A transitional journey from fisheries to aquaculture in Moyna

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A scenario of traditional capture fishery in Moyna with the eye of an artist.

Genesis

This story looks back a century from 1922 until 2022 over the fisheries scenario in Moyna, a community development block of East Midnapore District, West Bengal, India. Moyna is itself news in the context of aquaculture development. The Government of West Bengal proclaimed Moyna as an 'aquaculture hub', giving it a prominent place on the aquaculture map. The tremendous success of aquaculture practice in Moyna has strongly influenced farmers of surrounding districts to convert agricultural lands to aquaculture. Traditionally, capture fisheries in Moyna have had a rich heritage that strides across the twentieth century to meet the twenty-first with a steady progress. The long journey that began with traditional 'deep-water paddy cum capture fishery' to 'paddy cum fish farming' to aquaculture. Fish production in Moyna has reached a significant average yield of 12.5 tonnes/ha/year. This achievement has encouraged other aquaculture practicing areas to adopt similar practices.

The area under discussion is a basin covering around 147 km^2 that is susceptible to heavy rain and flooding. The entire area is situated slightly below mean sea level and is surrounded by three rivers namely the Kansai, Chandia and Keleghai. The Kansai River flows from north to south, covering the east side; the Chandia originates from Kansai at the north flowing west to meet the Keleghai, which in turn flows from west to east on the southern side to make confluence with Kansai in the south-east corner. All of these rivers are under tidal influence during high tidal spring surges. The rivers are mainly freshwater except for the south-east periphery area, which has brackish water with salinity ranging up to 5 ppt.

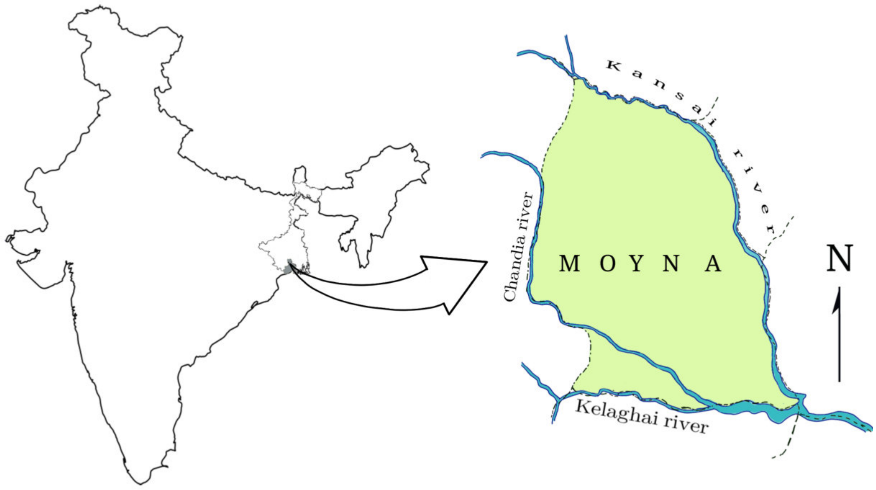
Traditional deep-water paddy cum capture fisheries

Early scenario

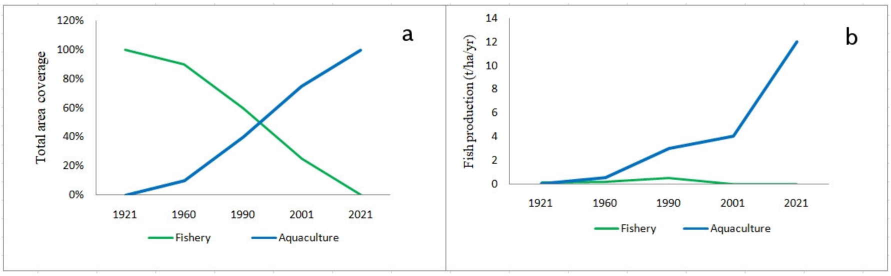
Before the shadow of climate change was felt there was a uniform trend of rainfall under southwest monsoon that would arrive early June every year in the eastern region of the Indian sub-continent, including West Bengal. There was a continuous moderate rainfall from early June to late September, with intermittent heavy showers. The cultivable lands were flooded with rainwater to as much as 30 cm depth, while lowlands had prolonged submergence with water depth ranging between 0.5-1.0 m, even 1.5 m in some areas. Traditional paddy cultivars with a plant height of around 1.40 m were grown in waterlogged areas in a practice known as deep-water paddy farming, which usually had poor productivity. The ecological conditions in deep-water paddy fields seemed unfavourable due to sudden fluctuation of water depth, and variable duration of submergence, depending on rainfall.

Ecological factors to support growth and development of fisheries

Given a vast area flooded during the monsoon, the natural fisheries resources became nature's gift to the common people of Moyna. The prevailing environmental conditions favoured paddy fields as a suitable habitat for fish growth and development. As soon as the rains started, fish migration from perennial water bodies to the newly submerged paddy fields was stimulated. Most paddy fields were connected by water bodies of diverse forms including ponds, canals, beels, jheels, and karanjali. Fish would migrate into paddy fields and spend a major part of their life cycle there. Parameters that supported fishery development included rainfall of around 175 cm annually with 113 days of rain per year; water temperature 27-31°C; pH, 6-8; and dissolved oxygen 8-11 ppm. Under the regime of such a freshwater environment, there were large numbers of diverse wild fish species, including large quantities of minnows.



An outline of Moyna Block.



A transitional shift from fisheries to aquaculture over the decades: a. area coverage, and b. fish production.

Plankton populations are an important food source for fishes and other aquatic biota, and phytoplankton also maintain dissolved oxygen levels in the water through photosynthesis. Periphyton - microalgae and other small organisms growing around paddy tillers - act as an ideal food for browsing fish species and benthic organisms. Although paddy production had a low yield, this was compensated by the production of a substantial number of wild fish. Thus, the deep-water paddy cum fishery was an ecosystem that provided both paddy and fish at the same time. It continued until more advanced fish farming techniques replaced the traditional system.

Deep-water paddy cum fishery: A nutritional support to poor people

Deep-water paddy varieties which were sown during April-May every year could grow into tall seedlings by July-August. The season is known as Kharif, which coincides with the breeding period of several indigenous freshwater fishes. People preferred these fish species for their unique taste as well as nutritional value. In addition to protein, these varieties of fish were valuable sources of minerals to combat hidden hunger and benefit poor people and assist in maintaining their health. People of all ages and economic status traditionally collected fish with indigenously made fish traps such as ghuni, mugri, and janta, which were made in such a way that fish can enter but not exit. Catching fish was a community event that would turn to a festive mood. The production of those traditionally grown fish might range up to 100 kg/ha/season, corresponding to 500 kg/ha/year. Surplus fish above immediate needs were preserved by drying with turmeric powder and salt. The poor used to consume these dry fishes during the lean period when the natural fish population declined, and the demand for fresh fish became high, which they could not afford.

A haul of harvested Indian major carp.

Deep-water paddy cum fish farming: A step towards aquaculture

An early system adopted as a trial

People of Moyna went ahead of its time because of their education. Moyna Pedi School which was established during British period illuminated knowledge among ordinary people who became advanced in all the fields including agriculture as well as fishery. With the long experience of 'deep-water paddy cum capture fishery', farmers of Moyna were able to think differently as deviating from the traditional practice of capture fisher to adopt fish farming in a few plots as a trial. With a favourable climate, they developed the suitable design of fish farming within capture fishery by implementing techniques such as fish stocking, manipulating stocking size, selection of species with preferred ratio, and cultivation time befitting with paddy saplings growth and development. During flooding, the field water contains more anions, such as carbonate, chloride, sulphate, phosphate and nitrate; metallic cations of calcium, sodium, potassium, magnesium and iron; and organic compounds of phosphorus and nitrogen, with increasing levels of organic carbon. The cumulative effect of rich inorganic and organic elements favours the growth of a diverse group of biotic communities such as phytoplankton, periphyton, benthos, zooplankton and other microorganisms which seemed to make a complete food web among different trophic levels of deep-water paddy cum fishery ecosystems. Such an ideal ecology promoted fish growth to a great extent as reflected in a good yield that farmers harvested and felt satisfied. The trial was successful.

In the course of time, 'deep-water paddy cum fish farming', established on a pilot scale, gained momentum because of two-threefold more yields of both paddy and fish crops as compared to earlier production. The success encouraged

A haul of harvested exotic fish.

Farmers use organic ingredients as fertilisers for apply in water bodies.

other farmers to bring more agricultural fields under such culture practice with sound technologies of scientific approach. As more high fish yields were harvested, more farmers stepped forward adopting deep-water paddy cum fish farming as a reliable cultivation practice. Needless to say, fish has always been a high demand commodity in Bengal. With time, fish became not only a primary crop but a major earner for the livelihoods of people of Moyna, while paddy seemed a secondary crop.

Construction of sink/basin/sump in paddy fields for paddy cum fish farming

Gradually, paddy farming got reorientation in its way. The high yielding varieties of paddy were introduced to Moyna during the 1980s. They made changes in the paddy fields by constructing a central basin/sump/sink with a few peripheral trenches along the dykes. As per individual needs, the excavation followed variable designs: 10m×10m×1m depth basin or 5m×5m×1m depth, covering 10-15% area of single paddy field. There were 2-4 sinks constructed in each paddy field and 40-50m×5m×1m peripheral trench. During flooding, fish use the sinks as passages to move around the paddy fields. In other seasons, the sinks provide a permanent refuge for fish when the water recedes from the paddy fields, and they provide a shelter to avoid high temperatures. The basins also act as water storage to irrigate paddy fields when there is an acute water shortage. In such a case, farmers used to harvest fish from sinks phase-wise. The advantage of such sinks was that a variety of wild fish species and cultivable ones congregate within them. Such a practice maintains the wild fish gene pool along with cultivable ones that could serve common people in providing much needed protein, vitamins, and minerals. However, change is the law of nature. Profitable paddy cum fish farming attracted farmers into stepping up to earn more income, which has in turn brought a paradigm shift in cultivation practices in Moyna. The entire cultivable land of Moyna that was paddy cum fish farming has been converted to aquaculture – a transformation that represents a sea-change in fish production.

Aquaculture practice: The only way of livelihood for people of Moyna

Fish production

The beginning of the 21st century witnessed the shifting of livelihoods from one practice to another. The entire agricultural land was converted to water bodies to dawn a large-scale aquaculture practice. A total water area of 7,550 ha including 7,000 ha freshwater and 550 ha brackish water areas comprises 4,465 freshwater and 929 brackish water coverage, with the size of individual water area in the range of 5-10 ha. The total production amounts to 84,000 tonnes of fish and 3,850 tonnes of prawn, averaging 10 tonnes/ha/crop (6-8 months). There is also a practice of farming a few exotic species introduced in the recent past. Given that aquaculture has a unique support system for only way of livelihood in Moyna, many academic institutes have shown their interest to know how farmers achieve such a tremendous yield. In this context, the Regional Research Center, ICAR-CIFA, Kolkata assesses the aquaculture activities of Moyna with a

Raking pond bottom after application of fertiliser.

Mechanised aerators to help maintain dissolved oxygen levels over a large water area.

specific motif as to make culture practice sustainable, keeping the ecological health of water bodies fresh and vibrant. We view the entire culture practice into specific segments: Fish farming, feeding operations, environmental health, disease prevalence, and fish trading. Dr Tarun Bera, Research scholar and academic who used to deal with different aspects of aquaculture also shared his experience with us.

Multiple stocking and partial harvest

Moyna farmers usually adopted two types of culture practices:

- The ‘multiple stocking and multiple harvesting’ method of culture practice: The initial size of the fishes in a single stocking range between 75 – 250 g, and the harvested size of the fishes was 500 g to 1 kg over multiple harvestings (4-5 times) and 10 months of total culture. Mainly, three carp species such as catla (*Labeo catla*), rohu (*Labeo rohita*), and mrigal (*Cirrhinus mrigala*), are stocked in the ratio 30:40:30 as a polyculture practice to utilise natural foods in different layers of a water body.
- Raising fingerlings: A few farmers procured carp spawn and raise them up to fingerlings. They stock Indian major carp with 700 kg fry (average weight 6.6 g i.e. 150 pieces/ kg) in a 0.4 ha pond with 1.8 m water depth.

However, the second practice does not seem to continue because of variability of market demand based on consumer preference. When farmers do not get an economic benefit, they immediately change their culture practice and switch over to either monoculture of single carp such as rohu, which is easy to transport long distances to market, or choose an exotic carp.

Saleable live fish kept within net enclosure with aeration facility.

Live fish lifted and weighed before loading into mini-truck.

Ingredients used as fertilisers

Farmers commonly use the following ingredients as fertilisers: black molasses (5 kg), yeast (2 kg), ground nut oil cake (43 kg) and mustard oil cake (50 kg) in a 0.4 ha pond at six-day intervals up to 75 days i.e. 12 times. After six days of stocking, fry are fed with a mixture of rice bran (100kg), ground nut oil cake (25 kg) and soybean dust (25 kg) in a slurry form every day up to one month. After 30 days, that feed was applied at 15-day intervals up to 75 days (i.e. 3 times), followed by pond raking.

Feeding operation

Common feed ingredients used are ground nut oil cake, maize, soyabean meal, micronutrient, probiotics, and mineral mixture in different proportions. The feed companies play a pivotal role in Moyna aquaculture. The farmers get branded commercial feed on credit and add some portion in their own prepared feed. They used different oil cakes and rice/wheat bran in the form of juice. The juice was used either weekly or bi-weekly for plankton production. The types of feed applied included pelleted feed, de-oiled rice bran, ground nut oil cake, and mustard oil cake. The amount of these feeds used in the different ponds was more than required quantities.

Environmental health – responsible management for sustenance

The pH of the water typically remains slightly acidic around 6.0 and dissolved oxygen (DO) is maintained around 6.0 ppm. The ponds have low salinity feature ranging from 0.03 ppt to 1.2 ppt. The electrical conductance varies from 0.8 to 2.33 milliohms/cm. The total dissolved solids were recorded in from 400 to 1,250 ppm, while the hardness was between 120 to 160 mg $CaCO_3$/l. Three types of conditions prevailed in culture ponds:

Loading live fish.

A series of mini-trucks each with 5 HP pump set on its overhead ready for transporting live fish to distant markets.

1. Pre-stocking ponds which are ready for stocking have the highest plankton population (average phytoplankton and zooplankton population respectively as 11×104 individuals/l and 5×104 individuals/l) with gross primary productivity and net primary productivity of 625 mg carbon/ m^3/hour and 250 mg carbon/m^3/hour.

2. Stocking ponds: Exhibited less plankton population (average phytoplankton and zooplankton population respectively as 6×104 individuals/l and 4.5×104 individuals/l) with gross primary productivity and net primary productivity of 50 mg carbon/m^3/hour and 25 mg carbon/m^3/hour.

3. Harvesting ponds have a higher plankton population (average phytoplankton and zooplankton population respectively 9×104 individuals/l and 5×104 individuals/l) than that in the stocking pond with gross primary productivity and net primary productivity as 175 mg carbon/m^3/ hour and 50 mg carbon/m^3/hour.

Disease prevalence

Disease problems mainly occur during June – September and cause economic loss every year. Bacterial haemorrhagic septicaemia, lernaesis, argulosis, dactylogyrosis, epizootic ulcerative syndrome, dropsy, ulcer and lymphocystis are significant problems. Parasitic diseases represented about 53.85% of problems, with 42.30 % being argulosis; bacterial diseases were around 30.77% of problems with red spots/red scales the most common issue at 15.38%; fungal diseases are about 11.54% of problems with dropsy at 11.54%, and other diseases around 3.85%. Farmers do not have a good understanding of how to treat different conditions and may use sanitisers, disinfectants, antibiotics, anti-parasitic medicines and probiotics to try and control disease outbreaks and also as prophylaxis measures.

Assessing pond condition through carbon footprint

Pond aquaculture has three levels of feed loading: Low (11 to 13 tonnes/year), moderate (16 to 18 tonnes/year) and high (30 to 32 tonnes/year). The ponds with high feed loading had the highest mean sediment accumulation rate (11.0 ± 3.0 cm/year), higher than the moderate (9.0 ± 2.5 cm/year) and lowest (7.0 ± 2.0 cm/year) groups. The group with high feed loading also has the highest mean carbon storage (704 ± 30 g carbon/m^2/year), significantly higher ($p < 0.05$) than the groups with moderate (506 ± 24 g carbon/ m^2/year) and low feed loading (343 ± 17 g carbon/m^2/year). The highest fish production is related to the minimum CO_2 emission that manifests to minimum inputs requirement. The principle of environmental management is to apply minimum inputs and maximum output in return as assessed accurately through carbon footprint study.

Fish trading: A livelihood option for self-employment

After harvest, live fish are kept within high net enclosures with aeration facilities. Every day live catla, rohu and mrigal of an average 1 kg weight are transported from Moyna via 250-400 mini trucks to different parts of Bengal from 100-300 km distant. In each mini truck, a large container wrapped with thick polythene is carried, with a typical capacity of 4,500 litres. One five-horsepower diesel pump is placed overhead on the mini truck for oxygenation through re-circulation. During transportation Glucon-D @ 1g/l is mixed for energy supply and Oxymore or Activate tablets are also used to

List of indigenous freshwater fish species recorded in deep-water paddy cum capture fishery:

Amblypharyngodon mola, *Anabas testudineus*, *Chanda nama*, *Channa marulius*, *C. orientalis*, *C. punctatus*, *C. striatus*, *Clarias batrachus*, *Colisa fasciatus*, *C. lalia* , *Esomus danricus*, *Glossogobius giuris*, *Gudusia chapra*, *Heteropneustes fossilis*, *Lepidocephalus guntea*, *Macrognathus aral*, *M. pancalus*, *Mastacembelus armetus*, *Monopterus cuchia*, *Mystus bleekeri*, *M. tengara*, *M. vittatus*, *Nandus nandus*, *Notopterus notopterus*, *Pseudambassis baculis*, *P. lala*, *P. ranga*, *Puntius chola*, *P. sarana*, *P. sophore*, *P. ticto*, *Ompok pabda*, *Osteobrama cotio*, *Salmostoma bacaila*, *S. phulo*, *and Xementodon cancela*.

improve oxygen supply to the fish. This is an indigenously developed technique that is capable of maintaining a substantial number of live fish during transport.

Conclusion

The ICAR-CIFA Regional Research Centre, Rahara, has studied aquaculture practices that farmers adopted on a large scale in Moyna. The centre has observed a gloomy picture with regards to the sustainability of future aquaculture practice, with the following issues requiring address:

- Excessive use of feed needs to be checked, with feed consumption monitored and rations adjusted based on need, to avoid excessive algal blooms and deterioration of water quality.

- When fish movement is unusual and they come to the surface to gasp, external water supply through fountains needs to be started using a pump. The density of plankton population is to be maintained proportionately, otherwise oxygen depletion may occur.

- Indiscriminate use of pesticides for prophylactic measures and disease control should be stopped, and controls on the legitimate use of antibiotics and chemicals for treatment of legitimate disease issues introduced.

Moyna started its journey on fish production long before aquaculture was widely practiced. Moyna has a rapidly growing aquaculture industry that employs a diversity of production systems and unique indigenous transport techniques. Given the widespread transition of farming land towards aquaculture it is vital that good husbandry is practiced to maintain the sustainability of the system and supporting environment.

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