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

Dewatering of pond prior to scientific aquaculture.

One farmer processing alum for its use in pond water.

Application of lime to maintain pH.

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.

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.

Fish growth, production, and economy

After three months of rearing, the mean total length of the fish increased to 21.756 cm ± 10.11 from the initial length of 12.475 cm ± 1.97, and the mean weight increased to 124.822g ± 46.71 from the initial weight of 22.638g ± 10.11. 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 (Figure 11). 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

Farmer measuring plankton in his culture pond.

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

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.

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