composite fish culture, where individual fish farmer beneficiaries selected for the scheme ‘Distribution of Indian major carp fingerlings in small water bodies’ at the block level participated as trainees.

- Training program on scientific fish culture of different fish species with special reference to air-breathing fish culture, where members of fish production groups (FPGs)/self-help groups (SHGs) selected for the scheme ‘Air breathing fish culture’ at the block level participated as trainees.



Training at Baruipur CD Block.

Training at Basanti CD Block.

Training at Bhangore-1 CD Block.

Training at Bishnupur-2 CD Block.

- Training program on Scientific fish culture of different fish species with special reference to polyculture, where members of FPGs/SHGs selected for the scheme 'Polyculture of pangus catfish with Indian major carps' participated as trainees.

- Training program on scientific fish culture of different fish species with special reference to composite fish culture, where members of FPGs/SHGs selected for the scheme 'Composite fish culture' participated as trainees.

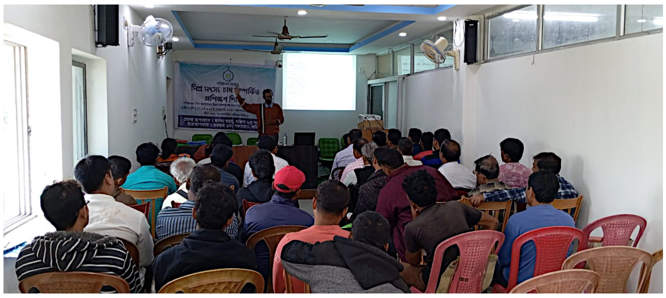
Scientific fish culture has been introduced in small earthen ponds (chambers) excavated under the scheme Jal Bharo Jal Dharo (JDJB) of the Government of West Bengal.

Other aspects of training programmes

In each of the consecutive three-day training programs, four theoretical classes were scheduled each day from 10:00 am to 5:00 pm, held at the Training hall/Meeting Hall of the respective Block Development Officer's office equipped with modern facilities. In this district, 10-18 villages constitute one Gram Panchayat (GP), 6-18 GPs constitute one Community Development Block, and 29 CD Blocks make up South 24 Parganas. The Fishery Extension Officer (FEO), posted as a State Government officer at the Block level, was the Nodal Officer for each of these trainings, with overall coordination, monitoring, and implementation by the office of the Assistant Director of Fisheries (ADF), South 24 Parganas at the District Headquarters under District administration. Printed booklets covering the topics of the training subject in detail in Bengali language were provided to each trainee.

Training at Kakdwip CD Block.

Training at Mathurapur-1 CD Block.

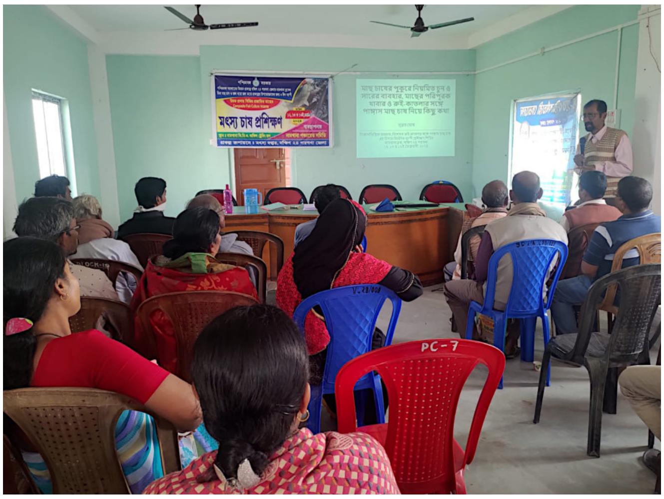


Training at Budge Budge-1 CD Block.

Training at Joynagar-1 CD Block.

Trainers/Lecturers in each of these training programs included FEOs from adjacent and nearby CD Blocks, the host FEO themselves, officers from the office of the ADF, South 24 Parganas, Subject Matter Specialists (Fishery) from Krishi Vigyan Kendra, personnel from the ATMA project under the Department of Agriculture, Government of West Bengal, and experienced and elderly fish farmers. I was one of the trainers in a few training programs, using audio-visual systems and PowerPoint presentation slides. In addition to the above, separate trainings were organised at the Block level by each office of the ADF (Brackishwater), South 24 Parganas (for brackishwater fish farmers), and the office of the CEO, Fish Farmers' Development Agency, South 24 Parganas. Estimation procedures for the pH of fish pond water, dissolved oxygen content, zooplankton density in pond water, and transparency-turbidity were demonstrated to the trainees. They were encouraged to apply for a Fisher Registration Card (FRC) that would be beneficial for them and made aware of the locations of registered and accredited fish hatcheries and carp seed rearing units in nearby and less-distant regions.

During the question-answer session, trainers addressed queries raised by trainees, including means to control the overgrowth of dense masses of unwanted slimy macroalgae Spirogyra sp lying just beneath the water surface of fish culture ponds; natural occurrences where *Chanda nama* and *C. ranga* try to tear off edges of fins of growing Indian major carps in such ponds; concerns that *Penaeus vannamei* culture is no longer as profitable as expected due to the high prices of shrimp feed, medicines, and pond inputs; methods to utilise brackishwater ponds alternatively; strategies to control the overpopulation of *Bellamya bengalensis* in fish ponds and also tadpoles; the correct proportion of ingredients needed to prepare farm-made fish feed; the proper dosage of potassium permanganate application in ponds (according to effective water area) for prophylaxis; issues related to fishes exhibiting stunted growth and mortality of growing fishes observed in composite fish culture ponds with apparently no external symptoms of microbial disease; sourcing pure varieties and high-quality seeds of Indian major carps and air-breathing fishes for stocking; fish farming in ponds with



Training at Namkhana CD Block.

high sand content; rural youths gaining improper concepts on biofloc fish farming and RAS by listening to YouTube channels; and several others.

The Matsya-karmadhyaksha

The Fishery Extension Officer (FEO) is responsible at the block level for overseeing the proper implementation of the development schemes of the West Bengal Fisheries Department and ensuring the successful completion of trainings. Additionally, the non-governmental position namely 'Karmadhyaksha, Matsya-o-Prani Sampad Bikash Sthayee Samity' exists individually in all 342 Community Development (CD) Blocks in the Panchayat Samity section across the 23 districts of West Bengal. Beneficiary-oriented schemes are successfully implemented when the FEO, Matsya-karmadhyaksha, and beneficiaries in a CD Block work together in close liaison and cooperation. The Matsya-karmadhyaksha serves as a people's representative in a particular CD Block and is associated with the proper implementation of departmental schemes. According to the West Bengal Panchayat (Panchayat Samity Administration) Rules, 2008, the Karmadhyaksha is required to have regular interaction with officers from the relevant government departments through organised meetings of the Sthayee Samity. Their role is to ensure that the programs and schemes, including training programs, implemented by such departmental officers do not have any mismatch and generate a unified impact on socio-economic development in rural areas.

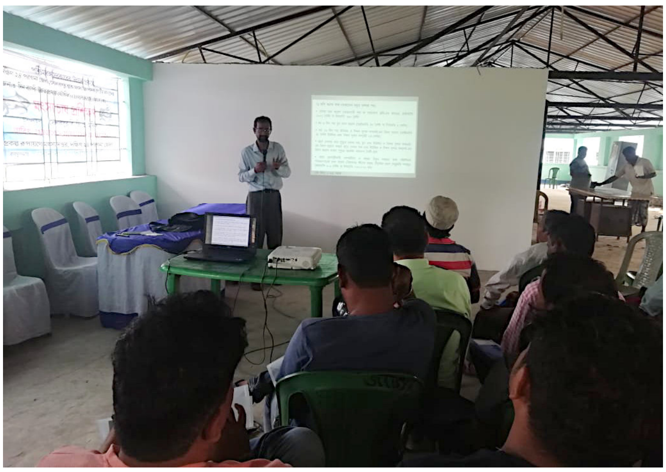
Following the West Bengal Panchayat Election 2023, Matsya-karmadhyaksha were newly appointed individually at the Block level in South 24 Parganas and other districts. However, it is likely that Matsya-karmadhyaksha(s) may not possess extensive knowledge about scientific fish culture and the improved management practices involved. The Hon'ble Minister of State, Department of Fisheries, Government of West Bengal believes that in addition to imparting training to fish farmers, FEO(s) as departmental officers should also instill the idea and concept of improved fish culture in Matsya-karmadhyaksha.

Epilogue

During the second half of 2023, the Hon'ble Minister of State, Department of Fisheries, Government of West Bengal, held two meetings with the Fishery Extension Officers (FEOs) of South 24 Parganas. While commending the efforts of the FEOs, the Hon'ble Minister emphasised the need to take fish farming more seriously and to work collectively towards achieving significant success. As part of the Fisheries Department's initiative, pH papers have been distributed to fish farmers at the Block level in West Bengal, and it is essential to assess how much they have benefited from this. The Minister urged the FEOs to elevate their level of thinking and be more proactive in updating themselves with newer methods of aquaculture.

The Minister highlighted the potential for youths and middle-aged individuals in villages to build their future by adopting fish farming, which can serve as a means of strengthening their livelihoods. Properly practicing fish farming can provide a continuous source of income for them. There is enthusiasm among youths and aqua-entrepreneurs to leverage research outcomes, technologies, and research facilities, in addition to utilising ponds suitable for freshwater and brackishwater aquaculture. It is crucial to teach rural youth and trainees the techniques for analysing basic pond water and soil parameters, as well as fish feed preparation. They should be inspired and motivated to work hard, adopt improved technologies, and apply their new skills and knowledge effectively.

The Minister expressed hope that a community of self-dependent, progressive, dignified, and honest fish farmers would emerge in different villages of the 312 Gram Panchayats in South 24 Parganas and other districts in the near future. Newly-formed SHGs and FPGs will take aquaculture seriously after receiving training and can access short-term loans for capital investment with interest subvention facilities. The Matsya Jeebi Credit Card scheme, a thrust area of the department, facilitates credit linkage with financial institutions for fish farming. Both individual farmers and FPG members must be guided to increase the fish production level of FPGs. Need-based training on scientific and modern fish culture methods should be provided to them, along with booklets on fish farming. Follow-up programs should reinforce different techniques and methods learned during the training sessions. It is essential to assess whether fish farmers are able to generate profits.



Training at Sonarpur CD Block.

The Minister emphasised that culture technologies for Indian major carps, air-breathing fishes, non-air-breathing catfishes, mud crabs, giant freshwater prawns, and shrimp differ in terms of supplementary feed and feeding, manure and fertiliser application, stocking density of early stages, pond water quality, prophylactics, consumer and market demand, nutritional importance, and care.

In the words of Late Dr. Satyendra Datt Tripathi, emphasis is being placed in India on increasing fish production and farmers' income by 200% to meet the challenges of rising demand for protein food and improving the economic status of fishers and fish farmers. I heard him speaking at the National Seminar on 'Priorities in fisheries and aquaculture' during March 11-12, 2017, where he emphasised, "… it will bring about an awakening in the minds of fish farmers that technology, appropriate and sound, if applied following the instructions of scientists and technical experts, would lead to an increase in production from their ponds."

Training programs organised by the West Bengal Fisheries Department at the beginning of this year have undoubtedly increased the knowledge and skills of participating fish farmers in South 24 Parganas and other districts, building confidence and capacity in them. We are at the gateway to a large-scale training and extension program to be launched by this Department in West Bengal.

References

1. Prasad, S. 1994. Training of agricultural development: a basic functional area. J. Rural Reconstruction, 27(1): 25-37.
2. De, H. K., Saha, G. S., Panda, N. and Mahapatra, A. S. 2010. Effectiveness of training programmes on freshwater aquaculture conducted by CIFA. J. Aqua., 18: 31-36.
3. Das, S. 1992. An approach to create competent extension services and training network. Meenbarta (a publication of Department of Fisheries, Government of West Bengal): 2-6.

Exploring the possibility of captive production of a near threatened catfish, *Rita chrysea* for Indian aquaculture

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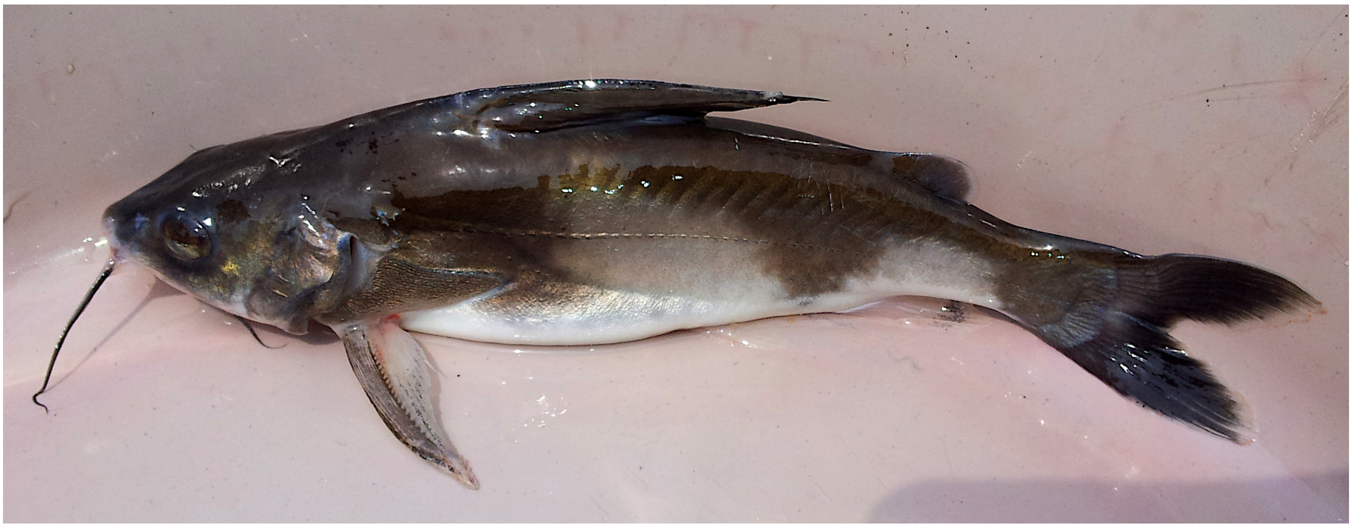


Adult Rita chrysea.

Agriculture stands firm as the backbone of the Indian economy, encompassing the veterinary and fisheries sectors. The relentless efforts of researchers and development workers in these domains have significantly contributed to improving farmers' economic prosperity and enhancing overall productivity in the agriculture sector. Despite the immense potentiality of aquaculture, its benefits remain largely unrealised by farmers. The aquaculture sector's potential has yet to be explored fully, lagging other agricultural sectors. However, recent years have witnessed continuous efforts by aquaculture researchers through training and demonstration, shedding light on the untapped potential of this sector.

India's strides in fish production can be attributed to dedicated research and development initiatives in aquaculture. Carps play a pivotal role in aquaculture production due to their high growth rate, distinguishing them from slower-growing varieties such as prawns and catfish. Farmers and entrepreneurs are increasingly venturing into diverse fish varieties beyond carp, leveraging resources to meet the escalating demands of India's vast fish-consuming population.

Researchers at ICAR-CIFA, Bhubaneswar, have achieved successful breeding and rearing of *Rita chrysea*, a near-threatened catfish species identified by the IUCN. This continuous effort aims to popularise the species through "catfish breeding and rearing" training programs for farmers, fostering its adoption in the future. This communication on the performance of this species in captivity serves as a step forward, potentially paving the way for the adoption of this species. Furthermore, the insights provided in this literature may contribute to ensuring the captive breeding and rearing of two other species, *R. pavimentata* and *R. rita*, in the future. These species, belonging to the same genus, dominate Indian river systems.

Species history

R. chrysea, a member of the Bagridae family, is a medium-sized freshwater catfish predominantly inhabiting the Mahanadi River system, coursing through the states of Chhattisgarh and Odisha in India, spanning 857 km. Commonly known as the "Mahanadi rita," this catfish thrives in reservoirs, check dams, and rocky stretches within the river system. During 1978-79, substantial landings of this catfish from the Mahanadi River system were recorded, ranging from 15-20 tonnes. Its popularity in the market, where it fetches prices ranging from INR 200-300 per kilogram (US$ 3-4 per kilogram), fuelled extensive fishing activities. However, the overexploitation of this species, coupled with the gradual degradation of its breeding grounds due to anthropogenic activities, has led to concerns about its conservation status. Although assessed as least concern by the IUCN due to insufficient information, *R. chrysea* is now listed as near-threatened.

R. chrysea is characterised by a lead-grey hue with a whitish underside and greyish bands along the dorsal aspect of its body. Its mouth is sub-terminal, featuring a longer upper jaw with teeth present on both the upper and lower lips. Three pairs of barbels are visible in the maxillary, nasal, and mandibular regions. Notably, the pectoral and dorsal spines are robust and dentated, while the adipose tissue is prominent, and the anal fin is deeply forked. Mature individuals typically measure around 24-25 cm and weigh between 120-140 g.

This catfish exhibits nocturnal behaviour, often venturing out during the night to feed in riverbeds. It is omnivorous, with individuals reaching 50 g considered as 1+ year old. Mature catfish weighing 50 g and above can be found in both sexes. As a monsoon breeder, reports from fishermen indicate the presence of 1-2 g-sized fishes during the post-monsoon period. The relative fecundity tends to increase with size, typically ranging from 8,000-10,000 in females weighing 50-130 g.

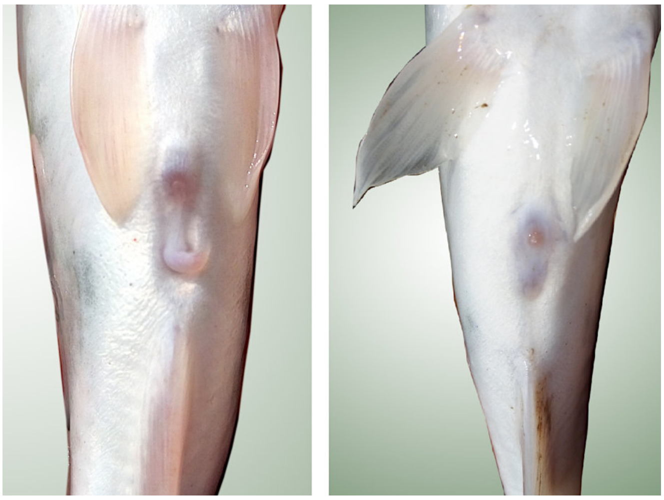
Captive broodstock development

The process of collecting fish from the Mahanadi River in Cuttack District, Odisha state, involved transporting the specimens to an indoor system for stress reduction. After spending two days in this controlled environment with aeration, the fish were released into a cement cistern measuring 50m² with a soil base. Within this environment, the fish exhibited shoaling behaviour and showed a preference for hiding within the rearing system. To accommodate this behaviour, hiding places were provided in the rearing tanks.

Initially, the fish were fed a pelleted feed containing 32% protein, placed in feeding baskets. However, it took the fish a week or more to acclimate to this feed, as they were accustomed to natural feed sources. Sensitivity to oxygen depletion was observed, with the fish surfacing during the morning hours, particularly noticeable in tank-reared fish. Regular water renewal was necessary to address this issue.

Observations notably revealed that broodstock were healthier in pond environments compared to tanks. This discrepancy in health could be attributed to the utilisation of compound feed along with the availability of natural food in pond water. Consequently, pond rearing of broodstock for this catfish species is considered a preferable option.

Broodstock.



Male (left) and female.

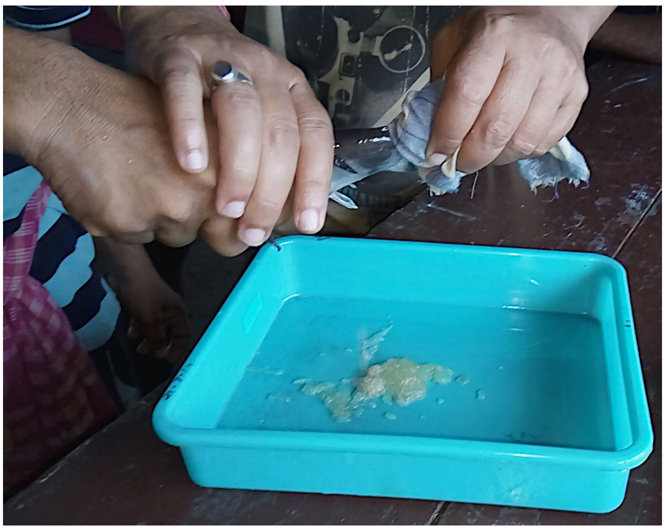
Induced breeding

During the monsoon months, distinguishing between male and female fish is straightforward. Males exhibit a pointed papilla, while females display a bulging belly. Preference is given to females with a reddish vent and a soft, bulging belly for induced breeding. Cannulation can be performed to ensure uniformity in egg size before selecting suitable females.

For induced breeding, females are injected at the dorsal side of the body with a synthetic hormone (Ovatide), a combination of sGnRHa and domperidone, at a rate of 1 ml/kg body weight. Males, on the other hand, do not require hormone injections. Injected females are separated from males and placed in tanks equipped with aeration.

Male testes resemble an accumulated mass with pointed thin free threads projecting out. Unlike some other catfish species, such as Clarias batrachus, there is no observed oozing of milt while stripping the male. The testes are then operated out and macerated in normal saline solution (NSS) to obtain sperm suspension before stripping the females.

Stripping of the female usually occurs at 13-15 hours post-injection. The eggs are extruded in a mass resembling a grape bunch through the vent. Fecundity ranges from 10,000-13,000 in 90-120 g females. The eggs are whitish grey, with a very tender outer covering and a size of 1.2-1.4 mm. One male's sperm suspension can fertilise the eggs of two females of the same weight. The egg and sperm suspension, mixed with a little freshwater, undergo gentle mixing for fertilisation.



Stripping eggs.

The fertilised eggs are then incubated in the hatchery, where the water is in a constant moving condition. This movement is crucial as the eggs are demersal in nature, and settling at the bottom of the hatchery could impede hatching rates due to oxygen shortage. Continuous water renewal is essential until hatching occurs. The fertilised eggs typically take 22-24 hours to hatch. The resulting hatchlings measure 3.5 to 4.3 mm in size and weigh 0.9 to 1.2 mg. Even with the yolk sac, these newly hatched larvae remain active, with the yolk sac providing vital nutrition during their initial life stage.

Larval rearing

Seeing the larvae in the water column poses a challenge due to their transparent appearance. The yolk sac is absorbed within 72 hours of hatching, necessitating external feeding for the larvae. Typically, these larvae do not readily accept compound feed in the initial days after hatching. Live mixed zooplankton or *Artemia* nauplii are preferred feeds during this stage. Given their delicate nature, maintaining a favourable water environment with sufficient oxygen is crucial.

Proper cleaning of the rearing tank's bottom is essential to eliminate potential sources of dead animal-origin feed. Prolonged exposure of larvae to such an environment may lead to oxygen depletion or secondary infections. Therefore, daily cleaning of the tank bottom, coupled with water renewal, reduces the risk of mortality. Attention to population size during rearing is also important. Rearing larvae at a density of 2-3 individuals per litre yields a survival rate of ≥ 80%, whereas doubling the density results in a lower survival rate of ≤ 40%.

Larvae reared for 10-12 days on live feed can be transitioned to compound feed for the remaining duration. During this period, the larvae typically grow to 40-60 mg over three weeks. At this size, catfish larvae exhibit hiding behaviour. However, it's noteworthy that these catfish larvae require an extended period during larval rearing, making the process time-consuming.

An attempt was made to rear them for 7-8 days and subsequently stock them for outdoor rearing to shorten the rearing period. Unfortunately, this approach resulted in a low survival rate, with complete mortality observed in 2-6% of cases.

Fingerling rearing

Optimal fingerling development involves rearing the fry for three weeks or more before transitioning them to outdoor rearing. The outdoor rearing system typically consists of a series of cement tanks equipped with water inlets and complete drainage facilities. While some rearing tanks may have their bottom covered with soil or sand to emulate a natural water environment, a notable drawback is the potential entry of compound feed into the substrate during fish feeding. This complicates feeding for the tiny fish. Therefore, tanks with a bare bottom are preferred.

Experimental results suggest that fish tend to grow better when provided with shelter or hiding places during rearing. Consequently, tanks are prepared with a minimum water height of one foot and equipped with hiding places before fry stocking for fingerling production. To promote better growth, it is advisable to stock fewer than 200 fry per square meter, considering their slow growth rate.

R. chrysea fingerlings.

Haul of juveniles.

Compound feed, in the form of crumble or dough containing 30-35% protein, can be provided near the hiding places, as most fish tend to take shelter there. Care must be taken to remove uneaten feed promptly, as its accumulation can negatively impact water quality. Additionally, the low water height in the tank may encourage the growth of filamentous algae, potentially restricting fish movement or leading to oxygen depletion.

The occurrence of asphyxiation in fish during the morning hours is a common observation during rearing. Therefore, intermittent water renewal is necessary throughout the 2-3 month rearing period. The fish typically exhibit a growth rate of 2-3 grams during this period, with a survival rate ranging from 50-70%.

Grow out culture

This catfish is recognised for its slow growth, both in natural water and captivity. Consequently, the stocking size significantly influences overall production. It is recommended to stock fingerlings weighing 8-10 grams, typically around 6-7 months old. Since the catfish lacks an air-breathing organ, utmost care is essential when transporting stocking material, whether sourced from the wild or a hatchery, to maintain optimal oxygen levels in the water.

Farmers often employ oxygen pipes connected to oxygen cylinders or small water pumps fitted in transport vehicles to ensure continuous aeration, preventing oxygen depletion. Minimising stress on the stocking material is crucial, and stocking seeds during the early morning can help reduce heat stress. In tank culture systems, providing shelter becomes necessary due to the catfish's inclination for hiding, while in pond conditions, ample natural hiding places are available.

Maintaining a water height of around 1.5 meters is recommended. The catfish readily accepts pelleted feed containing 30-32% protein and should be fed slightly over 3% of their body weight. However, feed consumption significantly decreases during winter months when water temperatures drop below 20°C. Adjusting feeding to less than 2% of body weight during this period can help manage feed costs.

Farmers can monitor feed consumption patterns throughout the year by inspecting feed trays, providing valuable insights for effective feed management. Fish cultured in tank conditions may exhibit asphyxiation during the early morning, a challenge often mitigated by water renewal. Notably, fish cultured in pond conditions demonstrate superior growth, with sizes ranging from 40-60g compared to 28-40g in tank conditions. This enhanced growth in pond conditions may be attributed to the utilisation of natural food alongside compound feed. Despite the slow growth, achieving a net production of up to two tons per hectare is feasible, and this size commands a robust demand in the fish market.

Disease incidence

High-density larval rearing (10-12 individuals per litre) can lead to stress-induced bacterial infections. The larvae exhibit sluggish movement and show reluctance to accept feed during the initial stages of infection. In such cases, it is imperative to promptly thin out the larvae and rear them in a new environment. This immediate action significantly reduces the risk of mortality without the need for additional treatment.

During the winter months, when fingerlings are exposed to low temperatures (below 20°C), observable symptoms include small red patches on the body and the loss of barbells. These manifestations are typically attributed to the combined effects of low temperature and poor water quality. Addressing this issue involves water renewal coupled with the application of CIFAX at a dosage of 1 litre per hectare in one meter water height, effectively treating the affected fishes.

Salient observations

- The wild stock can be successfully domesticated, and a broodstock raising program can be effectively carried out in captivity before initiating breeding.
- Due to the delicate nature of ovulated eggs, it is crucial to avoid incorporating hard substances while mixing egg and sperm suspension.
- Frequent checking of females may lead to stripping failure.
- All life stages of the fish respond well to compound feed.
- This catfish exhibits slow growth in nature and performs optimally at low population sizes in captivity.
- A minimum three-week larval rearing period is essential to achieve a high survival rate during subsequent rearing stages.

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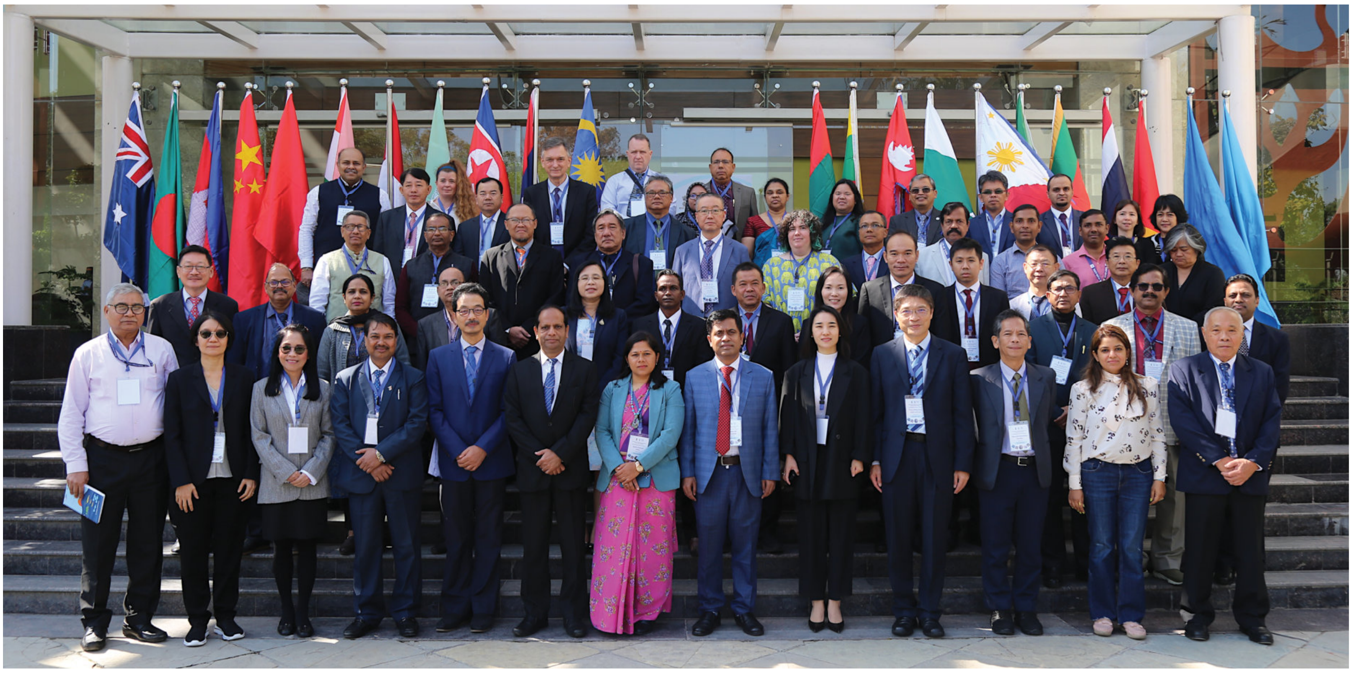
33rd NACA Governing Council held in New Delhi, India



Participants in the 33rd NACA Governing Council, ICAR Convention Centre, New Delhi, India.

The 33rd Governing Council was held from 5-8 March at the Indian Council of Agricultural Research (ICAR) Convention Centre, New Delhi, India. A record 18 member governments attended, along with four Regional Lead Centres (RLCs) for China, India, the Philippines and Thailand, the Food and Agriculture Organization of the United Nations (FAO), the Centre for Integrated Rural Development for Asia and the Pacific, the International Development Research Centre, the Southeast Asian Fisheries Development Center (SEAFDEC) and FUTURE FISH. India was elected as Chair and China as Vice-Chair of the meeting.

Several speakers addressed the audience in the opening ceremony. Dr J.K. Jena, Deputy Director General (Fisheries) ICAR and Chair of the Organising Committee, and Dr Huang Jie, Director General of NACA, welcomed delegates. Dr Pitchaya Chainark, outgoing Chair of the NACA Governing Council, and Expert in Coastal Aquaculture Research and Development, Thailand, gave the opening remarks. Special Guest Dr Abhilaksh Likhi, Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, and Chief Guest Dr Himanshu Pathak, Secretary, Department of Agricultural Research and Education and Director General of ICAR, Government of India, also addressed the meeting. The Vote of Thanks was delivered by Dr Promod Kumar Sahoo, Director, ICAR-Central Institute of Freshwater Aquaculture and Regional Lead Centre, India.

The discussions at the 33rd NACA Governing Council Meeting underscore the shared commitment of member countries to promote sustainable aquaculture development in the Asia-Pacific region. Collaboration, innovation, and investment in research and technology are essential to address challenges such as disease outbreaks, climate change impacts, and environmental sustainability. By working together through platforms like NACA, member countries can achieve their aquaculture development goals and ensure a resilient and sustainable future for the region.

Key issues of common concern included:

- Aquatic animal health and anti-microbial resistance (AMR): Members discussed biosecurity issues, including the need for guidance in the responsible use of veterinary medicines, and use of alternative strategies such as prevention and vaccination, as well as surveillance and monitoring, to minimise the risk of AMR developing.

- Climate change: The long-term impacts of climate change on aquaculture were an ongoing concern. Members were engaged in activities to reduce emissions in the sector, including through the use of innovative feed formulations, in addition to research on adaptation strategies and climate information and early warning systems to minimise losses.

- Capacity building and technology transfer: Members agreed to support requests for training and technical exchange in order to facilitate capacity building and technology transfer.

Other issues discussed included:

- The report of the 2nd High-Level Meeting on Aquaculture Transformation in Asia and the Pacific region, and associated White Paper, which identifies 20 action areas.

- NACA's One Community concept, which provides an inclusive and integrated framework for addressing social issues including, but not limited to, gender, youth, marginalised and vulnerable groups, and ageing communities.

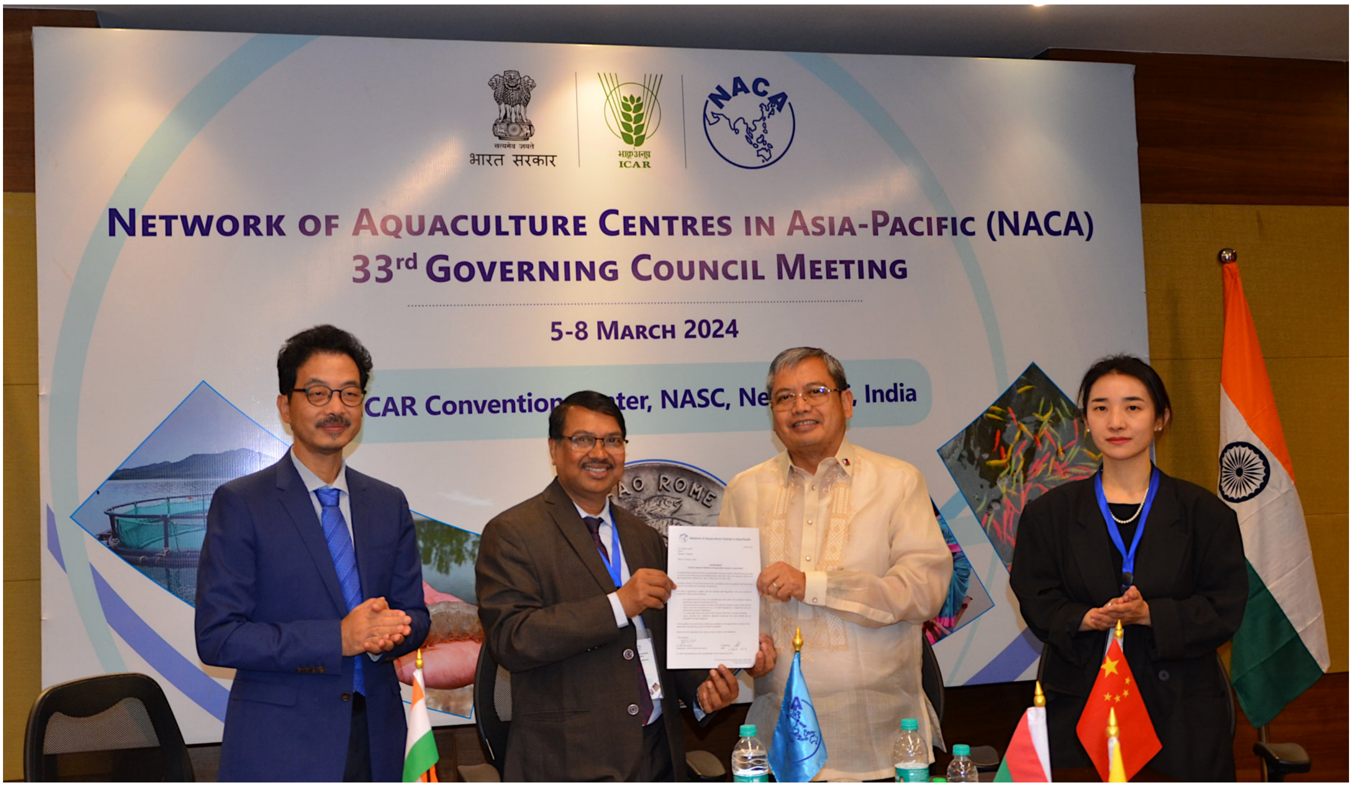
- Establishment of operational rules for subject-oriented collaborative networks within the NACA mechanism, such as the International Artemia Aquaculture Consortium.

The Chair thanked the outgoing Director General, Dr Huang Jie, who was completing his five-year term, for his leadership of NACA over the past five years and expressed appreciation for the work he has undertaken in an environment where expectations were ever increasing.

Members also welcome the newly elected Director General, Dr Eduardo Leaño, who would commence his term on 1 May (see article below).

Members expressed thanks to the Government of India, ICAR and the NACA Secretariat for their kind hospitality and excellent arrangements in facilitating organisation of the meeting. The Chair thanked members for the opportunity for India to host the meeting. The Vice Chair, China, extended a warm welcome for members to attend the next Governing Council, to be held in Shanghai in 2025.

Dr Eduardo Leaño elected as next Director General of NACA



From left: Dr Huang Jie (DG NACA), Dr J.K. Jena (GC Chair and DDG ICAR Fisheries, India), Dr Eduardo Leaño (DG Elect, NACA) and Dr Xiangzhou Liu (GC Vice Chair, Ministry of Agriculture and Rural Affairs, China)

The 33rd NACA Governing Council, currently in session in New Delhi, India, today elected Dr Eduardo Leaño as the incoming Director General of NACA. He will serve a five-year term beginning in May 2024 and succeeds Dr Huang Jie, who will complete his own five year term in April.

Dr Leaño is a national of The Philippines and currently serves as the Senior Programme Officer for NACA's Health and Biosecurity Programme, and Food Security, Safety and Certification Programme. He holds a PhD in Applied Biology from the City University of Hong Kong, a MSc in Fisheries from the University of the Philippines Visayas and a BSc in Inland Fisheries from Central Luzon State University.

Dr Leaño has previously worked as a Research Scientist in the Aquaculture Department of SEAFDEC, as a Research Fellow at the Taiwan Fisheries Research Institute, and as a Research Fellow and Adjunct Professor at the National Taiwan Ocean University.

Dr Leaño has co-edited and published seven books in aquaculture and aquatic animal health and published more than 50 scientific articles in international and national journals, proceedings and as book chapters.

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the Third Quarter of 2023

Listed below are the reported aquatic animal diseases submitted by countries in the Asia-Pacific region, which covers the third quarter of 2023. The original and updated reports can be accessed from the QAAD page at: https://enaca.org/?id=8

Finfish Diseases

- Infection with *Aphanomyces invadans* (EUS): Bangladesh in catla (*Catla catla*), mrigal (*Cirrhinus mrigala*) and rohu (*Labeo rohita*); and India in snakehead (*Channa marulius*).

- Infection with red seabream iridovirus (RSIV): Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*), seabass (*Lates calcarifer*) and silver seabream (*Rhabdosagrus sarba*); Hong Kong (reported as ISKNV) in hybrid grouper; and India (reported as ISKNV) in seabass.

- Infection with tilapia lake virus (TiLV): India in tilapia (*Oreochromis niloticus*), and Philippines in adult tilapia (*Oreochromis* sp.).

- Viral encephalopathy and retinopathy (VER): Australia in barramundi (*L. calcarifer*); and Chinese Taipei in hybrid grouper, giant grouper (*E. lanceolatus*) and Malabar grouper (*E. malabaricus*).

- Carp edema virus disease (CEV): India in koi carp (*Cyprinus carpio*).

- Enteric septicaemia of catfish (ESC): Vietnam in catfish (*Pangasius macronema* and *P. hypophthalmus*).

Molluscan Diseases

- Infection with abalone herpesvirus: Australia in blacklip abalone (*Haliotis rubra*)

- Infection with *Perkinsus olseni*: India in farmed mussel (*Perna viridis* and *Mytella strigata*).

Crustacean Diseases

- Infection with white spot syndrome virus (WSSV): Chinese Taipei in whiteleg shrimp (*P. vannamei*); India in black tiger shrimp (*P. monodon*) and *P. vannamei*; the Philippines in *P. vannamei* (PL, grow-out culture, and adult), *P. monodon* (PL and grow-out culture, broodstock), and mudcrab (*Scylla serrata*; broodstock); and Vietnam in *P. vannamei*.

- Infection with infectious hypodermal and haematopoietic necrosis virus (IHHNV): Australia in wild *P. monodon*; and, the Philippines in *P. vannamei* (grow out culture) and *P. monodon* (PL).

- Acute hepatopancreatic necrosis disease (AHPND): The Philippines in *P. vannamei* (PL and grow-out culture) and *P. monodon* (grow-out culture) and *S. serrata*; and Vietnam in *P. vannamei*.

- Infection with Infectious myonecrosis virus (IMNV): India in *P. vannamei*.

- Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP): Chinese Taipei in *P. vannamei*; India in *P. vannamei*; and the Philippines in *P. vannamei* (PL and grow out culture) and *P. indicus* (grow-out culture).

Amphibian Diseases

- Infection with *Batrachochytrium dendrobatidis*: Australia in 90x Southern bell frog (*Litoria raniformis*), 10 x striped marsh frog (*Limnodynastes peronii*), and 10x spotted marsh frog (*L. tasmaniensis*).

Other Diseases

- Bangladesh reported Infection with *Streptococcus agalactiae* in tilapia (*O. niloticus*), and Infection with *Aeromonas* spp. in shing catfish (*Heteropneustes fossilis*) and gulsha (*Mystus cavasius*). India reported Infection with tilapia parvovirus in *O. niloticus*.

E.M. Leaño
Senior Programme Officer
Health and Biosecurity

We are hiring: Professional Associate, aquaculture transformation

- Position type: Full-time contract up to 18 months
- Salary: $2,500 per month plus benefits
- Duty station: Bangkok
- Application deadline: **15 April**

About us

The Network of Aquaculture Centres in Asia-Pacific (NACA) is an intergovernmental organisation that promotes rural development through sustainable aquaculture and aquatic resources management.

NACA seeks to improve the livelihoods of rural people, reduce poverty, and increase food security. The ultimate beneficiaries of NACA are farmers and rural communities.

Job description

We are seeking a highly qualified and motivated individual to join our team as a Professional Associate.

The successful candidate will oversee the implementation of a project focused on aquaculture transformation through innovative aquaculture and nature-based solutions, and the development of national innovation and investment plans for sustainable aquaculture.

This is a full-time contract position for immediate appointment, with a duration of up to 18 months, involving both local and international travel.

Responsibilities

- Lead and manage the implementation of the aquaculture transformation project under the supervision of the Principal Investigator, ensuring adherence to project timelines, budget, and deliverables.
- Collaborate with stakeholders, partners, and project team members to achieve project goals and objectives.
- Provide technical expertise in aquaculture and nature-based solutions to support project activities.
- Prepare and submit project reports, documentation, and communications as required.
- Coordinate and facilitate workshops, trainings, and meetings related to the project.
- Monitor and evaluate project progress and outcomes, identifying and addressing any challenges or issues that may arise.
- Represent the organisation at relevant conferences, events, and meetings as needed.

Requirements

- MSc in an aquaculture-related discipline (PhD preferred).
- Proven experience in project management and implementation, preferably in the field of aquaculture, natural resource management or rural development.
- Excellent written and spoken English language skills, with proficiency in report writing.
- Strong interpersonal and communication skills, with the ability to work effectively with diverse stakeholders and team members.
- Willingness to undertake both local and international travel as required.
- Preference will be given to citizens from NACA member states (Australia, Bangladesh, Cambodia, China, Hong Kong SAR (China), India, Indonesia, Iran, Saudi Arabia, Korea (DPR), Lao PDR, Malaysia, Maldives, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam).

How to apply

Interested candidates should submit i) a cover letter and ii) resume/CV to **info@enaca.org**. Incomplete applications will not be considered.

Please indicate "Professional Associate - Aquaculture Transformation" in the subject line.

Those candidates selected for interview will be notified by 20 April.

NACA is an Equal Opportunity Employer. We encourage applications from all qualified individuals.

Network of Aquaculture Centres in Asia-Pacific

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