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Invasive apple snails in Timor-Leste

Freshwater cage aquaculture in India

Fattening mud crabs

Aquaponics

Aquaculture Asia

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

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NACA

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

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Cost-benefit analyses and rural development

"We need you to provide a cost-benefit analysis."

This is a request that we receive several times a year from funding agencies. These requests usually originate from the finance department of the entity in question. They want to know what the return was on their investment was. There is an unstated expectation that the benefit must exceed the cost. It needs to make *financial* sense.

Our problem is that, in dollar terms, we don't really have a good answer for them.

The main benefits of rural development projects do not lie in financial returns. They lie in capacity building. This takes many forms such as improved education, health, nutrition or income. It's about increasing opportunities and quality of life for people, especially disadvantaged groups. These are not things that you can measure in dollars.

Exhibit A: The photo below is of a power line in Laos, connecting a village school to the power grid for the first time. The local community paid for the connection themselves. They raised the funds by selling fish they grow in an irrigation reservoir. And they learned how to grow the fish by participating in a donor-funded development project.

Was it "worth it"? In dollar terms, we could have paid for the installation of a power line at a fraction of what the project cost. But that was not the point. The project built the capacity of the community. The community now has a sustainable source of revenue and is using it improve facilities. They plan to install a piped water supply to the village. The kids have better access to animal protein. Their parents now have more time to work on the farm because they don't need to go fishing. Years after the project ended, the community still grows fish of their own initiative and most importantly, they're doing it all *themselves*. Neighbouring communities have reached out to them and begun their own fish culture activities.

The impacts of this project may continue to play out for decades, perhaps generations, and have already spread well beyond the villages targeted by the project. So was it *worth* it? Of course it was. But can we put a dollar value on the "benefit"? Not a chance.

We don't do development projects to generate financial returns. We do them for other reasons.

Simon Wilkinson

Unforseen consequence: A power line connecting a rural school in Laos to the electricity grid. It was paid for by a rural community using profits they made from fish culture.

AQUACULTURE ASIA

CONTENTS

Current status of freshwater cage aquaculture in India: Towards blue revolution

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A full view of cages.

Aquaculture provides the cheapest source of animal protein to about 13% of the world population and employs an estimated 24 million people. The industry is projected to meet the global deficit of fish protein by 2020 due to stagnant marine fish landings. Although the sector is diverse in terms of species cultured and farming practices, cage culture has been identified as one of the most efficient approaches to utilise untapped water bodies.

The practice of cage aquaculture originated around 200 years ago in Cambodia, wherein fishes especially catfish (*Clarias* sp.) were held in cages with primary objective of keeping them alive until sold[4]. China contributes around 68.4% of the global freshwater cage culture, followed by Vietnam (12.2%), Indonesia (6.6%) and the Philippines (5.9%). Presently, around 70 species are being reared in cages in freshwater globally, with *Pangasius* being the dominant species accounting to 41.1%, followed by Nile tilapia *Oreochromis niloticus* (26.7%), common carp *Cyprinus carpio* (6.6%), *Oreochromis* spp. (5.1%), rainbow trout *Oncorhynchus mykiss* (4.1%), and salmon *Salmo* sp. (3.7%).

In India, the first attempts were initiated using airbreathing catfishes in swamps and Indian major carps in the Yamuna and Ganga rivers. Later, the Central Institute of Fisheries Education conducted cage culture for rearing fingerlings and table sized fishes in the Powai, Govindsagar, Halali, Tandula and Dimbe reservoirs. Several attempts were made but success remained unremarkable until the last decade, when a notable success in cage culture has been achieved. A decision to increase in fish production from cage culture was made and this technology has been promoted by various state government schemes such as the National Mission for Protein Supplements and it has become established in Tamil Nadu and Jharkhand.

Amur carp.

Scope of cage culture

The scope of cage culture in India is bright especially in freshwaters due to the availability of nearly 2.25 million hectares of pond and tanks, 3.0 million hectares of reservoirs and 0.78 million hectares of beels, swamps, and other water bodies. So far, cyprinids, perches, snakehead, and catfishes have been cultured in cages with success. Cage culture can be done in extensive, semi-intensive and intensive modes in selected water bodies. As an extensive method, cage culture does not require supplementary feed but rather utilises phytoplankton and zooplankton from the water bodies. Cage culture as a semi-intensive practice requires a low protein supplementary diet (<30%) and if feed exceeds 30 percent of protein content the practice can be considered to have crossed the threshold to become an intensive method[4]. As a relatively new aquaculture technique in India, skills in cage culture need to be disseminated to farmers. Unplanned expansion of cage culture can lead to undesirable environmental impacts and therefore there is also a need for proper guidelines to be established to ensure sustainable growth of this sector without any undesired impact on the environment.

Site selection for cages

Site selection is one of the most important factors for successful cage aquaculture practices, with considerations including water quality, water depth and currents required to be considered before finalising the site for deploying cages. Optimum water quality is essential to obtain maximum yield from the cage culture units.

Essential water quality parameters such as dissolved oxygen, temperature, pH and ammonia should be routinely monitored during culture.

Dissolved oxygen should not fall below 5mg/l; as wind action and photosynthesis are the primary sources a location with better wind and wave action ensures proper oxygen levels are maintained for the cultured animals. Low dissolved oxygen levels (less than 4mg/l) may cause mortality, lower survival rate and poor growth.

Temperature is a major physical parameter controlling molecular dynamics and biochemical reactions. Unfavourable temperature affects the fish health, feeding behaviour, and reproduction rate. Optimum temperature requirement ranges between 24 to 30°C for most of the warm water species.

pH is another important parameter, which can vary due to intake and release of CO_2 during photosynthesis, respiration and decomposition. An optimum pH of 6 to 9 is necessary for the enhanced fish growth and high pH can lead to a rise in ammonia level in the water bodies. Ammonia comprises of ionized ammonia and unionized ammonia. Ionized ammonia is more toxic to fish. Temperature and pH can influence the ammonia concentration above its optimum (maximum) level of 0.02 to 0.05mg/l.

The appropriate water depth for successful cage aquaculture is about 6 metres. Earlier experiences in cage culture reveal a minimum of 1 m distance as a requisite between the bottom of a cage and the floor of the water body in order to prevent undesirable environmental effects. The selected location should have a water current speed in the range of 20 to 30 cm/second to maintain good water quality conditions within the cages. When the flow speed exceeds 40cm/second, feed may be lost from the cages into the natural system; the shape of the cage also changes potentially stressing the fish, which may adversely affect yield. Hence, proper study of the water current speed and pattern is also an essential consideration in siting cages.

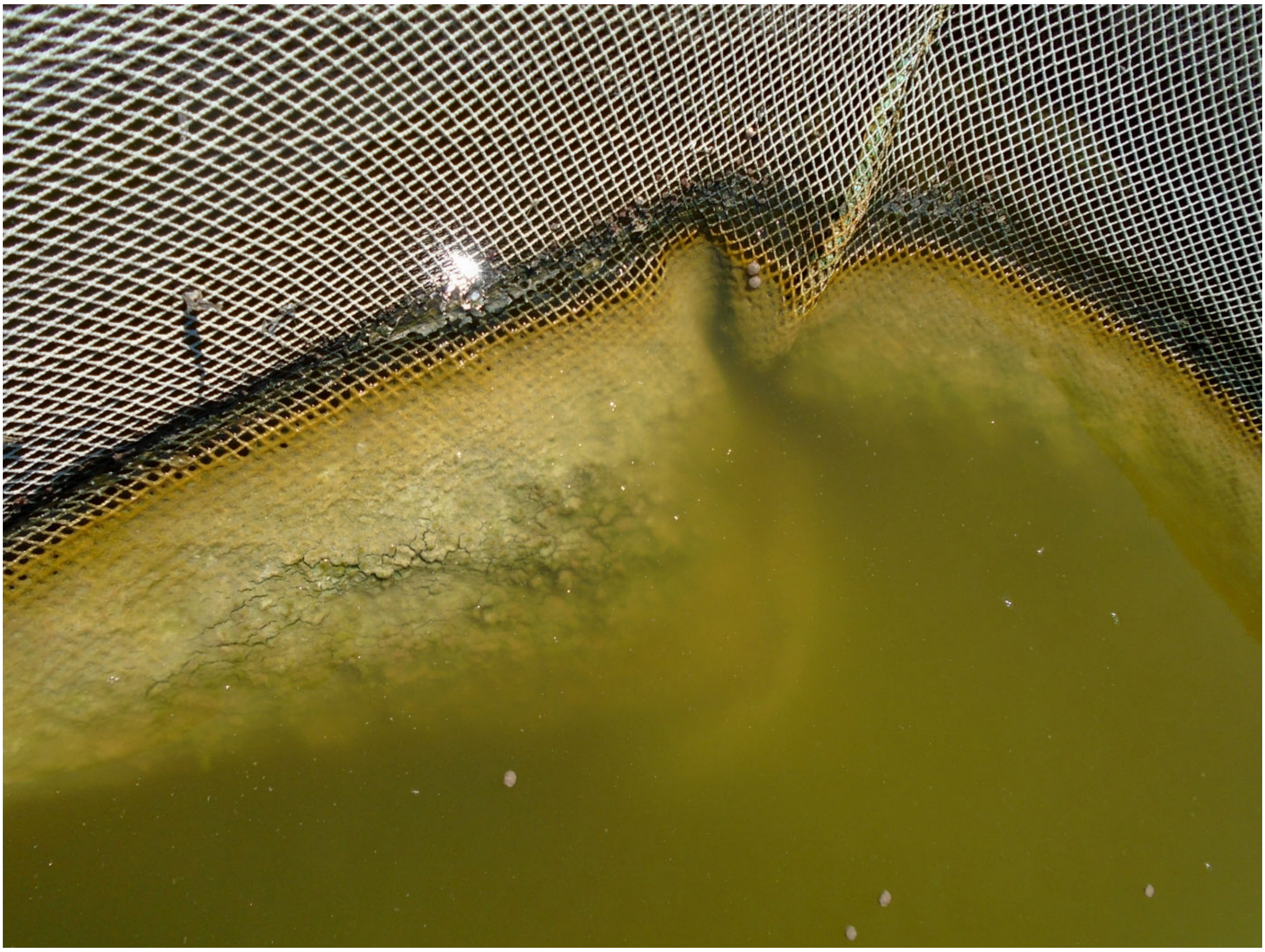
The site should be free from excessive wind and wave action as such conditions can make it difficult to maintain the cages and during extreme weather can even result in collapse of the cage system. It is better to avoid sites prone to flooding, fish breeding grounds, local fishing regions, regions receiving industrial effluent and locations with high fish populations.

Advantages and disadvantages

Cage aquaculture techniques are easy to learn and the activity requires considerably less space as compared to traditional pond culture. Efficient use of extensive water bodies such as reservoirs and lakes is made possible with cage culture. Cages provide an environment for easy monitoring of fish health, diseases diagnosis and health management. Individual cages also provide scope for quick and complete harvest; making it economically viable as compared to other extensive fish culture methods. However, there are certain limitations. Natural calamities may collapse the culture system; there is the risk of water quality deterioration and disease may spread faster than extensive culture systems, due to the high density of the fish. Cages can also create issues with other stakeholder groups such as fishers.

Cage construction

Four types of cages namely surface floating, fixed, submersible and submerged cages can be practiced. Of these, the floating cage is most widely adopted, easy to manage, and most appropriate for the Indian environment. The cage position in water can be easily adjusted according to the water level. Framework materials include aluminium, galvanised iron, rigid PVC and HDPP pipes. Empty barrels, HDPP jerry cans, airtight PVC pipes and fibreglass are used to float



Fouling.

the cages. Netting and cage materials should be strong, durable, lightweight, corrosion, and weather resistant, fouling resistant, easily repairable, inexpensive and readily available.

Cage shape

Cages can be round, rectangular, octagonal and square, there is no impact on production. However, in freshwater reservoirs, rectangular shaped cages are usually prefered due to cost and construction advantages, availability of raw materials, assemblage and transportation of the components. The size of the cage varies with the scale of operation, the habitat of species, the phase of fish (larvae, fry, and finger-lings), financial and managerial management. The World Bank suggested cage size is about 4 x 4 x 3 m, but others have recommended 4 x 4 x 2.5 m or 5 x 5 x 2.5 m with good results. The minimum cage depth should be 0.9 to 1.6 m.

Cage grouping and mesh size

Cage grouping is another important issue, which is similar to the distance between the cages. Cage batteries can comprise perhaps 20 to 24 units arranged in 2 rows of 10-12 cages each. It is essential to maintain a distance between the cages to facilitate water exchange and dissolved oxygen levels. The minimum requisite distance between the cage culture units is 20-25m.

The mesh size can be decided taking into account size of fish stocked. Generally maintaining larger mesh is better for fish stock as it allows for improved water exchange and dissolved oxygen levels and less fouling. Knotless mesh is recom-mended, as it allows better water exchange than normal knotted mesh. A mesh size of 4 – 6 mm^2 for fry rearing and 16 – 20 mm^2 for grow out are recommended. Another study [13] reported 1 cm as the net mesh size and the same can be increased up to 3 cm for an average fish size about 11.6 cm, which equals to approximately 25% of the body length.

Cages should be covered by a net to prevent the fish escape by jumping or bird predation. Larger water bodies are better suited for cage culture rather than small water bodies due to stable water quality that is less easily affected by fish waste. However, 0.5 – 2.5 hectare ponds are also suitable to install cages.

Species selection

The species selected for cage culture depends on the local/regional market demand, high market value and seed availability. Of this, higher market value species could generate higher income. The most preferred species in one market may be the least preferred in another market thus if overlooked by the fish producer, poor species selection can lead to poor marketability and loss. Another vital aspect is seed availability, if hatchery for a species is absent in the local region, it must be avoided as it could result in dependence on wild collection or incur high transportation cost if purchased from far off places. The selected species should have the fast growth, higher survival, lower food conversion ratio, ready acceptance of feed, a rapid adoption of artificial diet, ability to withstand overcrowding, good flesh, capacity to tolerate wide range physical and chemical parameters and higher resistance to diseases. Species that have been identified as

Figure 1. Top 10 fish seed producing states in India.

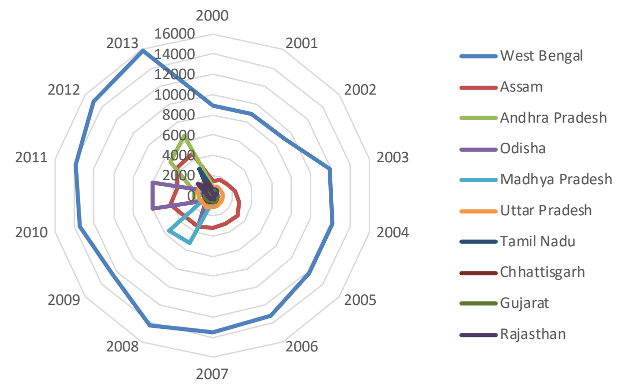
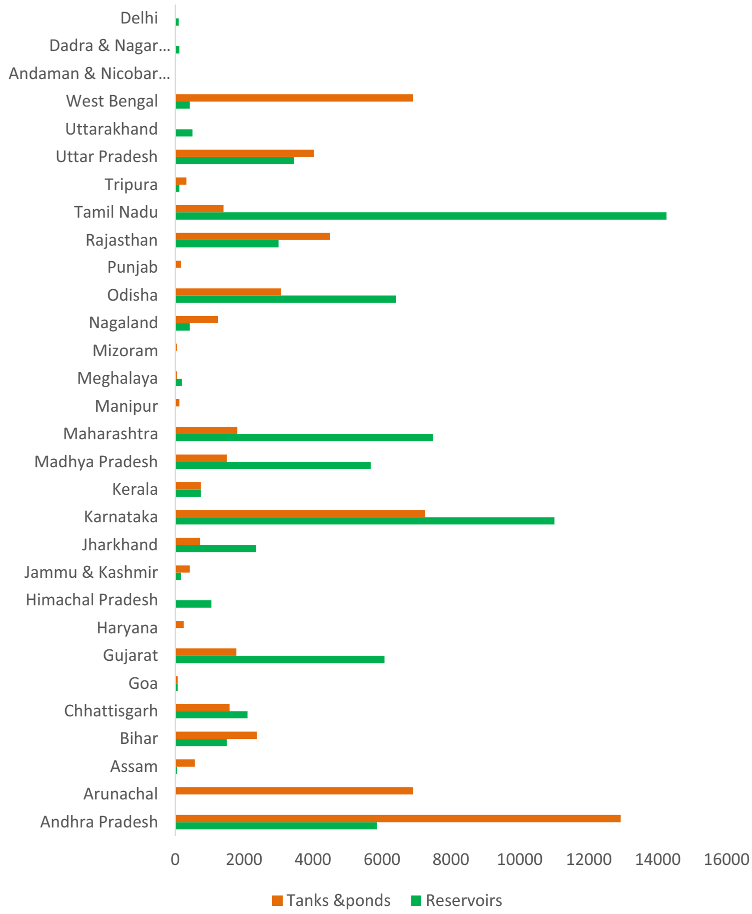


Figure 2. Projected fish production in reservoirs, tanks and ponds through cage culture.



the most suitable candidates for cage culture include tilapia, pangasius, Indian major carps, air-breathing fish, climbing perches, snakeheads and freshwater prawn.

Seed source and transportation

Seed should be obtained from a reliable fish hatchery, after checking for quality to ensure high survival and growth rate. Thus while purchasing farmers should check the seed quality by observing active swimming and ready acceptance of natural or artificial feed. The seed should be packed in plastic bags, with 1/3 water and 2/3 oxygen, however, seed should

Above: Young pangasius. Below: The result of improper cage management.

During sampling.

While feeding.

be transported by the shortest possible way and transport should be in the morning or late afternoon. After arriving at the cage site, float the plastic bags in container with water for 15 to 20 minutes. Open the plastic bags and slowly splash small amounts of water to equalise the water temperature in the bag and container, allowing the fishes to swim out by themselves. Then, give seed a dip treatment using salt (5%) or potassium permanganate (3-5%) to remove ectoparasites prior to release into the cages.

Stocking density

Stocking density in cages refers to the number of fishes stocked per cubic metre, which has an effect on the growth and survival, water quality and health of fishes. Stocking density varies with carrying capacity, feeding habit of fish, and stocking size. In addition to this, an even size at stocking is recommended for easy handling, evading predation and cannibalism and overcoming harvesting difficulties. An optimum stocking density is essential to get good growth and survival. The stocking density is directly proportional to the fish size. Feed accessibility is challenging in higher stocking density but it can be overcome by widely spreading feed within the cage. For cage culture, 15g fish with a stocking density 80 fish/m^3 is ideal and if managed under best management practices can ensure a survival rate of 98 to 100%.

Tilapia

Tilapia has shown higher growth at the stocking densities of 100, 150 and 200 kg/m^3, with an initial stocking size ranged 25 to 30g for *Oreochromis niloticus.* However, 80kg/m^3 produced better growth with lower FCR than stocking densities of 100kg/m^3 and 120kg/m^3. Production cost increased with stocking density. Stocking density in cages of nursery was up to 3,000 individuals/m^3 for 7 to 8 weeks with a weight of 10g.

Carps

The recommended stocking density for Indian major carps is about 80 fish/m^3 with a minimum recommended stocking size of 15g. Fry of Indian major carps up to 25mm are suited and advanced fry 35mm and fingerlings 50mm can be harvested. The stocking size of minor carps, in polyculture (*Labeo rohita, L. calbasu, L. gonius, Gibelion catla* and *Cirrhinus mrigala*) is about 1.3 to 2.6 g (40 – 65 mm) and they can be harvested about 15 – 36g with the survival of around 70%.

Pangasius

For fry (20mm) and fingerlings (50mm), an optimum stocking density of pangasius about 500 to 600 individuals/m^3 and 80 to 100 individuals/m^3 respectively. Periodic sampling is essential to assess the fish growth rate and health condition. In general, the culture duration in cages is from 6 – 8 months.

Feed and feeding

Feed provides balanced nutrition needed by the fish in the form of granules or pellets. Floating pellets are better for cage culture rather than sinking pellets. Floating pellets also help farmers to observe the feeding response and health of fish. If sinking feed is used, extra care must be taken to ensure that feed is not wasted and utilised properly. If automatic feeders are used, floating feed is recommended to avoid feed waste. Fish feed must have the adequate nutritional components to fulfil the requirement of the fish. Although it varies with species, 20-30% of protein is sufficient for larger fishes in semi-intensive cage culture. However, 32 – 36% of protein is requisite for small tilapia and catfish (1 to 25g size). Also, a minimum of 6 to 8 hours is required for the feeding and two feedings per day is satisfactory.

Good feeding practices have to be maintained to reduce the feed wastes. Feed quantity should not exceed 3 to 5% of the body weight. The feeding ration has to be adjusted couple of times in a month through sampling. The percent of feeding can be reduced with increasing culture days but the feed size increased with fish culture days. Mash type feed is not advisable as such feed can be left uneaten, drop out of the cage and can deteriorate the water quality.

Management practices

Water samples should be collected frequently from inside the cages to evaluate the water quality parameters such dissolved oxygen, ammonia, and phosphate, and periodically recorded to observe changes and adjust management accordingly. Cages should be cleaned on a needs basis, to avoid excessive algal growth which may reduce water exchange. The health of stocked fish should be checked regularly, if any infection is observed they need to be quarantined and treated according to the symptoms.

Harvest and marketing

One or two days before harvest feeding should be stopped and harvesting shall be done in a phased manner and sale of larger sized fishes should be first, followed by smaller sized fishes. This ensures maximum returns from the crop. The advantage of cage culture is the facility to harvest the required quantity with minimum labour and maintaining the balance of stock alive at a minimum cost.

Towards the blue revolution

The remarkable emergence of aquaculture as an important and highly productive activity is often called the ‘blue revolution’. Aquaculture is increasing the economic prosperity of fishers and contributes to rural food security through the use of water bodies in a sustainable manner with the concern of biosecurity and the environment.

The projected fish production requirement for India is 13 million tons in 2020 against present production of 10.06 million tons. The Government of India has targeted to increase the present fish production by threefold and thereby implemented various schemes such as the fish brood bank, aquaculture intensification in ponds and tanks, reservoir fisheries development, cage and pen culture, infrastructure for post-harvest, modern fish markets and a disease surveillance program through the National Fisheries Development Board. However, of these, cage culture has been identified as the most promising tool to meet the increasing demand for fish production.


Sampling pangasius for length and weight.

The National Fisheries Development Board plans to install 300 cages in inland water bodies with an anticipated fish production of 5 tons /cage. After the installation of all the cages, the annual fish production would be alike 1,500 tons from these NFDB cages alone.

For the implementation of cage culture, water resources are very important and Figure 1 depicts state wise inland fish production (cage culture production information is not available). The Chandil Reservoir in Seraikela Kharsawan District of Jharkhand State, has a water area of over 18,000 ha. A significant income was generated from the cage culture of *Pangasius sutchi* in addition to the traditional capture fisheries. Similarly, Bhavanisagar Reservoir in Erode District of Tamil Nadu has the water area of 7,876 ha. There 40 cages were installed to enhance the fish production through this culture technique. A total of 60 cages were installed in five reservoirs (Sriramsagar, Sriramsagar, Kadam, Pocharam and Koilsagar) in Telangana State. Two batteries of 6 cages (6 x 4 x 4 m) were implemented in each of these reservoirs.

If cage culture is implemented in around 70% of the available reservoirs, tanks and ponds the anticipated increase in fish production is estimated to be on the order of 94,000 tonnes. This clearly indicates that cage culture is a useful method to enhance the fish production and which also provides economic opportunities for rural communities.

Fattening of mud crab *Scylla serrata* in estuarine region of south-eastern West Bengal, India

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Adult crabs in market.

Crab fattening as a livelihood generating activity

Live mud crab *Scylla serrata* of large size has gained in importance due to its high export value and good overseas demand. Its export from India has increased markedly over the last fifteen years with the boost occurring after the introduction of crab fattening. In the Indian Sundarbans region in south-eastern West Bengal, agricultural crops are not high yielding due to the salinity of soil. The availability of commercially-important fishes and their stock in brackishwater rivers and creeks has been gradually decreasing during recent years, thus impeding fishing activities. Many households in coastal belt of West Bengal collect riverine tiger shrimp (*Penaeus monodon*) post-larvae but it has a long-term negative impact on aquatic biodiversity. Commercial *P. monodon* farming has also suffered multiple setbacks mainly due to flare of viral diseases.

In this context, mud crab offers an alternative to *P. monodon*. In crab fattening, the turnover is fast, the period between investment and return is relatively short, a lower level of investment and risk is required, costly pelleted feed is not required and it can be practiced in small water bodies. Crab fattening has emerged as a promising component in coastal aquaculture and as a profitable vocation with prospect of high returns in Indian Sundarbans, as a result of which the activity has spread organically amidst the North and South 24 Parganas districts.

Crab fattening in small enclosures

During July-August 2018, I held conversations with three well-established and professional crab fatteners in the estuarine region of North and South 24 Parganas to gain knowledge on the state-of-the-art of fattening of *S. serrata* meant exclusively for export to Singapore, Malaysia and China. Sri Oli Ahmed Mollah at Village Dhamakhali in North 24 Parganas is maintaining nine earthen chambers of 160-180 m^2 each, water depth 1.2 m, located at the confluence of two tidal rivers, the Kalagachhia and Rampur. In each of these tide-fed crab fattening enclosures have been established with strong net fencing supported by split bamboo screens up to a height

Chambers of Sri Jana.

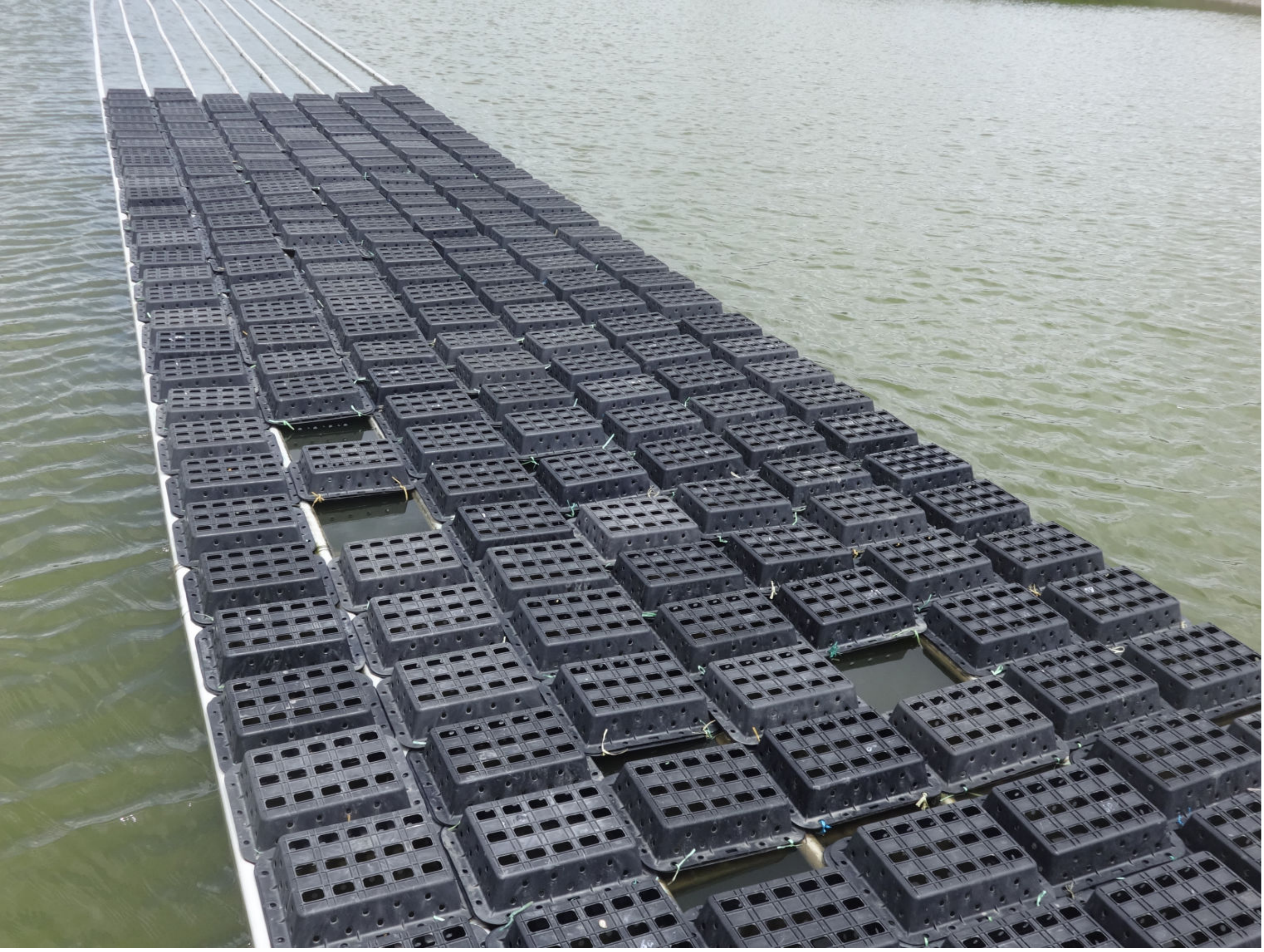
of 1.8 m from the bottom. Sri Mollah stocks male and female crabs separately, of size 200-500 g and 150-250 g, respectively @ 100kg/chamber. These are bought @ Rs 300-500/kg from fish merchants of Dhamakhali market supplied by crab collectors of the Indian Sundarbans region.

Crabs are fed daily with cut pieces of fresh brackishwater finfishes *Johnius* sp. (Rs 25-40/kg), *Setipinna phasa*, *Coilia dussumieri* and sometimes *Tilapia nilotica* @ 10% of body weight. Sri Mollah fattens his stocked crabs for 15-16 days during June-July to October and 25 days during November to February-March, within which their shells are hardened with an additional weight of 40-50gm as they gain meat. Ripe ovaries develop in females. He supplies the healthy ready-for-market crabs (males 500-700 g; females 250-300 g) in early morning to a company in Baghajatin area in south-eastern Kolkata, who are eminent exporters of live mud crab. He gets Rs 650-800/- per kilogram of fattened crabs and earns a profit of Rs 9,000-24,000/- from 90kg produce in 15 days (considering 90% survivability). Crabs fetch a much higher price in winter (Rs 900/kg). Excluding the period April to June, crab fattening is done here round the year. After two successive crops, Sri Mollah drains the water from the fattening chambers and applies $CaCO_3$ @ 12kg and Zeolite @ 4kg/160 m^2 mixed with bottom earth to eliminate obnoxious gases. Oxygenation of water is carried out when crabs rise up to the surface and cling onto the net screen.

The crab fattening methodology of Sri Jagannath Jana at Village Rampur Khiristola is quite similar. Sri Jagannath owns a total 2,880 m^2 water area; a set-up comprising five chambers of 240 m^2 each, three chambers 360 m^2 each and the largest one 600 m^2. Water exchange takes place in each daily at depth of 0.45 m via tidal influence of Bidyadhari River. Sri Jana stocks 250-300 male and 450 female crabs separately in every 240 m^2 area (total weight 100kg; females 180-250 g, males 400 g) and applies 8kg feed daily for every 100kg crabs. He realizes a high demand during winter. After one crop, he applies 5kg $CaCO_3$, 1kg bleaching powder and 1.5kg Zeolite / 240 m^2 over water mass and subsequently the bottom mud is raked. Sri Jana supplies his harvested fattened crabs (carapace width 13-16cm) in the forenoon hours to an agency reputed in mangrove crab exports near Muchipara Police Station in Sealdah, Kolkata via an auction point in Canning Fish Market and gets Rs 600-700/kg produce. Export trade of fattened live mud crabs of the Indian Sundarbans is undertaken by nine exporters located in and around Kolkata1. Sri Jana has experienced higher mortality of stocked crabs during summer. In cases when fishermen go for long duration trips in the deeper waters of Matla and Thakuran estuaries, wild-caught adult crabs are kept on-board for 3-4 days before being sent to market. Such crabs are stressed probably vulnerable to infection, Sri Jana opined.

Sri Mollah with male crab that needs fattening.

Female crab needs fattening.



Crab fattening boxes on a raft.

Buying crabs for fattening

Live *S. serrata* are caught by marine fishermen and crab collectors from the Sundarbans delta in sizes of 350-400 g (2.5-3 individuals/kg), 250 g and others. There are five grades of weight of male crabs which are bought by crab fatteners, with price varying from Rs 300-350/kg for 100-150 g size to Rs 450-700/kg for 400-500 g males. There are two grades of females sold at Rs 350-450/kg for 150-200 g and Rs 500-600/kg for those above 200 g. These are also available at Najat, Sorberia, Amtoli, Malancha, Brindaban Bazar, Chunokhali, Taldi, Canning wholesale fish and shellfish markets. Mud crabs grow up along the rivers and canals namely the Saptamukhi, Thakuran, Matla, Bidyadhari, Gosaba, Herobhanga and Raimangal in the Indian Sundarbans, also reckoned as estuaries. Important mud crab landing areas in the two districts are Basirhat, Basanti, Sonakhali, Port Canning, Kakdwip, Satjelia, Kumirmari and Namkhana. Both grow-out crab culturists and crab collectors supply healthy live adult crabs to the markets. Among those caught, Sri Mollah, Sri Jana and other crab fatteners choose soft-shelled females with under-developed ovaries and males (somewhat lean) that have to grow to fill their new shells with meat (after moulting). Such adult crabs (CW: 8-14cm) are not accepted in export trade and thus need fattening.

Crabs undergoing fattening in boxes.


Crab fattening chambers of Sri Mollah.


Crab fattening chambers of Sri Jana.

Sri Majumdar with crab fattening box.

Plastic boxes for crab fattening at Namkhana

In order to prevent cannibalism among crabs and increase yield of fattened mud crabs, since December 2017, Sri Dibakar Majumdar at Village East Ganeshnagar South 24 Parganas has adopted the advanced Vietnamese concept of crab fattening technology in durable, perforated and submerged-type boxes in his 3,000 m^2 pond (90 m x 36 m; depth: 1.2 m), and is the first person to introduce the technology in West Bengal. He stocks females with an infirm outer covering and under-developed ovary individually in each box. His pond is within the tidal influence of the Saptamukhi River; 20% water is exchanged on every full moon and new moon. Boxes are positioned on floating rafts made of eight parallel 5 cm PVC pipes; one such raft holds up to 1040 boxes from one end of pond to another. Five rafts can be positioned in the pond at one time. Sri Majumdar is also a manufacturer of fattening boxes with the emblem 'Bengal Mud Crab Aquaculture', each 33.5cm long, submerged portion 14.4-16.5cm high, made of durable plastic, weighing 720 g with 6-7 years longevity and sold @ Rs 200/piece.

Female crabs 150-180 g size (Rs 300-350/kg) are stocked; *S. serrata* of the Indian Sundarbans region and those brought from Gujarat are fattened here for 25 days and 42-45 days respectively. At times when the supply of small-sized *Johnius* sp. and other fishes (Rs 20-25/kg) are insufficient, soft-shelled snails, mussel meat and pieces of *Tilapia nilotica* are fed to crabs @ 10% of body weight daily. It is easy to monitor the condition of crabs undergoing fattening in boxes, and individual feeding results in higher feed utilisation, Sri Majumdar opined, who is maintaining a stock of 7,000 boxes. Fattened females with 25-30 g increase in individual weight are sold @ Rs 750-800/kg and air-lifted to Singapore on same evening. Sri Majumdar applies 30kg dolomite in the pond at an interval of 15-18 days. He is doing grow-out monoculture of baby mud crabs (50-80 g), *Mystus gulio* and monosex tilapia in his other three brackishwater ponds of 3,000-3,500 m^2 each. Sri Majumdar estimated an income and net benefit of Rs 57,600/- and 22,600/- respectively from a crop of 45 days; considering 500 female crabs are fattened in boxes in 640 m^2 water area and 180-200 g weight of each at harvest with 80% survivability.

End note

According to three crab fatteners, profit from tiger shrimp *P. monodon* farming is not guaranteed every year. Profit margin is realized after six months of farming but in *S. serrata* grow-out culture and fattening, it is realized from the third month. In these two districts, crab fattening is usual in the Gosaba, Basanti, Minakhan, Hingalganj, Hasnabad and Sandeshkhali areas. At times when flight service from Kolkata airport to importing countries is irregular, traders and agents keep the live produce with them for 2-4 days and fatteners get a price of Rs 150-200/kg less for the crabs supplied. Better economic return is realised from crab fattening in comparison to grow-out culture. In recent years, there is a rapid growth

Adult crabs in market - smaller size.

Another view of Sri Majumdar's pond.

View of Sri Majumdar's crab pond.

Large crab still needs fattening.

of crab markets in West Bengal[2]. Mud crab traders and exporters in Kolkata sort the fattened crabs supplied to them into specific grades and accordingly fatteners are paid. Sri Majumdar stated that during November to January of the next year, the price of female fattened crabs reaches up to Rs 1800-2100/kg. In addition to male fatteners, appropriate training and extension services are expected to enhance the skill and knowledge of women involved in crab fattening in deltaic Sundarbans[3].

Author left with crab farmers at Gosaba.

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Crabs brought for fattening.

Aquaponics: Sustainable farming method in the fight against hunger

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Aquaponics is a closed-loop system, in which the waste water produced from a store tank of fish is being utilised as fertiliser to feed the vegetation bed. In turn, the plant life filters the liquid through its roots and then the cleaned water is again utilised in the aquarium. So, this is a symbiotic and integrated system in which both the systems (aquaculture and hydroponics) are benefitted with each other and eliminates the drawbacks of each. The third participants are microbes (nitrifying bacteria). These bacteria convert ammonia from the fish waste first into nitrites and then into nitrates. Nitrates are the form of nitrogen that plants can uptake and use to grow. The solid waste excreted by fish is converted into vermicompost to use it as food for the plants.

Aquaponics is a natural and sustainable practice that mimics processes in lakes, ponds, rivers and other waterways. The only input that we have to provide into this system is fish food. Fish will eat food and excrete waste which is then converted by nitrifying bacteria into the form that the plants can use. In return, the plants help to purify the water. You cannot use herbicides, pesticides or other harsh chemicals in an aquaponics system, making the fish and plants healthful and safe to eat.

Problems with traditional farming methods include:

- Pesticide and artificial nutrient usage.
- Weeds, pests and soil-borne insects.
- Intensive land, labour and capital requirements.
- Knowledge required to know when to water, when and how to fertilise, and to assess the composition and condition of the soil.
- Transport and logistical demands - traditional farms are often located thousands of miles from where the food is consumed.

Aquaponics can alleviate some of these shortcomings:

- Aquaponics mainly depends on the continuous recycling of nutrient-rich water between crop compartments. In this farming system, there is no toxic run-off from either hydroponics or aquaculture.
- Aquaponics uses a much lower amount of water in comparison to the traditional soil-based culture practices.
- It is an environmentally friendly approach. So, the use of chemicals such as pesticides or herbicides is avoided.

Gardening chores are cut down dramatically or eliminated. The aquaponics grower is able to focus on the enjoyable tasks of feeding the fish and tending to and harvesting the plants.

- Aquaponic systems can be put anywhere in a greenhouse, basement, living room or even outside. By using grow-lighting, space can become a productive garden.
- Aquaponics is a farming method that is an efficient use of space. A farmer having less space can earn more by using this farming method.

Methods of aquaponics widely in use

Deep water culture

Deep water culture or raft based growing method uses a foam raft that is floating in a channel filled with fish effluent that has been filtered to remove solid wastes. Plants are placed in holes in the raft and the roots hang freely in the water. This method is most appropriate for growing salad greens and other fast growing, relatively low-nutrient plants. It is also most commonly used in larger commercial-scale systems.

Media-based aquaponics

Media growing involves growing plants in inert planting media such as expanded clay pellets or shale. The media provides both the biological filtration (conversion of ammonia to nitrates) and mechanical filtration (removal of solid wastes) in the same system. Media based systems are great for home and hobby scale systems so you can grow a wide variety of crops. In particular, large fruiting plants do really well in addition to leafy greens, herbs and other varieties.

Nutrient film technique (NFT)

NFT systems work by flowing nutrient-rich water through a narrow trough, such as a PVC pipe. Plants are placed in holes drilled in this pipe, and the roots dangle freely in this stream of water. This method of growing works very well for plants that need little support, such as strawberries (pictured) and other herbs. NFT is also a great way to utilise unused space because they can be hung from ceilings above other growing areas.

Vertical aquaponics

One of the greatest aspects of aquaponics is its ability to grow an incredible amount of food in a very small area. No method does this better than vertical aquaponics. Plants are stacked on top of each other in tower systems. Water flows in through the top of the tower, and flows through a wicking material that the plants roots absorb water and nutrients from. The water then falls into a trough or directly into the fish tank. This form of agriculture makes the most of each square foot of space, and works very well with leafy greens, strawberries, and other crops that do not require support to grow.

Components of an aquaponic system

Aquaponics consists of two main parts i.e., aquaculture (raising aquatic animals) and the hydroponics (growing plants). The nutrients released in fish wastes are toxic to aquatic animals but also contains the essential nutrients for the plant growth. Although consisting primarily of these two parts, aquaponics systems are usually grouped into several components or subsystems responsible for the effective removal of solid wastes, for adding bases to neutralise acids, or for maintaining water oxygenation. Typical components include:

- Rearing tank: Tanks for raising and feeding the fish.
- Settling basin: Unit for catching uneaten food and detached biofilms and for settling out fine particulates.
- Biofilter: To grow nitrifying bacteria for the conversion of ammonia into nitrates, which are usable by the plants.
- Hydroponics subsystem: the portion of the system where plants are grown by absorbing excess nutrients from the water.
- Sump: the lowest point in the system where the water flows to and from which it is pumped back to the rearing tanks.

Depending on the sophistication and cost of the aquaponics system, the units for solids removal, biofiltration, and/or the hydroponics subsystem may be combined into one unit or subsystem, which prevents the water from flowing directly from the aquaculture part of the system to the hydroponics part. By utilising gravel or sand as plant supporting medium, solids are captured and the medium has enough surface area for fixed-film nitrification. By combining both biofiltration and hydroponics, it allows the aquaponics to eliminate the need for an expensive, separate biofilter.

Selection of vegetable to grow in aquaponics

- The fish and plants for an aquaponic system should have similar needs for temperature and pH. Warm, fresh water fish and leafy crops, such as lettuce, greens and herbs will do the best.
- In a small aquaponic based garden, you can grow vegetables that do not need heavy nutrient input. Lettuce, kale, watercress, arugula, decorative flowers, mint, herbs, okras, spring onions and leek, radishes, spinach and other small vegetables.
- Beans, broccoli, cabbage, cauliflower, cucumbers and tomatoes can require more nutrition and a well-stocked or more advanced aquaponic system.
- Avoid growing plants that need acidic or alkaline water, because those levels of pH can definitely harm the fish.

Tips for setting up of an aquaponic garden

- Start from a small garden. After that go for the bigger ones.
- As a backup, keep different power sources because in an aquaponic system, it is vital to keep the water flowing and the oxygen pumps on.
- Make sure to properly feed the fish for their survival and growth as depletion of fish stock makes this cultivation system impossible.
- Constant supply of food input is required to the fish to get regular fish waste for using it as feed for your plants.
- Provide proper aeration to your plants and fish is essential. All the organisms (plants, fish and bacteria) in the system need oxygen for their survival and performing their function efficiently.
- Select plants having similar water condition needs as the fish and this will results in greater success.
- Remove some excess fish waste when necessary because too much can harm the health the fish (water quality should be monitored to maintain acceptable parameters).
- Keep an eye on the level of pH because it is crucial for both the fish and garden.
- Fish tanks should be made of glass or food grade plastic.
- Avoid using any pesticide other than organic, or any other substances that can and will harm the fish or the beneficial bacteria.

Conclusion

Aquaculture and its next-generation evolution, aquaponics, is one answer to our need for a more sustainable food supply. Aquaponics is a unique system that uses the waste products from fish production to supply nutrients to growing plants. The water, which has been cleansed by the growing plants, is then recirculated back to the fish. It requires around one tenth of the water needed for conventional crop production. This allows for aquaponic production of both crops and fish in areas where there is a scarcity of water or fertile land.

Aquatic invasive apple snails (*Pomacea* spp.) in Timor-Leste: Current status, spread and management in rice fields

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Introduction, history and spread

There is no exact information as to when the freshwater invasive apple snail (*Pomacea* spp.)in the family Ampullariidae, was first introduced into Timor-Leste. Anecdotal evidence indicates that these exotic snails were introduced by Indonesian transmigrates, and they deliberately brought to Timor-Leste for food, because at that time Timor-Leste was still an Indonesian colony. It is locally known as "keong mas, keong murbei, siput murbai. In Indonesia, the studies on snail taxonomy are mainly based on morphological characteristics (Marwoto, 1997; Isnaningsih & Marwoto, 2011). They concluded that there are many variations in size, shell color, and shape of the spire and its aperture shape that can be used to separate four species [*Pomacea canaliculata, Pomacea maculata* (*Pomacea insularum*)*, Pomacea scalaris* and *Pomacea paludosa*] that invaded rice farms in Indonesia (Marwoto *et al,* 2018). Thus, it is likely that species of *Pomacea* in Timor-Leste is likely to be same as that of Indonesia. In literature many *Pomacea spp.* have commonly been referred to as golden apple snails, or GAS, often without clarifying specifically which species, was involved, or indeed simply assuming it to be *Pomacea canaliculata* (Cowie *et al*, 2017). For clarity, this article avoids this ambiguous common name designation. Therefore, it is very difficult at this time to pinpoint the exact pathways, source of introductions, and the number of *Pomacea* species that have been introduced to Timor-Leste, unless preserved specimens are examined using molecular and morphological approaches (Hayes *et al,* 2008).Correctly identifying the invasive species is one of the most fundamental prerequisites when attempting to control it (Joshi *et al,* 2017).

Rice cultivation in Timor-Leste

The land area devoted to rice cultivation each year is 38,000 ha (FAO, 2011). The average land holding by the farmers ranges from 1-3 ha. There are farmers that owns more than 3 ha, but not all of the land is utilized due to limited labor and land preparation costs. The most common rice varieties planted are IR8, IR64, Membramo, Nakroma, PSB RC 80, and Ciheran (Oxfam, 2008). The average rice yields range from 2.5-3 t/ha. The rice production cost incurred by farmers per ha on an average is USD $ 300-500, which includes costs for land processing, tractor rentals, planting, pest control, fertilizers and others. The rice cropping calendar is as follows: During the main season, rice is planted in lowland areas in December-January in the northern parts and a month or two later on the south coast, and harvest from May to July. During the second rain peak in the south (May-June), farmers plant a second crop of irrigated rice and harvest from August to December (Oxfam, 2008).

Invasive apple snail eggmasses on transplanted rice, Timor-Leste. (Credit: Americo Alves Brito).

Damage by invasive apple snails to rice plants, Timor-Leste. (Credit: Americo Alves Brito).

Rice is established by two methods: Transplanting and direct-seeding. However transplanting is a common method carried-out in areas with irrigation facilities, and also in areas where the water is always available throughout the rice growing season. Irrigation water in many of the irrigated rice areas are available only when river water level from the source has increased to the level of the intake of the irrigation systems (MAFF, 2018). In areas where the water source is lacking and have no irrigation facilities, and dependent on rainfall, then farmers resort to direct-seeding method. If tractors are unavailable, buffaloes puddle the paddies. Otherwise, there is little animal traction in Timor-Leste (Lopes & Nesbitt, 2012). Rice is planted once a year, but there are areas, where farmers are able to plant twice.

The total rice production in Timor-Leste is about 207,500-249,000 t. Harvested rice is bought by the Government, private companies, and NGOs. Depending on the quality of rice, the average price in the local markets ranges from USD $ 0.60 - 0.80/kg. Milled rice are sold in cans with approximately one kilogram. Prices for local rice sold by farmers in the local markets are around USD $ 0.50/kg, and those sold by NGOs are USD $ 1/kg milled rice. The HACELDA company buys rice grains directly from farmers with the basic price of dry grain at the farm level is US $ 0.45 / kg, and after milling is sold at US $ 1/kg. Farmers' estimated revenue (income) in each cropping season/ha is from US$ 800-1000. The Ministry of Agriculture and Fisheries allocates a special budget to buy rice seeds from the seed breeder group, namely the association "Anaprofiku" with a price per kilo of seeds which is US $ 1.50/kg. Such rice seeds are distributed to farmer groups in the territory of Timor-Leste, and are not for consumption.

Impact of invasive apple snails

The first reported damages by *Pomacea* spp. in Timor-Leste on rice was around 1985, in the southern part (Maunfahi and Suai districts), and the western part (Bobonaro district) (Figure 1), with approximately 700 ha, and 80 ha damaged, respectively in both transplanted and direct-seeded rice systems (Figures 2 & 3). However the current data on the extent of spread and damage to rice at the national level is lacking. Thus, there is a urgent need for systematic surveys on the areas invaded, and the rice crop losses.

Control of invasive apple snails

Two active ingredients (a.i.) of synthetic molluscicides (metaldehyde and niclosamide), used in Timor-Leste. All the four molluscicide formulations sold in Timor-Leste are imported from Indonesia. Siputox 5G is a granular formulation with a.i. metaldehyde; while Kencida 500 EC, Keong tox 250 EC, and Nicolasan 250 EC are liquid formulations with a.i. niclosamide (Table 1). In Timor-Leste there are no chemical pesticide manufacturing/formulation companies, thus all molluscicides are imported from Indonesia.

Molluscicides are applied 1-2 times at the time of rice transplanting (Figure 4) or direct-seeding (Figure 5) in each rice planting season, but there are certain areas that do not apply molluscicides because of their non-availability at the

Dead invasive apple snails in field treated with metaldehyde pellets (Siputox 5G), Timor-Leste. Note metaldehyde pellets in black circles. (Credit: Americo Alves Brito).

farmers' level. The price of molluscicides ranges from USD $ 15-17per liter or kg, but farmers get molluscicides from the government assistance program through the Ministry of Agriculture, in areas with heavy snail damage.

Non-chemical methods used by rice farmers are as follows:

- Replanting missing rice plants is normally done by farmers, but transplanting older rice plants is not practiced.
- Several farmers collect snails, and then crush them
- Install screen traps on the water channel into the rice field
- Using the roots of the tuba plant (*Derris* sp.)
- Human consumption of snails is not common in Timor-Leste, though some people eat them
- Feeding ducks with collected snails is practiced by some farmers.

Presently most of the snail management techniques could not be easily adopted by farmers as these are labor-intensive, not economical, not effective to reduce snail numbers at non-damaging levels, and not environment friendly (Joshi, 2007). Thus, new innovative approaches should be developed and promoted to manage the invasive snails, especially in direct-seeded rice fields.

Conclusions

Invasive apple snails (*Pomacea* spp.) were first detected around 2015 in Timor-Leste rice fields, further limiting already low rice yields/ha. Their control has triggered the use of imported synthetic molluscicides. To our knowledge the other negative impacts of this freshwater snail on non-target fauna and flora including human health and the environment are still unknown. Thus, long-term control and containment is needed

Table 1. Molluscicidal formulated products traded in Timor-Leste.

Product Name	Company Name (Supplier)	Ingredient	Package	Price (USD $)	Date & License No.
Siputox 5G	PT TAni MAs Subur	Metaldehyde	250 g	US$ 14	30-April 2014 RI 3491/4-2009/T
Kencida 500EC	PT. Agro Sejahtera Indonesia	Niclosamide	200 ml	US$ 14	12-December2018 RI. 01050120093345
Keong tox 250EC	PT. Santani Sejahtera	Niclosamide	200 ml	US$ 14	4-Januari 2018 RI 01050120083051
Nicolasan 250EC	PT. Bio Agritech Nusantara	Niclosamide	200 ml	US$ 14	15-Januari 2014 RI 3358/12-2008/T

Dead invasive apple snails in direct-seeded rice field treated with metaldehyde (Siputox 5G) pellets, Timor-Leste. Note the colored metaldehyde pellets on the soil surface (Credit: Americo Alves Brito).

to reduce ecological and economic losses. International collaboration with infested countries in ASEAN region is needed for accurate species identification, and for better understanding of invasion biology in order to develop effective ecologically sustainable snail management options.

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Joint FAO-NACA workshop reviews aquaculture farming system classification scheme

Left to right: Mr Zhou Xiowei (FAO), Dr Cherdsak Virapat (DG, NACA) and Prof. Xu Pao (DG, Freshwater Fisheries Research Center).

Aquaculture is a fast moving industry. Continous innovation is driving the adoption of new technologies and farming systems. As a result there is a need to update FAO's farming system classification scheme. FAO and member countries use this scheme for the preparation of statistical data.

NACA and FAO organised an expert workshop to review the existing classification system. The workshop aim was to bring the system up to date with contemporary practices. The Freshwater Fisheries Research Centre (Wuxi, China) hosted the workshop from 3-5 December 2018. FFRC is a NACA Regional Lead Centre.

Prof. Xu Pao, Director General of FFRC opened the workshop. Dr Cherdsak Virapat, Director General of NACA gave opening remarks. Mr Zhou Xiaowei of FAO (but also a former FFRC and NACA staff member), welcomed participants.

Invited experts included:

- Mrs Liu Yadan (Chinese Fishery Society).
- Mrs Gao Hong Quan (National Fisheries and Aquaculture Technology Center, China).
- Prof. Peter Edwards (retired, Asian Institute of Technology).
- Prof. Pham Quoc Hung (Nha Trang University, Vietnam).
- Mr Aji Bayu (Ministry of Marine Affairs and Fisheries, Indonesia).
- Mr Suthep Putippayawongsa (Coastal Aquaculture Specialist, Thailand).
- Mr Pongpat Boonchuwong (Department of Fisheries, Thailand).

Experts presented recent advances in farming systems in their respective countries and sectors. Participants reviewed the current farming system classification scheme and proposed amendments.

We were also privileged to visit two innovative farms to observe new practices, one growing growing European pike perch and a second using an in-pond raceway system, described in a separate article (this issue). The workshop outcomes will be published as an FAO Circular in due course. The NACA Secretariat would like to thank FFRC for hosting the meeting and for their excellent hospitality.

Join us for the Global Conference on Aquaculture 2020

FAO and NACA have signed an agreement to convene a global conference on aquaculture in 2020. This will be the fourth conference in a series that began at the dawn of the industry in Kyoto, 1976.

The *FAO Technical Conference on Aquaculture* was the first mainstream international aquaculture meeting. It marked a turning point in the transformation of the industry from art to science. It was the first meeting to consider the social, food security and regulatory aspects of aquaculture development. The conference adopted the *Kyoto Declaration on Aquaculture*, the first such policy instrument.

FAO and and NACA convened a second conference in Bangkok, 2000. The *Global Conference on Aquaculture in the Third Millennium* reviewed progress. Aquaculture had become more science-based, and more important in a rural development context. The conference adopted the *Bangkok Declaration and Strategy on Aquaculture Development*. The declaration provides guidance for sustainable socioeconomic and environmental aquaculture development.

The *Global Conference on Aquaculture 2010*, Phuket reviewed the changing role of aquaculture. Social issues including gender had come to the fore. Technological advances were surging. Disease issues were rife. Decades of experience allowed more informed debate on these issues. The conference adopted the *Phuket Consensus*. This was a re-affirmation of commitment to the principles of the Bangkok Declaration.

Aquaculture 2020 will be held late September in Shanghai, China. Arrangements, programme and partner details will be announced via the NACA website in due course.

Expert Consultation on Genetically Responsible Aquaculture

The loss of genetic diversity in broodstock remains an issue of great concern. Many standard hatchery practices can reduce the genetic diversity of seed. The impact on farm productivity and stock health is unknown but may be significant.

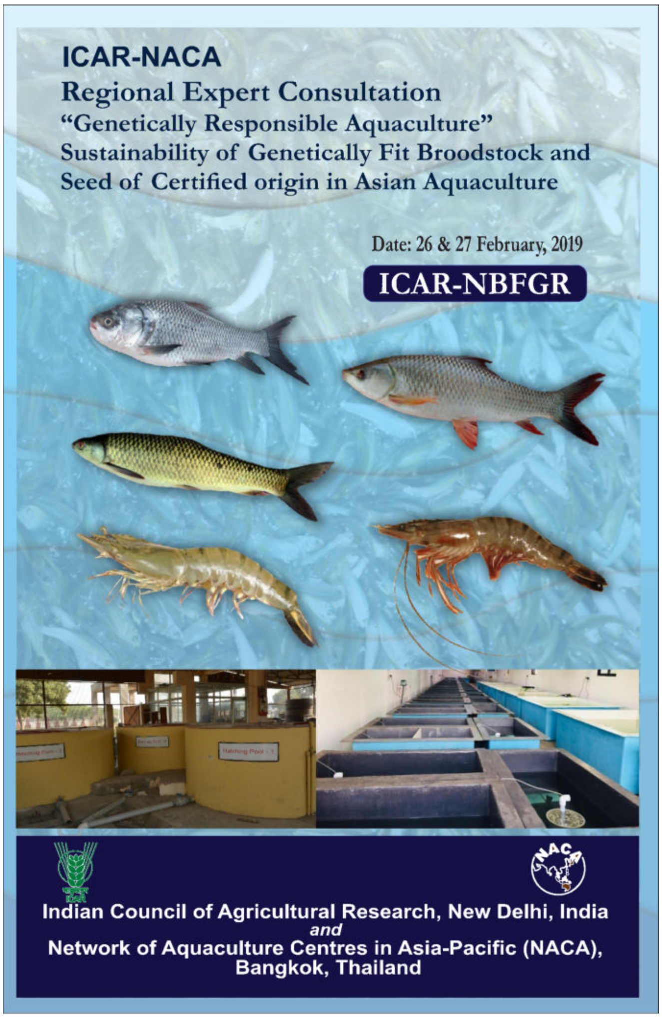
Commercial interests have eased these concerns by offering stocks selected for improved growth. Specific pathogen free seed is also available for some species. But in recent years there has been evidence of seed substitution by third parties. It is difficult for farmers to know if they are getting what they pay for.

The Indian Council of Agricultural Research (ICAR) and NACA will convene the consultation from 26-27 February 2019. The consultation will be hosted by the ICAR National Bureau of Fish Genetic Resources (NBFGR) in Lucknow, India.

The aim of the consultation is to find ways to assure genetic quality in seed production systems. Experts will discuss broodstock management and mechanisms to verify seed origin and quality. The goal is to empower farmers and monitoring agencies with quantifiable standards. Procedures for germplasm exchange and maintenance of on-farm genetic diversity will be proposed.

Representatives from NACA member states are invited to attend. Local expenses (accomodation, meals and transportation) will be borne by the organisers. Official nominees should contact kuldeepklal@gmail.com by **20 January 2019**. Please send a copy of your passport to support the necessary clearances.

For more information please download the prospectus from: https://enaca.org/?id=1027



Strengthening governance in aquaculture

Asia has experienced rapid development of aquaculture in the past four decades. This has improved food security, livelihoods and economic development in many Asian countries. It has also become the main source of fish products in the region.

Per capita consumption of fish in Asia increased from 10 kg in 1977 to 24 kg in 2015. Fish now comprises 23 percent of total animal protein in Asian diets. As of 2016, the total value of Asian aquaculture reached 210 billion US dollars. Aquaculture provided 18.5 million jobs in primary production. It provided an equal number in downstream industries.

Yet aquaculture as a new industry is poorly regulated in many countries. Its development has come with environmental problems, animal disease and food safety issues. These have resulted from both inadequate laws and poor enforcement.

By 2030 the world will need another 30 million tonnes of food fish to meet growing demand. Most of this must come from aquaculture. The governance of the aquaculture sector must improve to achieve this sustainably.

The Asia-Pacific Fishery Commission has identified governance as a threat to sustainable aquaculture growth. In response, NACA and FAO will organise a consultation to discuss governance of the sector. FAO has also commissioned NACA to prepare a regional review of regulations.

The review will examine demographic changes in Thai and Cambodian fishing communities:

- What are the changes in demography (ageing, migration) in the fishing communities?
- How are people adjusting in response to changing fisheries conditions and labour availability?
- What are the consequences from these adaptation strategies? Are there any gender differences in the impact of such adaptation strategies?
- What support do fishing communities need to remain sustainable?

Further details on the consultation will be published on the NACA website in due course.

Pike perch and in-pond raceways

In pond raceway system producing largemouth bass. Current through the system is generated by air lift, with the blowers visible on the right side streaming air across angled plates.

During our visit to China for the FAO-NACA workshop on classification of aquaculture farming systems (see cover article), we were fortunate to visit two innovative farms in the Wuxi area.

In-pond raceways

In-pond raceway systems are gaining popularity in China. We visited a farm using in-pond raceways to grow largemouth bass *Micropterus salmoides*, pictured above.

The farm operates a battery of five floating raceways within a five hectare pond. Each raceway is approximately five metres wide, 20 metres long and 2.5 metres deep. Made of fibreglass, the raceways have a plate set on a 45 degree angle at the front end, deep side first. A blower emits a stream of bubbles along the bottom of the plate, generating flow through the raceway by air lift. At the rear of the raceway a sump collects solid wastes for removal by pump.

Concentrating fish in the raceway allows for efficient feeding, aeration and monitoring. As the raceways are of the floating variety, the farm can move them if needs be. The removal of solid wastes reduces the nutrient load on the pond environment.

The raceway system has allowed the farm to increase production. Before adopting the raceway system the farm produced around 72 tonnes of fish from the pond. Each raceway can produce around 15-20 tonnes of fish per year for a total production of 75-100 tonnes. Fish can still be grown in the surrounding pond, although at a reduced rate.

The raceways required significant capital investment, around two million Yuan (US$300,000). This included all equipment including watch house, feed store and backup generators. The rate of return was high; farm gate revenue is around seven million Yuan per year. The capital investment was rapidly recovered but high-value species must be grown to achieve this. The farm has a second production site producing Japanese seabass, *Lateolabrax japonicus*.

The farm has encountered one issue with the system. As largemouth bass have sharp spines they can injure one another in the close confinement of the raceways.

European pike perch

The second farm we visited is growing pike perch, *Sander lucioperca*, native to continental Europe and western Asia. Pike perch is a cool to temperate water species. The fish is being grown in deep ponds of around 4.5 metres depth to help maintain a steady temperature. The farm recirculates water, there is no discharge.

The 40 hectare farm has a hatchery on site and produces its own seed. Fish are stocked in May at around 5cm body length and at a density of around 18,000 individuals per square metre. The growout period is twelve months. Growth is not uniform with fish varying from 0.6 - 1 kilogram. The farm also sells seed to other farmers.

Pike perch need live feed as they will only eat dead fish when very hungry. A local carp species is also grown on site as forage. Each hectare of pike perch needs around 2.5 to 3 hectares of forage fish to support it. The forage fish are fed with commercial feeds. The farm has three sites with total production of pike perch exceeding 100 tonnes.

An unusual species in the local context, pike perch attracts a good market price. The farm receives around US$15 per kilogram with retail at least double that. The live restaurant price is around US$87 per kilogram. The farm has expanded into agro-tourism including fee-paying fishing. It has an attached restaurant where anglers can eat as well. Inflatable carry bags allow anglers to take their fish home live, should they choose.

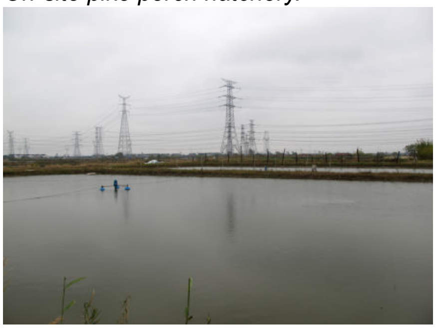
Incidentally, there is one recorded case of a large pike perch (8 kilograms) attacking and injuring tourists in a Swiss lake. The fish was later caught, cooked and served to the victims by the local police!

Real-time water quality monitoring

Both farms featured real-time water quality and video monitoring systems. Probes in each pond, and in the rear of the raceway system, measure water quality. The data is broadcast live to a base station in the main office and displayed on a screen in view of the manager's desk. Staff can access the real time data on their mobile phones. The system logs the data and can broadcast warnings to staff if a problem arises.

European pike perch in an inflatable carry case to allow anglers to take their catch home live.

On-site pike perch hatchery.



Grow out ponds are 4.5 metres deep to stabilise water temperature.

Quarterly Aquatic Animal Disease Report, April-June 2018

The April-June edition of the Quarterly Aquatic Animal Disease Report contains information from twelve governments in the Asia-Pacific region. The foreword discusses three recent aquatic animal health consultations:

- ASEAN Regional Technical Consultation on Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia, held 20-22 August 2018.
- Regional Consultation and Related Study on Antimicrobial Resistance Risk to Aquaculture in Asia, 4-6 September 2018.
- Preliminary Consultation on Monitoring of Antimicrobial Resistance in Bacterial Pathogens in Aquaculture, 16-17 September 2018.

The report is available for download from: https://enaca.org/?id=1024

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