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AQUACULTURE ASIA

Aquaculture in Hubei Province, China

Measuring empowerment via self-help groups

Pigeon pea cultivation on pond dykes

Ornamental fish in India

Climbing perch culture

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AQUACULTURE ASIA

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Sustainable intensification of aquaculture

Feeding the world has always been a problem. Historically the problem has not been the amount of food produced - there is theoretically enough to go around - but rather it has been inequitable access to and distribution of food that has been the issue. With around one billion people going hungry today this problem obviously remains unsolved, but at least the supply is there to meet the need if we can ever find ways to address the shortcomings of our social, economic and political systems.

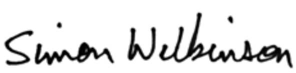
But can we really afford to keep taking the supply side for granted? World population is forecast to exceed 9 billion people by 2050. To maintain per capita food availability at present levels, agricultural production across all sectors including aquaculture must increase by around *60 per cent*. Consider also the implications for our already stressed natural resource base – where is the farmland going to come from? The water? The feeds and fertilisers? How about the energy? There's an awful lot of fossil fuel in the human food chain right now and climate change increasingly looks like a ton of bricks overhead; an economic externality that may soon be internalised in a rather inconvenient manner if we do not take steps to avoid it.

Put simply our existing agricultural practices will not scale another 60 per cent. The natural resource base required to support this kind of expansion just isn't there and other industries are also competing for access to the limited resource base. There is only really one way out: To increase the *efficiency* of our farming systems. We need to increase agricultural production while also decreasing the unit production environmental footprint. We need to intensify production in a *sustainable* manner.

Asian aquaculture has grown rapidly over the past three decades, and now represents more than 90% of global aquaculture output by volume. The growth of the industry has largely been a result of two major factors; intensification through technological advances and increased use of feed and other resource inputs. While the growth of Asian aquaculture has contributed to food security and rural livelihoods, it has also caused significant environmental disturbance.

Intensifying aquaculture in a sustainable manner is a massive challenge, essentially it means learning to do *more with less*. Aquaculture (and more broadly, agriculture) must become a more efficient user of natural resources, both in terms of farm productivity and environmental efficiency. Each kilogramme of food grown tomorrow must have less environmental impact than it does today. We need to start building the more efficient farming systems of tomorrow today.

FAO, the Asia-Pacific Fisheries Commission and NACA will convene a regional consultation on the sustainable intensification of aquaculture in Bangkok from 9-11 October. We feel certain that this is going to be a key theme in the NACA work programme for the foreseeable future. The presentations from the meeting will be made available for download as podcasts on the NACA website in due course.



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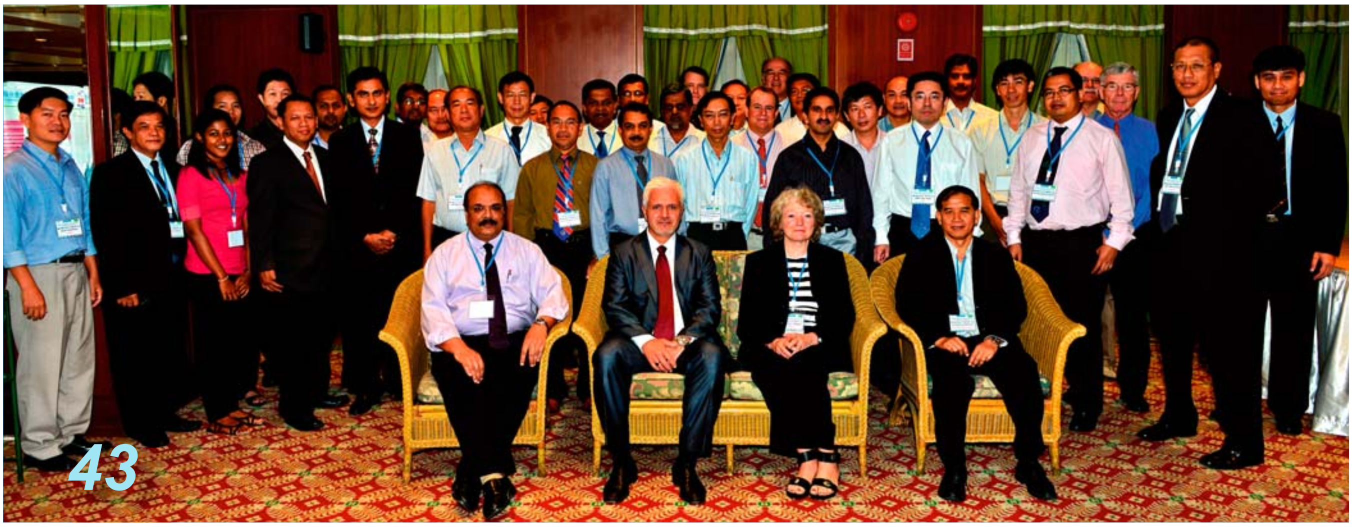

Peter Edwards writes on

Rural Aquaculture

Aquaculture in Hubei Province, Central China

I finally accepted a couple of long standing invitations to visit China again in May and June this year. The first leg of the three week visit was hosted by Professor Wang Wei Min, an Asian Institute of Technology (AIT) Masters degree alumnus who is currently Dean of the Fisheries College of Huazhong Agricultural University in Wuhan. On the second leg of the trip to China, I accompanied Zhou En Hua, my interpreter over 30 years ago during a six week consultancy for UNDP/ FAO on integrated farming through the NACA Regional Lead Centre in Wuxi, who is currently the Technical Manager for Freshwater Aquaculture for the American Soybean Association, on a field trials assessment in North, Central and South China. The third leg of the trip to visit the EU-funded project 'Sustainable and Ethical Aquaculture Trade' (SEAT) sites in Guangdong Province in South China was sponsored by Dr David Little, the project coordinator.

In this column I report on the first leg of my visit to Hubei Province in Central China, the province with the highest fish production in the country. As I was shown such an amazing range of recent developments in Chinese aquaculture in three quite different regions of the country, my next two columns in subsequent issues of the magazine will cover the second and third legs of my rather intensive visit to China.

Dr Edwards is a consultant and Emeritus Professor at the Asian Institute of Technology in Thailand where he founded the aquaculture programme. He has over 30 years experience in aquaculture education, research and development in the Asian region. Email: pedwards@inet.co.th.

Wuhan

Huazhong Agricultural University (HAU)

I was based at HAU which ranks first among the agricultural universities

Large-scale carp farm, Jingzhou.

in China. The University has a long history of over 100 years having been established in 1898 as the Hubei Farming School. As well as functioning as a university, HAU is also a nationally important base for training senior special agricultural personnel and developing agricultural science and technology. The Fisheries College, one of 10 fisheries colleges at the university level in China, was established in 1993 and was derived from the Department of Fisheries of the former Huazhong Agricultural College itself established in 1970. The Fisheries College has four departments and offers one national key discipline: Aquaculture. There are currently 75 faculty members in the HAU Fisheries College, 821 undergraduates and 305 graduate students including five international students. The major research focal areas are fish genetics and breeding, fish diseases and control, fish nutrition and feeds, and fish resources. The college has well equipped laboratories and experimental hatcheries and grow-out facilities.

There are no free lunches in this world so I gave a seminar to the faculty and students of the Fisheries College entitled 'Recent developments in Asian inland aquaculture' based on my Keynote for the Asia-Pacific Chapter conference of the World Aquaculture Society in Kochi, India in January 2010. I particularly modified my presentation to include Chinese traditional integrated aquaculture systems that I reported on over 30 years ago that have mostly disappeared from the major freshwater aquaculture areas in China, and which today's Chinese students are only vaguely familiar with.

Baishazhou Terminal Market, Wuhan

A large variety of live fish were being traded on this large city fish market, arriving in large aerated tanks on huge trucks: many species of carps, big mouth catfish (*Silurus soldatovi meridionalis*), loach (*Misgurnus anguillicaudatus*), rice field eel (*Monopterus albus*), a couple of species of snakehead, Chinese soft shell turtle (*Pelodiscus sinensis*) and red crawfish (*Procambarus clarkii*).

Dr Cao Xiaojuan with the hybrid sturgeon, and the farm manager Jingzhou.

Circular spawning tank for sturgeon and hatchery building in the background.

Inside the sturgeon hatchery, Jingzhou.

Sturgeon fingerlings are nursed in tanks.

Although I did not have the opportunity to observe loach and rice field eel culture, I was informed that they are both raised in cages in ponds, as well as in rice fields with the loach to a greater extent than the rice field eel.

East lake, Wuhan

The 32 km^2 East Lake, the largest 'city lake' of China, has been designated as a 'Key National Scenic Area'. It is now a major tourist site with pleasure boating and numerous gardens and is the site of the China Plum Research Institute and the China Lotus Research Center with over 500 varieties of lotus (*Nelumbo nucifera*).

When I previously visited Wuhan in 1985 during my early aquaculture career researching wastewater-fed aquaculture, there was a large wastewater-fed fish farm in the East Lake but this no longer operates. However, in a tenuous link with traditional Chinese aquaculture, I was delighted to discover some of the abandoned nursery ponds adjacent to derelict farm buildings with the demolition order still attached to a wall.

Sorting sturgeon fingerlings in a nursing tank.

Jingzhou

Large carp farm

The first farm we visited in Jinzhou, a major aquaculture area to the west of Wuhan, was a huge 200 ha farm leased from the city government, the largest farm in the city. The farm was producing a total of 2,000 tonnes/year of Chinese carps in pellet-fed aerated ponds with average production of 37.5 tonnes/ha/year. Grass cut from the pond dikes was only used to feed grass carp broodstock in winter with pelleted feed

The company photographer at Jingzhou Tianjia Animal Feed Co.

Field work is fun - travelling to a cage site on the Qing River reservoir with surrounding mountains like in a traditional Chinese landscape painting.

being used for the rest of the year. Pond sizes ranged from 0.27 to 4.0 ha with the optimum pond size for grow-out of 0.67 ha. While black carp (*Mylopharyngodon piceus*) was raised in monoculture, three other species were raised in polyculture: Grass carp (*Ctenopharyngodon idella*) as the dominant species stocked at 5 fingerlings/m^2, with bighead carp (*Aristichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) each stocked at a lower density of 2.5 fingerlings/m^2, to give a high total stocking density of 10 fingerlings/m^2. The growth cycle in temperate Jingzhou was 2 years: 8 months to raise grass carp to 0.5 kg; and 1.5 years to marketable size. Marketable sizes were 2.5 kg for grass carp, 1.5 kg for bighead carp and 1.0 kg for silver carp. There was no marketing problem with the following farm gate prices: black carp, US $2.4-3.3/kg; grass carp, $1.7/kg; bighead carp, $1.4/

Small-scale carp farmers, Jingzhou.

Sturgeon and channel catfish as well as Chinese carps are raisd in cages in Qing River reservoir.

kg; and silver carp, $1.5/kg. An estimated 70% of the city's total aquaculture production came from large farms according to the farm manager.

Small carp farm

A small-scale farmer and his wife were interviewed on their single 0.5 ha pond farm, one of many such farms in the area. Previously they caught wild fish in a reservoir but were relocated by the government as fish catches had declined to this area in 1979, formerly a swamp that was converted to fish ponds. They fed pellets to a polyculture of black carp, bighead carp, grass carp and silver carp and produced 15 tonnes/ha/year. The couple expressed satisfaction with fish culture and reported that the price of grass carp had risen this year to $1.7/kg from last year's $1.2/kg.

Sturgeon farm

Fingerlings of three species of sturgeon (*Acipenser*) as well as a hybrid were being produced on a private farm, the area leased from the local government. The fish came from the Yangtze and Amur rivers in China, and from Russia. The farm comprised a large outdoor broodstock holding tank, an outdoor circular spawning tank and an enclosed 2,300m^2 nursery with aerated concrete tanks. The fingerlings were produced in two stages in the aerated tanks in the enclosed hatchery to stock grow-out cages in a reservoir.

Jingzhou Tianjia Animal Feed Co.Ltd.

The largest feed mill among 20 mills in the province was producing 100,000 tonnes of mainly sinking pellets per year, with the amount increasing each year indicating expansion of Chinese aquaculture. The largest production was for grass carp, followed by common carp (*Cyprinus carpio*), black carp and channel catfish (*Ictalurus punctatus*). The feeds contained 10-15% of transgenic soybean mainly from the USA with some from China, as well as other meals such as cotton and rape seed meals. The owner reported that he would use more soybean if the price were lower. Fish meal was not used in grass carp pellets.

The company was established 8 years ago with technical assistance from an agricultural science college. The owner used to work as a salesman for another company before he set up his own factory. The business was clearly very profitable as the owner had planted five 100 year old ornamental trees which cost $15,000 each.

Qing River Reservoir

The most enjoyable field visit of the entire visit to China was travelling by boat on the narrow 100m deep Qing River Reservoir with the mist covered peaks of the surrounding mountains reminiscent of Chinese landscape paintings. The reservoir was located only about 20 km to the south of the

Three Gorges Dam on the Yangtze River. The dam on the Qing River was constructed in 1995 with cage culture introduced in 1996. Individual cages ranged from 20-50 m^2 with a depth of 3m. The number of cages per farmer ranged from 20 to 200 with an average of 50 cages.

Cage farmers were locals who had been displaced by flooding when the dam was constructed. The interviewed farmer used to grow rice in the former valley. He raised black carp, channel catfish and sturgeon in the main pellet-fed inner cages and bighead carp in an outer cage without feed. One tonne of sturgeon was harvested from a 20 m^2 cage, equivalent to 17 kg/ m^3. The farm gate price for relatively small 1 kg sturgeon was $3.8 - 4.6/kg although that for 25-50kg fish was $30/kg. However, quite expensive feed with more than 40% protein was used costing $1.2- 1.5/ kg. The farm also served as a demonstration farm for local extension.

Cages in Qing River reservoir with a traditional Chinese painting-like scenary.

Yidu City

The Tianxia Sturgeon Stock Company located in Yidu City near the Three Gorges Dam had a 'sturgeon factory' which maintained very large specimens of 16 kinds of sturgeon (11 species and 5 hybrids) in huge aquaria for conservation as well as broodstock. More than one third of the factory area was covered by aquatic plants which treated recycled water. The company provided fingerlings to more than 5,000 farmers to raise sturgeon in cages in the Qing River Reservoir who produced 10,000 tonnes of fish annually, one third and one quarter of the Chinese and global production of sturgeon, respectively. The Company had patented the closed recirculating system for raising sturgeon and according to the company brochure, 33 local farmers were profitably raising the fish in 150 m^2 household units in the basement of their houses.

Sixteen species of sturgeon are raise in the Tianxia Sturgeon Stock Company, Yidu City.

Shekou

Hubei Zheng Long Farm

The private farm, located about 50 km north of Wuhan, was owned by Zheng Zhi, who practised medicine for 10 years before he started to farm fish 20 years ago. The farm produced seed of many species. Hubei Province is an important producer of seed which is exported all over China, by air if the distance is too great by road. The farm had a good gravity-fed water supply from a nearby reservoir. It produced a total of 5 billion 0.5 cm fry of several species of carps each year: black carp, crucian carp (*Carassius carassius*), common carp and silver carp. It was towards the end of the carp breeding season when I visited the farm and only black carp was then being spawned.

Hubei Province was the largest producer of channel catfish in China, up to 100,000 tonnes /year, most of which was exported to the USA as the cost of production in China was much lower than in the USA. The farm produced 1-10 million fry of channel catfish annually depending on the market which sold for Yuan 0.1/0.8-0.9 cm fry ($1 = Yuan 6.5). However, the production of channel catfish had declined due to

Above, below: Sturgeon species are held separately in huge tanks.

The East Lake, Wuhan, is now a major tourist attraction.

the detection of antibiotics in exported fish which was causing great hardship to local farmers although the Chinese Government was now setting quality standards for export.

Channel catfish was being spawned in large earthenware jars suspended in the pond. Workers were observed picking out dead eggs from egg masses to minimise disease.

The farm was also producing lotus in old ponds with deep fertile mud without using fertilisers even though it was more profitable to raise fish as lotus required less labour and was less risky. The lotus was planted in March and harvested in November to December. Lotus seeds costing $3.1/kg were planted at 4.5 - 7.5 tonnes/ha and produced 30 - 45 tonnes of tubers with a farm gate price of $0.6/kg.

I observed Mandarin fish or Chinese perch (*Siniperca chuatsi*) fingerlings in the same tank with carp fry as live feed. The farm was producing 10,000 - 30,000 Manadarin fingerlings/year which were sold for $0.23/ 2.5cm fingerling to other farmers for grow-out. Four times as much area was reported to be required to produce carp finger-lings for feed as the area for grow-out of Mandarin fish in monoculture. However, Mandarin fish had a highfarm gate price of almost $10/kg compared to a cost of production of $2.5/kg. Mandarin fish fingerlings were stocked at 1.5 - 3.0/ m^2 and were mainly fed silver carp fingerlings although those of Wuchang fish (*Megalobrama amblycephala*) were reported to be the best at the beginning of the culture period as they were smaller and therefore easier to eat. Silver carp fry were stocked at 1,200 - 1,500/m^2 in separate ponds and were caught to feed the Mandarin fish. Mandarin fish was reported to be harvested at 0.6 kg in 3-4 months, so with a survival rate of 80%, the produc-tion was 9-18 tonnes/ha.

Mandarin fish were also reported to be stocked at a very low stocking density in polyculture with carps and other species to feed on wild fish. The farm was also producing fingerlings of big mouth catfish, which were being sold at $0.23 for a 6-8 cm fingerling. As the fingerlings were cannibalistic, they had to be well fed with chironomid worms at night to stop them eating each other. Big mouth catfish was also raised in polyculture at low density to feed on small wild fish, with a farm gate price of $2.5/kg.

The remains of an abandoned wastewater-fed fish farm, East lake, Wuhan.

Fish arriving live in aerated tanks at Wuhan Baishazhou Terminal Market Company Ltd.

Rice field eel (above) and loach (below) are major species traded at the market.

Two high speed train tracks pass through Hubei Zheng Long Fish Farm, Shekou.

Washing channel catfish eggs, Hubei Zheng Long Fish Farm, Shekou.

Ornamental fish farming - a successful cottage industry in rural and urban India

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Oscar, Astronotus ocellatus, photo Jón Helgi Jónsson.

The ornamental fish industry is an aquaculture based business that supports this globally popular hobby. World-wide, the ornamental fish industry is worth hundreds of millions of dollars and supports thousands of rural people in developing countries. World imports of ornamental fish were valued at US$ 308.9 million in 2006[1]. More than 120 countries are involved in the ornamental fish trade and there are about 1,800 species of ornamental fishes available in the market. The USA, Europe and Japan are the largest markets for ornamental fishes and more than 65% of exports are supplied by Asia; encouraging news for developing countries in the region. In many developing countries the culture of ornamental fish provides income and self-employment opportunities for people with limited land and capital resources.

Status of ornamental fish farming in India

India is still a minor player, contributing just 1% of the total ornamental fish trade at present. An estimate carried out by the Marine Products Exports Development Authority of India, MPEDA, shows that there are estimated to be one million ornamental fish hobbyists in India. The internal trade in ornamental fishes is estimated to be about US$3.26 million and the export trade is about US$380,000[2], with an annual growth rate of the trade of about 14%. The export trend of ornamental fishes from India is illustrated in Fig. 1 over 10 years.

A rich diversity of species and favourable climate, cheap labour make India suitable for ornamental fish culture. Tamil Nadu, Kerala and West Bengal are the major states involved in ornamental fish farming. Exotic fish dominate the Indian market, representing about 99% of the industry, with about 288 exotic species already recorded. More than 200 species of these freshwater fish are bred in different parts of India. The common exotic ornamental fishes bred and marketed are given in the Table 1, being mainly carps, live bearers, cichlids and barbs.

On the other hand, 90% of native ornamental species are collected from the wild and reared to meet export demand (Table 2). Presently about 100 native fish species have been earmarked as aquarium fish. About 90% of Indian exports depart from Kolkata followed by 8% from Mumbai and 2% from Chennai.

Figure 1. Export trend of ornamental fishes from India (Source: MPEDA, 2005)

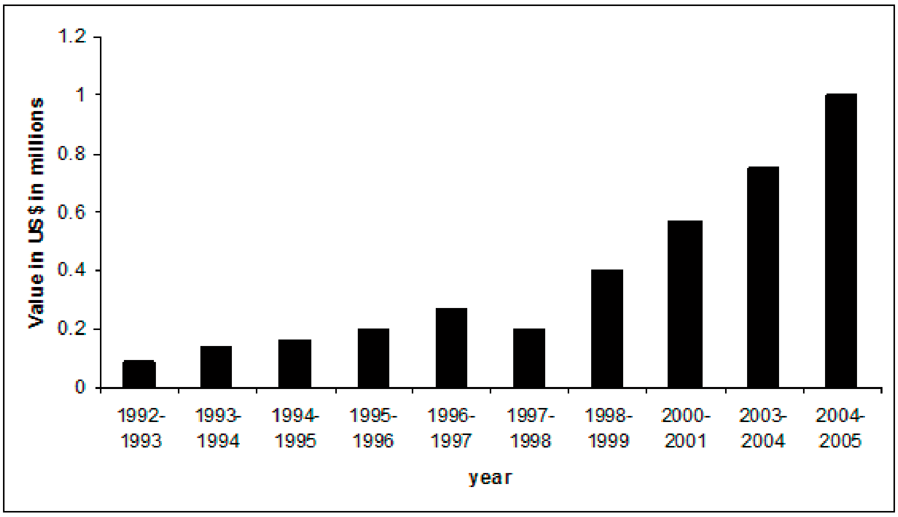


Figure 2. Average number of families involved in ornamental fish breeding, collection and allied activities in India during the last five years

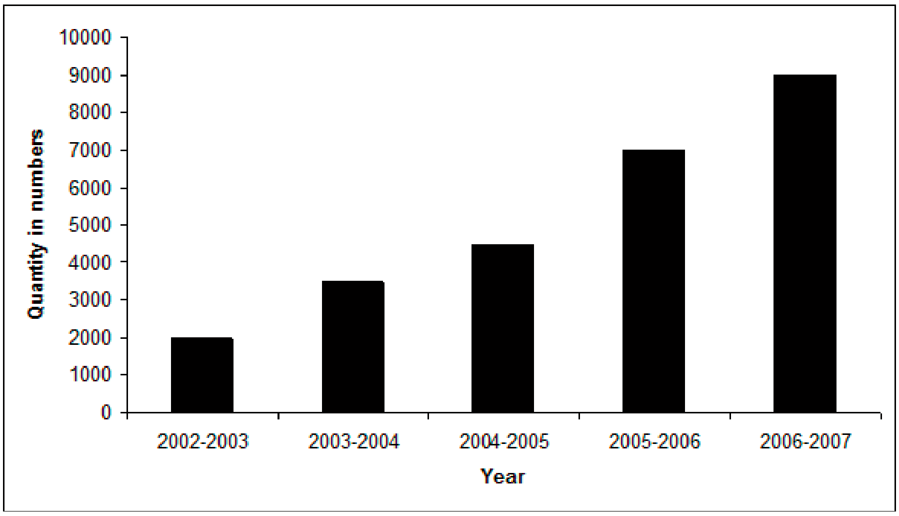
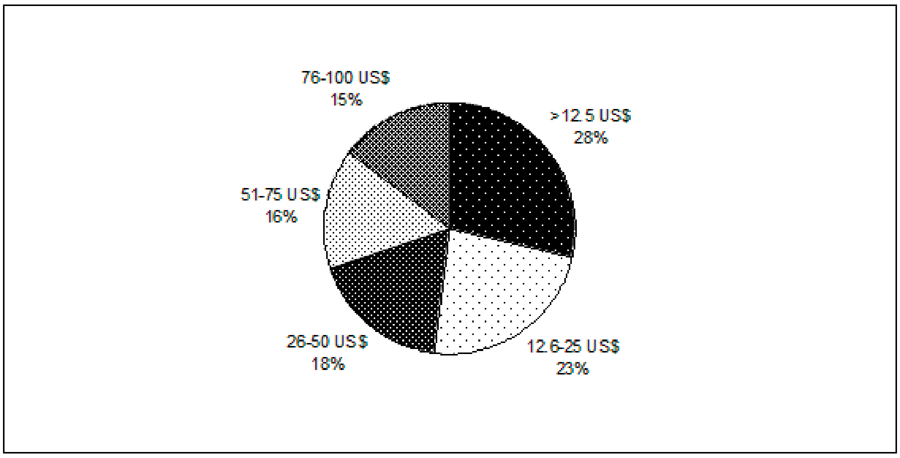


Figure 3. Percentage wise average monthly income of ornamental fish farmers of rural India



In the year 2006-2007 it was estimated that about 9000 families were involved in ornamental fish farming to maintain their livelihood in India (Fig. 2). Generally men have other professions and they only look after the seed collection and marketing. Women do the everyday care like water exchange, feeding, disease treatment and breeding of certain commercially important fishes.

States involved in ornamental fish breeding/collection

Tamil Nadu

In Tamil Nadu, Chennai is one of the most important ornamental fish production centres. Chennai as a metropolitan city has excellent transport facilities and easy access to international airports, which are the main reason for successful ornamental fish production in this city. Chennai is famous for ornamental fish cultivation by small scale producers, with about 600 families earning their livelihood through ornamental fish cultivation in Kolathur. On average each household peoples earns over US$125 per month through ornamental fish farming. Near Chennai, at a village called Gummidipoondi, women's self-help groups have successfully taken up breeding and culture of ornamental fish to earn their livelihood. On the commercial front, the ornamental fish trade is a growing business in Tamil Nadu, which is turning out to be the major production and export centre.
In Chennai, many farmers grow fish in their backyards and sell the stock to larger companies, which are engaged in the export business. The State Government owned Tamil Nadu Fisheries Development Corporation (TNFDC) rears popular varieties such as goldfish, angelfish, mollies and fighters in its farm near Coimbatore. Ornamental fish culture in Chennai is a mixture of both domestic as well as commercial scale production, which largely caters to the export market. Backyard ornamental fish breeding is also undertaken in other villages of Tamil nadu, helping the rural people raise their monthly income on a regular basis even when there is no available farm work.

Kerala

In Kerala, there are 73 potential ornamental fishes available. The important native ornamental fishes viz., *Puntius denisonii* (Denison's barb), *P. arulius* (Aruli barb), *P. ticto* (ticto barb), *P. vittatus* (koolie barb), *P. fasciatus* (melon barb), *Parambasis thomassi* (glass fish), *Horabagrus brachysoma* and *H. nigricollaris* (yellow cat fish) have already secured positions in the national and international markets. The Western

Red ocar. Photo Ramesh NG.

Ghats region of Kerala is a biodiversity hotspot for native ornamental fishes in India.

West Bengal

Kolkata is the major distribution and export center have become the major ornamental fish producing zone of India. In West Bengal there are more than 2,000 people involved in ornamental fish trade including ornamental fish breeders, growers, seed and live food collectors, traders and exporters. About 150 families are involved in ornamental fish farming to maintain their livelihood. More than 500 families use it as an additional income generating business[3]. Some low-income suburban fisher folk have successfully established ornamental fish farming as a small scale business, with small scale farmers typically earning an additional monthly income of US$ 50–100. Generally men have other professions and they only look after the seed collection and marketing, while women and children do the everyday care such as water exchange, feeding and disease management. West Bengal is mainly engaged in breeding and rearing of common exotic live bearers and egg layers. The largest wholesale ornamental fish market of India is located in West Bengal. There are about 52 native fish species in West Bengal that have been recorded as aquarium fish. Native ornamental fish species include *Colisa chune* (honey gourami), *Puntius conchonius* (rosy barb), *Brachydanio rerio* (zebra fish), *Chanda nama* (glass fish) and *Botia lohachata* (reticulate loach). In West Bengal, two parallel marketing procedures exist for exotic and native fish. In the case of exotic species, more than 99% is consumed by the domestic market with only a few species such as gold fish and angelfish exported. On the other hand, 90% of native ornamental species are collected and reared to meet export demand.

North Eastern States

The north east Indian states are blessed with indigenous fishes of high ornamental potential. The hill regions in this part of India provide a variety of microhabitats for many colourful native and endemic ornamental fishes. There are 92 species of indigenous ornamental fishes available in this region with good trade potential[4]. Endemic species such as *Channa barca, C. aurantimaculata, Puntius gelius, P. manipurensis, P. shalynius, Botia spp., Oreichthys spp., Badis assamensis, Chaca chaca* and *Polyacanthus spp* have already been made available to the global market based on wild collection. The legal and sustainable exploitation of endemic ornamental fishes in this region can provide new avenues of employment, besides providing a source of foreign exchange earnings for the region. The department of fisheries in this region have recently established an aquarium fish production unit to meet local demand and to train local youth. At present 58 species of ornamental fishes occurring in the Northeast are being exported as per data from the Marine Products Exports Development Authority of India. Ornamental fish culture and breeding technologies are available that can help people to earn their livelihood by harnessing the domestic and international market opportunities for native species in this region[5].

Ornamental fish breeding techniques

In India the ornamental fish breeders are mainly engaged in breeding of live bearers and egg layers. The egg layers lay sticky or non sticky eggs on the glass wall or aquarium plants. Some species show parental care and some destroy their eggs so different breeding setups are needed for effective breeding of different species. Live bearers release young ones in batches and are very easy to breed, although they have the habit of eating their young ones immediately after release, so breeding traps are necessary to protect the young ones from the parent. The number of eggs in egg layers and number of young ones in live bearers depends on the species, size and age of the parent fish.

Tiger barb, Puntius tetrazona. Photo: Faucon.

Table 1: The top ten ornamental fishes produced in India

Common name	Scientific name
Gold fish	*Carassius auratus*
Molly	*Poecilia latipinna*
Guppy	*Poecilia reticulatus*
Platy	*Xiphophorus maculatus*
Swordtail	*Xiphophorus helleri*
Koi carp	*Cyprinus carpio var. koi*
Angel fish	*Pterophyllum scalare*
Oscar fish	*Astronotus ocellatus*
Fighter	*Betta splendens*
Tiger barb	*Barbus tetrazona*

Table 2: The top 10 indigenous ornamental fishes of India

Common name	Scientific name
Deninson's barb	*Puntius denisonii*
Rosy barb	*Puntius conchonius*
Honey gourami	*Colisa chune*
Zebra fish	*Brachydanio rerio*
Glass fish	*Chanda nama*
Reticulated loach	*Botia lohachata*
Black knife fish	*Notopterus notopterus*
All black shark	*Labeo calbasu*
Pencil gold Labeo	*Labeo nandina*
Hi fin barb	*Oreichthys cosuatis*

Rearing tank

Cement cisterns, all glass aquaria, earthen ponds and earthen pots are widely used as culture tanks in India. The urban and suburban landless farmers generally use cement cisterns in the backyard or on the roof. Two or three cisterns are sufficient for a small rearing unit (3m x 2m x 1m). Cement tanks are built above ground level for easy drainage. Indoors, all glass aquaria are preferred for breeding purposes as heaters and aerators can be used. Farmers use small earthen tanks for rearing juvenile ornamental fishes. Marginal farmers even use large earthen pots of 1.5m diameter for rearing the larval and juveniles. In India the ornamental fish keepers generally provide around 20cm^2 of surface area for each 1 cm length of ornamental fish in the rearing unit.

Feeds and Feeding

Although the aquarium market is flooded with imported feeds, small scale farmers can not afford to buy them due to their high cost. In rural areas, the farmers themselves find alternate low cost live foods such as daphnia, green water and infusoria as larval feeds. In areas where salt pans are available the farmers collect *Artemia* nauplii to feed the young ones. The breeders are fed with blood worms, *Tubifex* and prepared feeds. Generally farmers prepare on-farm moist feeds using raggi, wheat bran, rice bran, ground nut oil cake and locally available cheap non-conventional ingredients. By doing so, they are able to save 25-28% of feed cost.

Health cover

In rural areas particularly university trained ornamental fish farmers and women self help groups use herbal extracts such as aswagandha, garlic, turmeric and aloe to prevent diseases. Onion and salt are found to be the best natural medicines to cure parasitic diseases in the majority ornamental fishes. The farmers could make savings of 15-17% on medicinal cost due to utilisation of herbs available in their region.

Involvement of rural women in ornamental fish industry

In southern, India, women's involvement in ornamental fish culture is growing rapidly. A large number of poor women are engaged in traditional aquaculture activities and make an important contribution to the rural economy. Women are engaged in ornamental fish breeding in backyard. Women earn a significant supplementary income


Rosy barbs, photo Kkonstan.

from this activity and increase the family income considerably. Backyard ornamental fish breeding is an economically sound practice because it requires very little space, skill and time and has the potential to improve the economic condition of the household. It has been found to offer immense scope for improving the livelihood of rural women in India. Women selling ornamental fish every month to local aquaria can earn a regular income of US$12.50 – 25 per household per month, with a production cost of only 4% of this income as no extra labour was employed[6]. The used water from the culture tanks is often siphoned out and used to fertilise a kitchen garden. Backyard ornamental fish breeding is a new income generating activity can become a powerful tool in improving the livelihood and economic security of the rural poor. The percentage-wise average monthly income of ornamental fish farmers of rural India is illustrated in Fig. 3.

Conclusion

The tropical climate in India is ideal for breeding and growing wide varieties of ornamental fishes. India has significant potential to increase the supply of ornamental fishes in the world market, notably through popularising its own indigenous species, which are popular with international hobbyists. With breeding and culture technologies already available, coupled with expert technicians, breeders and growers, India can easily achieve the goal of making the ornamental fish trade a multimillion dollar industry. Popularisation of small scale household units of ornamental fish culture has the potential to boost rural and urban income significantly, improving the livelihoods of rural people. Backyard ornamental fish breeding is an economically sound practice because it requires very little space, skill and time and has the potential to improve the economic condition of the household. It has been found to offer immense scope for improving the livelihood of rural women in India. It can be practiced even in urban areas with little alteration of backyard or even the roof of a dwelling. It requires less initial investment than other firms of aquaculture. Very sophisticated or complicated equipment is not necessary so the initial investment is minimal in backyard ornamental fish culture and breeding, making it a suitable activity for poor, small-scale or landless farmers. As little labour is needed, men, women or elders can easily run small home units to earn addition.

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Measuring empowerment of women through self-help groups in aquaculture

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Self-help groups are a tool that can help people to escape poverty and improve rural development outcomes (Das, 2003). A women's self-help group may be composed of around 10-20 women of with some similar goals and interests to undertake various activities with a common objective for socio-economic development of the members. A common strategy in the formation and organisation of women's self-help groups is to pool their savings regularly, and to make small interest bearing loans to the group members from the common fund. The group dynamics and cohesiveness, natural inclination for savings and peer pressure for loan repayments contribute to a large extent to the sustainability of these groups.

Mission Shakti, a campaign for a holistic approach for empowerment of women was launched on 8 March 2001 by the Government of Orissa with a target to form 200,000 women's self-help groups by 2008. Capacity building of the existing groups and formation of new groups are prime objectives of this mission. As of December 2008 an overwhelming number of approximately 302,110 women's self-help groups had been formed in Orissa with approximately 3,625,360 members associated via Mission Shakti (Anon, 2007-08[1]).

Role of aquaculture

Aquaculture plays a multi-dimensional role in rural communities, contributing to many aspects of daily life including food security, employment, income, resource utilisation and finally the general improvement of the livelihoods and socio-economic status of people that are directly or indirectly connected with the exploitation, production and processing of fish (Ninawe and Diwan, 2005). These days, an increasing number of rural women are associated with aquaculture due to its compatibility with existing livelihoods activities and good production and earnings potential. Orissa has a vast potential for both fresh- and brackish-water aquaculture, with around 118,000 ha of freshwater ponds and tanks; 180,000 ha; 171,000 ha of rivers and 197,000 ha of canals (Anon, 2000-01). After framing the State Reservoir Policy in 2003 approximately 138 reservoirs above 40 ha mean water surface area were transferred to the Fisheries and Animal Resource Department for scientific intervention and 467 reservoirs below 40 ha MWSA were transferred to Gram Panchayats (a local self-government unit at the village or small town level). These Gram Panchayats ponds are leased out to women's self-help groups on a one to five year basis for aquaculture activities. There were approximately 63,292 tanks with an area of around 50,300 ha in 6,234 Gram Panchayats in the entire state during 2007-08 (Anon, 2007-08[2]).

The Governments of India and Orissa have commenced initiatives for capacity building of women's self-help groups in terms of human resource development and technical know-how. With the assistance of credit facilities from banks and other financial institutions, the groups are capable of achieving sustainable progress in aquaculture. An increase in fish production has resulted in an annual incremental improvement to the income of the groups, which further leads to improve the socio-economic condition of the group members and their families. Through internal lending, the members take loans from the group savings at a nominal rate of interest and use for their personal or family expenditure. Thus, the members of the women's self-help group are economically empowered and as a result of which their socio-economic conditions are improved in a developmental process. As a whole, aquaculture activity have brought a radical change in an integrated manner by empowering the women economically and intellectually. Self-reliance and dignity of life is the ultimate outcome of their empowerment.

Measuring empowerment

We conducted a study to try and measure the empowerment effect in Puri District of Orissa using a statistical approach. Secondary data on women's self-help groups involved in aquaculture, mainly fish farming activities was collected from three blocks viz. Puri Sadar, Pipili and Brahmagiri of Puri District. A list of women's self-help groups with linkages to banks during 2004-05 was collected from the respective block offices. The list contains a total of 39 women's self-help groups in all three blocks, who are doing fish culture as their main economic activity. A random sample of eleven women's self-help groups, comprised of four from Puri Sadar, four from Pipili and three from Brahmagiri blocks who have linked with bank during 2004-05 were selected. For the present study, the year 2005-06 was taken as the baseline. A follow-up survey was conducted consecutively for three years (2006-07 to 2008- 09) for concurrent evaluation. Year wise annual income, profit, loan and savings of the groups for a period of four years i.e. from 2005-06 to 2008-09 have been recorded from the account books and registers of these eleven women's self-help groups. A total of 86 members from the groups who were available across all four years of the study were selected for interview to collect primary data on their achievements with the help of a pre-structured and self-administered questionnaire.

Measuring women's empowerment is challenging, because the term itself is often poorly defined (Gurumurthy 1998; Kishor and Neitzel 1996; Mason 1986). The key underlying concepts that define women's empowerment is conceptualised as a function of women's access to and control over resources, which extends to their decision making capabilities regarding household decisions, employment, income, household assets and expenditure, fertility, sexuality, freedom of movement and their control over material and intangible resources such as property, information and time; their position within the household vis-a-vis other male and female household members; their experience of domestic violence; and their education (Gurumurthy 1998; Dyson and Moore 1983). In the present study, where aquaculture is undertaken as a group activity by women's self-help groups, the following dimensions of empowerment are presented with their selected indicators and explanation.

Different dimensions of empowerment, selected indicators and explanation of various terms used in this study:

- **Economic empowerment** is measured by the change in annual income of the self-help groups undertaking fish culture activities.

- **Annual income** is generated from the group activity i.e. fish culture. It is the financial assets of the group; depending on profit gained, loans taken from the bank or any other finance institution during a financial year and the annual savings of the group.

- **Intellectual empowerment** is measured by composite index of literacy development, skill development and awareness development.

- **Literacy development** varies amongst members of the group as individuals have different levels of education, including illiteracy. Illiterate women may use thumb impressions to mark documents only. In the process of doing group activities, members help themselves to upgrade their literacy level. It has been observed that a few members who were illiterate at the beginning of the study i.e. during 2005-06 were able to put their signature and some had gained the ability to read after the end of observed period i.e. during 2008-09. In this study, an attempt has been made to measure the level of literacy development of the group members during the observed period. For measuring literacy development index, the following scores have been assigned: Thumb impression, 1; sign only, 2; read only, 3; read and write, 4.

- **Skill development**: At the time of formation of the groups, all the members were given basic training on group formation and its functioning. In due course some of the group members have also undergone training on accounts and book keeping and technical aspects of fish farming. Scores were assigned as follows for different types of training: Basic (2 days), 1; accounts and book keeping (2 days), 2; technical (5-10 days), 3.

- **Awareness development**: Group members were also given scope for participation in different meetings and workshops at panchayat/block/district level. They were also given scope for attending various camps on health, family welfare, consumer rights/awareness, right to information act and similar training. Scores were assigned as follows: For attending each type of meeting/camp, 1.

- **Self-reliance empowerment** is measured by the index of development in level of decision making, having right to freedom and justice, protest against gender discrimination, exploitation and prejudice; action against social injustice/ crime and/or family torture; increase in confidence level; and contest for political posts. After some years of group activities, the members that had been economically empowered and as a result of which they may gain confidence and feel competent enough to take decision independently, take risks and some women could even participate in political movements or contest in panchayat elections. Scores assigned for such activities were as follows: Decision making, 1; right to freedom and justice, action against social crime etc., 2; increase in confidence level, 3; contesting a political post, 4.

Calculating the empowerment index

Before the empowerment index of a women's self-help group is calculated, an index needs to be created for each of these dimensions. To calculate these dimension indices – economic, intellectual and self-reliance, the minimum and maximum values (goal posts) are chosen for each underlying indicator. Performance in each dimension is expressed as a value between 0 and 1 by applying the following general formula (Anon, 2002).

Dimension index = (Actual value – minimum value) / (Maximum value – minimum value)

The above formula is adopted from the Human Development Report, 2002, UNDP. The empowerment index is then calculated as a simple average of these dimension indices.

Findings

On analysis of the data, we made the following observations:

Table 1 shows that the progress of leasing out Gram Panchayat tanks for fish culture in case of women's self-help groups is comparatively much higher (about 9 times) than the men's self-help groups in terms of the number of tanks leased out and water area coverage. The phenomenal change could be attributed to reliability on women, their active participation in group activities, group cohesiveness and self-confidence.

Table 1: Progress of leasing out G.P. tanks in pisciculture in Orissa (Upto Dec. 2008)

Group	No. of SHGs	No. of tanks leased out	Area in ha
Men	837 (10.2%)	875 (10.2%)	1,800 (15.3%)
Women	7,346 (89.8%)	7,707 (89.8%)	9,964 (84.7%)
Individual	14,345	17,203	21,667
Primary Fisheries Co-operative Societies (PFCS)	6	15	411
Total	22,534	25800	33,842

Source: Directorate of Fisheries, Orissa, Cuttack

We also observed that the number of women's self-help groups based on different range of annual incremental income varies according to their performance in group activities. The number of groups having annual incremental income less than Rs.1000 is recorded as 15 and the next range of annual incremental income (Rs.1000-2000) is generated by 14 of the women's self-help groups, which is graphically presented in Figure 1.

Calculation of empowerment Index

For calculation of empowerment index, a composite index of economic empowerment, intellectual empowerment and self-reliance empowerment is calculated with proportionate weightage. Since economic empowerment is the prime objective of the self-help groups, it has been given 50% weightage whereas intellectual empowerment and self-reliance empowerment indices have been given 25% weight each.

Comparison of empowerment index in 2005-06 and 2008-09

In order to determine the significant increase in level of attainment of empowerment of women of the women's self-help groups undertaking fish culture activities, a null hypothesis (H_0) is set up to determine whether there is any significant difference between the empowerment index before and after the study period i.e. during 2005-06 and 2008-09 .

Null hypothesis (H_0): Fish culture activities did not bring about any change in the empowerment index of the members of the women's self-help groups. A paired t-test was done with the help of SPSS to test the hypothesis.

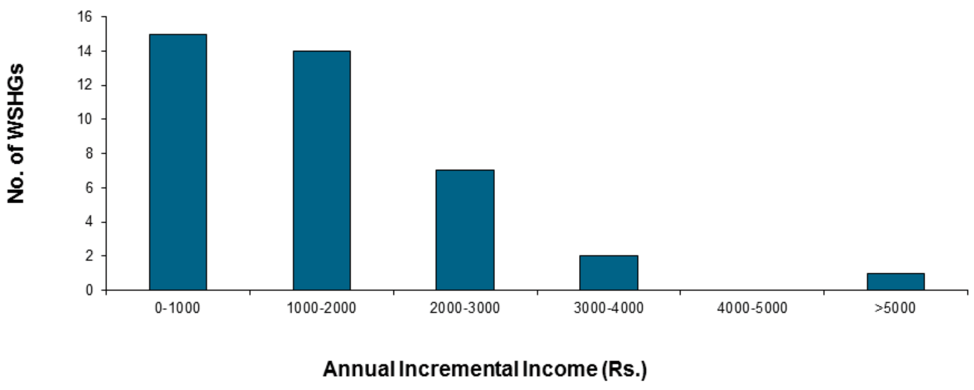
Conclusion

A brief summary of the analysis of survey results shows that the empowerment indices of elevensample women's self-help groups during 2005-6 and 2008-09 were observed to be 0.22 and 0.42 respectively. By using a paired't 'test, we found that the probability of accepting the null hypothesis (homogeneity of two sample means before and after) is less than 5% ($p < 0.05$) and hence, we conclude that the empowerment index of the women's self-help groups has increased significantly from the year 2005-06 to 2008-09. This indicates that the members of women's self-help groups that engaged in fish culture were empowered economically, intellectually and self-reliantly in a developmental process through the aquaculture activity.

Table 2: Empowerment Index of the WSHGs during the period 2005-06 to 2008-09

Women's self-help group	Economic empowerment index		Intellectual empowerment index		Self-reliance empowerment index		Composite empowerment index	
	2005-06	**2008-09**	**2005-06**	**2008-09**	**2005-06**	**2008-09**	**2005-06**	**2008-09**
Dharitri SHG, LNPur, Sadar	0.24	0.32	0.19	0.41	0.04	0.42	0.18	0.40
Rajalakhmi SHG, Khandighara, Sadar	0.23	0.30	0.15	0.44	0.04	0.44	0.16	0.37
Jayadurga SHG, K. Jagannathpur, Sadar	0.22	0.23	0.15	0.48	0.09	0.49	0.17	0.32
Maa Tarini SHG, Olang, Sadar	0.29	0.74	0.14	0.46	0.11	0.45	0.21	0.60
Maajagatjanani SHG, Dandamukundapur, Pipli	0.37	0.49	0.39	0.52	0.14	0.52	0.32	0.51
Gouri SHG, Oracola, Pipli	0.55	0.46	0.30	0.45	0.06	0.48	0.37	0.46
Narisangani SS, Kamakantia, Pipli	0.34	0.30	0.39	0.45	0.13	0.46	0.30	0.38
Subhechha SHG, Siula, Pipli	0.16	0.17	0.30	0.43	0.15	0.51	0.19	0.32
Maa Harachandi, Godabari, Brahmagiri	0.12	0.46	0.31	0.85	0.13	0.45	0.17	0.56
Pragati SHG, Sishupari, Brahmagiri	0.31	0.47	0.15	0.36	0.02	0.24	0.20	0.39
Trinathdeva SHG, Bidurabanka, Brahmagiri	0.25	0.34	0.16	0.36	0.11	0.35	0.19	0.35

Figure. 1: No. of WSHGs based on Annual Incremental Income (Rs.)



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Success Story: Pigeon pea *(Cajanus cajan)* cultivation over fish pond dykes - an economically viable farming approach

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India is an agrarian country and almost 60% of the total population depends on agricultural activities for their livelihoods. High population growth, rapid urbanisation, increased use of land for housing, industrial and other activities has led to the decrease in per capita land availability for agriculture purposes. Sustainable and efficient use of available land and water resources is the need of the hour for optimising agricultural production to fulfil the growing demand for nutritious foods and to provide income for farmers. As land is a fixed factor of production, hence, intensification options accompanied by improved techniques could increase production considerably[1].

In addition to available agricultural land area, India is endowed with 2.36 million ha of ponds and tanks, 3.15 million ha of reservoirs, 0.24 million ha of flood-plain wetlands, 4,500 km rivers, 120,000 km of canals and some 2.7 million ha of estuaries and lagoons. A large and frequently underutilised area adjacent to these water bodies in form of their earthen sidewalls, bundhs or embankments is available, offering significant potential for the cultivation of vegetables or seasonal crops. Although, the area of land available with these water bodies varies from place to place depending upon the size, slope, location, soil texture and possible competing uses, approximately 10-20% land area of fish culture ponds is generally available in the form of pond dykes or embankments. However, due to lack of awareness of appropriate crops and farming methods on such land, in the majority of cases it remains under- or utilised throughout the culture period. Selection of suitable crops and their cultivation on pond dykes offers an opportunity for farmers to diversify their production, improved farm production and enhance farmer income and profitability[2].

In the northern states of India, a major segment of the population subsists on vegetarian food and decorticated cotyledons of pulses known as 'dal',

Pigeon pea, Cajanus cajan. Photo Tau'olunga.

which have an important place in the food basket of every household. Among all pulses, pigeon pea has a very high demand and contains about 20-21% protein with important amino acids like methionine, lysine and tryptophan. Among all important pulse crops, pigeon pea is the second largest in terms of production after chickpea and 90% of total world production is contributed by India,[3,4]. With a view to utilising embankments, we trialled pigeon pea *(Cajanus cajan)* cultivation to increase nutritional security and generate additional income in rural areas. Mutual benefits of integrating pigeon pea with fish culture ponds are discussed below.

Fish culture in Sirhir village

The fish farm where we conducted our trials is in the village Sirhir, located about 40 km away from the main city of Allahabad, Uttar Pradesh, India. Fish culture in this area began in the 1980s, initially starting out in an old weed infested village community pond of about 4 ha, with cultivation of indigenous and exotic carp species. After seeing the satisfactory profitability in fish culture over a period of time, the farmer prepared another five ponds for fish culture ranging from 0.5 to 0.1 ha, from 2002-04.The work was carried out under the extension programme of the Central Institute of Freshwater Aquaculture, Bhubaneswar from 2002-2004 at Allahabad.

For the trials, two grow out ponds, one 4 ha and the other 0.5 ha were stocked with rohu *(Labeo rohita)*, catla *(Catla catla)*, mrigal *(Cirrhinus mrigala)*, grass carp *(Ctenpharyngodon idella)*, silver carp *(Hypophthlimichthys molitrix)* and common carp *(Cyprinus carpio)* in the ratio of 25:25:20:15:10:5. A few specimens of tilapia, a banned species also entered in the larger perennial pond.

Three other ponds (0.3 ha) were used as buffer nursery ponds for growing stunted fingerlings of carps and stocking

Rearing pond with full grown pigeon pea.

of fry at the rate of 300,000 /ha. Trials to grow giant freshwater prawn (scampi) *Macrobrachium rosenbergii* with other carp species in a pond of 0.2 ha along with rohu, catla and grass carp, was also undertaken, with a stocking rate of 5,000 fry /ha and 5,000 post larvae/h of scamp. Ponds were manured with 5-6 tonns of cow dung/ha/year, nitrogen fertiliser at 50 kg/ha/year and single super phosphate at 350 kg/ha/year in all the fish culture ponds. A combination of easily available paddy straw (1-2 tonnes/ha) and urea/cow dung also applied in one corner of each pond. The large pond of 4 ha was frequently used by cattle for bathing and therefore, lower dose of cow dung were used in that case to compensate.

Supplementary fish feed was provided consisting of rice polish and mustard oil cake in 1:1 @ 1-2 % was given throughout the culture period in baskets. In the nursery ponds, the same feed was applied @3-5% of total body weight of fishes. Regular water quality management, supplementary feeding, monitoring of growth and health of stocked species was conducted. Since the seed was available throughout the culture period hence, multi-stocking and multiple partial harvesting strategies were adopted.

Pigeon pea over pond dykes

Pigeon pea *(Cajanus cajan)* is an annual woody stemmed leguminous plant belonging to the family Fabaceae which grows up to 3-4 m in height[4,5]. About 0.55 ha (10% area) of land in the form of the embankment crown, which had a width of 1.5-2.5 m and the upper slope area was used for growing the long duration Bahar variety of pigeon pea, which takes approximately 240 days to reach harvest. Seed was sown in mid-June. A total of 12 kg of treated seed was used. Depending upon the availability of space, seed was sown in two to four rows on each embankment. Plant to plant distance was maintained about 15-25 cm and rows were spaced at 40-75 cm. Both sides were usually used while middle portion was left as an approach path. During the initial months the entry of cattle was restricted to spare the crop. Since pigeon pea is a leguminous plant the application of nitrogen fertiliser was minimal and other fertilisers, mainly phosphorus sources, were used at the prescribed rate of 20-26-10 NPK. Weed eradication and other activities were regularly undertaken giving due consideration to fish ponds also. The seed started germinating after two weeks and flowering started in October onwards. The harvesting was done in February. The initial irrigation was provided from the pond water.

Outcomes

In a culture duration of about 18 months a total of 7,000 kg of fishes including tilapia , 10.64 kg of prawns and approximately 152,000 grass carp juveniles and 60,000 advanced fry were realised from the fish ponds, while from the embankment a total of about 509 kg of whole pigeon pea was obtained. Cyclic stocking and harvesting was adopted. In the local fish markets fish above 700-800 g sizes are well accepted and fetch a normal price of Rs. 30-35 per kilo (US$ 0.55 – 0.63).

The farmer had gained rich practical experience gained over the years through practicing fish culture and through regular interaction with local fish experts, who provided valuable input into the development of the farm. To extend aquaculture activities and facilities, new fish ponds were gradually prepared and put into operation. However, this placed financial constraints on the farmer, which later provided the motivation for him to try and improve the yield and financial returns from of all the farm resources at his disposal, including the pond embankments.

Factors in the success of this farm include: Growing six carp species in composite culture mode; the application of better management practices such as stocking larger size seed, maintaining proper water depth; demand driven rational use of inputs in ponds, use of paddy straw-urea-cow dung in combination to enrich detritus and other plankton based food chains; provision of basket feeding to avoid feed wastage and reduce water quality deterioration. Besides this, the addition of a new commodity, giant freshwater prawn, and nurseries as buffer ponds for growing stunted fingerlings were the activities undertaken to augment the farm production and productivity. Unwanted terrestrial weed removal from pigeon pea areas was undertaken and used for feeding the grass carps fingerlings/ adults.

Young pigeon pea. Photo: Amalan619.

Apart from two or three months from April to June when water temperature reached to 34±2°C with declining water depth in the presence of high biomass leading to deterioration in the water quality of the pond, water quality was generally managed by topping up the pond with freshwater. For the rest of the time, normal environmental parameters prevailed with a higher level of total nitrogen ≥65mg/100 g of pond bottom soil sediments. However, the increase of nitrogen level may vary from farm to farm depending upon the intensity of cropping and prevailing soil quality. Regular dropping and decomposition of pigeon pea leaves and leaching of nitrogen during rainy season via the embankments might be cause to add extra nitrogen fertilisation to the ponds. However, an increase of nitrogen and other nutrients in well fed fish ponds at advanced stages of culture is normal trend because of high biomass, feed application and increased volume of wastes from the fish[6,7]. However, in the present case after five to six months of culture a steady increasing trend was more distinct and therefore, compared to normal ponds, pond manuring and fertilisation doses were lowered to compensate. This highlights the need to carefully observe water quality and adjust management measures appropriately.

In India among all pulses, pigeon pea has a very high demand as a staple diet because of its sweet taste and high nutritional value. It is considered to be an integral food for everyday meals, particularly in vegetarian diets for supplementing energy rich cereals, mostly used in the split form as dal. In southern states of the country, young pods are also used in a popular vegetable dish called sambhar. In rural areas it is also used as fodder for livestock.

The fish pond embankments provide an ideal space for pigeon pea cultivation as it requires upland areas where water retention of the soil should be low during the growing period. The long and deep roots of this crop holds the pond embankment soil firmly and thus effectively control soil erosion, provide stability and strength to embankments soils. The occurrence of agricultural hazards such as flooding and water logging are important factors that can result in low yields from pigeon pea[3]. Co-cultivation has been found to be highly beneficial both to pea and fish production. Under this integration

Pigeon peas. Photo: C.L. Ramjohn

pigeon pea benefits from an ideal site for its growth, flowering and fruiting because of minimal water retention. It has been observed that during extreme winter months, prolonged foggy conditions in this area effect adversely the growth of pigeon peas, however, under present study the effect was minimised due to presence of pond water which helped in speedy condensation of water vapour in to water drops. Further, direct sunlight available on the embankment helped in good growth of pigeon pea plants. Irrigating the peas with nutrient rich pond water enhanced the growth of the plants and helped to manage water quality.

At the same time fish pond also got benefited many ways. Being a leguminous plant pigeon peas improve the soil characteristics and fertility and ensure better growth to succeeding crops. It has been reported that up to 200 kg N ha^{-1} can be fixed in soil by long duration pigeon pea crops and the beneficial effect on subsequent crops is equivalent to about 40 kg ha^{-1} [8]. In some countries pigeon pea foliage is used as green manure. During heavy rains, the soil erosion was drastically reduced in pigeon pea bearing embankments of this fish farm due to the deep roots of plants. Dropping of dried leaves into the ponds helped in improving pond water and sediment characteristic. The

View of pigeon pea growing on the pond dykes.


Catch of fish and prawns; pond with pigeon peas on dykes in background.

detached leaves of pigeon pea plants gradually decompose providing nutrients and natural foods for benthic fauna, detritus, phytoplankton and zooplankton and ultimately for the cultured fish. This was evident by the rich growth of plankton in the pond water.

In addition to the above, each and every part of pigeon pea plant is used for house hold activities and has multipurpose utility. The left over woody part of pigeon pea plants are used as firewood, for fencing, making thatched houses, baskets, brooms etc. and have high demand in rural areas. Moreover in this integration, during thrashings and making pigeon pea dal, granulated and powdered by-products were used in the ponds to feed the fish.

The integrated approach trialled here not only helped in providing multi-purpose products for market but also gave an advantage over other fish culture practices in terms of offsetting production costs, more efficient utilisation of farm space, shortening the investment return period due to cyclic harvesting, and spreading the risks of production failure by diversifying production. As the farm site happens to be a low lying area the variety used is not normally grown in this area. Cultivation of pigeon pea over the fish pond dykes by the progressive farmer not only increased the production, productivity and return (69.8%) of this fish farm but also helped in popularising the variety for this application in the area.

Conclusion

This type of beneficial diversification in fish farming with cultivation of field crops was found to be quite useful for resource poor farmers in terms of assisting them to generate additional income, increase employment and improve their dietary standards. The work carried out in this farm brought positive changes in terms of enhanced fish production, soil water amelioration, erosion control and strength to ponds dykes and increased economic benefits with the production of nutritious vegetarian and non-vegetarian protein rich foods at local level. Possibilities to further increase farm returns through short duration high yielding, pest-resistant varieties of pigeon pea could be explored in future. The work and output of the farm was successful in generating enthusiasm in local fish farmers. Our observations have shown the possibility of growing these two high protein commodities in a way that is beneficial to each other, particularly in low lying flood prone areas.

Acknowledgements: The author express his thanks to The Director, Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar for providing guidance and facilities at the Centre and to Dr. Ballbir Singh, retired Principal Scientist, CIFRI, Allahabad for his encouragements. Thanks are due to Shri Indresh Pandey, Progressive farmer, Sirhir, Allahabad for his dedicated work and support. The work was carried out under the extension programme of CIFA at Allahabad Centre.

Photo credits

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Sambar - a south Indian dish, made with pigeon peas. Photo: Ramesh NG.

Culture of freshwater climbing perch, *Anabas testudineus*

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The climbing perch, *Anabas testudineus* is one of the important air-breathing fish .It has a wide range of geographical distribution due to its exceptional physiological adaptation with respect to air-breathing habit and salinity tolerance. It is widely distributed from fresh water to estuaries in India. Its natural distribution ranges from India and China across to Cambodia. In India it is popularly known as 'Kavai' in Hindi, 'Kou' in Orissa, 'Koi' in West Bengal, 'Kai' in Assam etc. and is a preferred fish with a high market price in many states like West Bengal, Tripura, Assam, Bihar, Orissa and even in southern India. Climbing perch contains high quantities of physiologically available iron and copper essential for hemoglobin synthesis, easily digestible fat and many essential amino acids viz. histidine, lysine, leucine, tryptophan and isoleucine. Due to its air breathing ability and tolerance to a wide range of adverse environmental conditions, the fish is being considered as a promising candidate species for culture in the water bodies where carps cannot be cultured. The neglected swampy water bodies and derelict ponds can be utilised for its mass scale culture where these can be stocked as a candidate species. Anabas can be reared or cultured in large tanks and ponds to control aquatic insects and some weed fishes.

Owing to lack of adequate seed and larval rearing techniques climbing perch has not received as much attention from farmers as it perhaps deserves. The Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, has standardised the techniques of seed production and larval rearing. The techniques developed by CIFA are described below.

Broodstock management

Maintenance of healthy brood fish is a prerequisite for successful seed production in captivity. The brood fishes collected from culture ponds, are stocked in cement tanks at the rate of 15/sq.m (wt 40-100 g). They are fed with a mixture of feed ingredients such as fish meal, groundnut oil cake, soybean meal and rice bran augmented with vitamin and mineral mix, and with a protein content of approximately 30%. The fish are fed twice daily @ 5% of their body weight. Good water quality is maintained through frequent replenishment of the same. In culture conditions, *Anabas testudineus* attains maturity in the first year, when it grows to a size of 14-18.2 g and 8.0-9.2 cm.

Males and female fishes develop their distinguished secondary sexual characters during breeding season. Females exhibit prominent outgrowth at the vent in the form of genital papilla when gently pressed at the abdomen. Males do not show such characters, but when the abdomen is pressed gently milt comes out. Gravid females have bulging abdomen. In nature climbing perch breed according to the favourable conditions and breeding grounds, but in captivity they can be induced to breed through hormone administration.

Breeding

The breeding season for climbing perch starts from April and continues until late August with a peak in May-June. Fish weighing 40-80g are taken out of the brood stock tanks and kept separately in FRP tanks for breeding operation. Ovaprim is injected intra peritoneal in males and females, @ 50-100 μl/ fish depending upon the condition of the brood fish. The hormone is injected during the evening hours in a single injection. The injected fish are released in breeding pool. It takes around 7-8 hours to spawn after administration of hormone. Under captive conditions the fish can be induced to breed at any desired time by adjusting the time of injection. The fertilised eggs are small, almost circular and lighter than water, measuring about 0.82mm in diameter after water hardening. They float on the surface and look like non-adhesive tiny crystal beads. Viable living eggs are transparent, while the unfertilised eggs look opaque or milky. On average, a female weighing 50-60 g may produce 10,000-12,000.of eggs. The fertilised

eggs are incubated in stagnant water in plastic tubs/FRP tanks. The time duration from the time of administration of hormone to hatching out is about 22-26 hours depending upon the water temperature, which should be maintained in the range 26-30ºC.

Multiple breeding of *Anabas testudineus* for mass scale seed production

Although the fish breed only once in a year in nature CIFA has succeeded in breeding the fish repeatedly or several times in the same year to meet the demand for seed. The brood fish are maintained in a pond/tank (outdoor) providing feed with high protein ad libidum with regular monitoring of water quality. Healthy and mature fish of 40 g and above are first induced to breed in March. After prophylactic treatment with potassium permanganate the same fish were maintained separately with utmost care to mature again. Within 50-60 days they will be ready to breed in the month of May/June. Thus adopting this technique the growers/ farmers can enhance the seed production.

Larval phase and seed rearing

The newly hatched larvae measure 1.6-1.8 mm in length and rest in an upside down position. They are reared in indoor rearing tanks of 500 l capacity with water depth of about 40 cm, which may be adjusted later on depending upon the size of the juvenile fish. Water is drawn into the tank after filtering with a nylon cloth to prevent the entry of large plankton, as these are potentially harmful to the small larvae. Feeding initiates by the third day as they have two to three days of food available from their yolk sac. Experiments conducted in CIFA clearly indicate higher survival; good health and faster growth if 40% of the water surface is covered with floating aquatic plants such as *Pistia* and *Eichhornia*. The root of these plants not only provides sufficient food in terms of periphyton but also absorbs noxious gases that accumulate in the water, during rearing. The quantity of feed depends on the density of larvae reared in the container, the growth of the spawn including their acceptance of the food provided. To increase the survival rate, the identification of acceptable feed and particle size during rearing matter a lot. The three-day-old spawn are fed with thoroughly sieved zooplankton to avoid the entry of Cyclops and Daphnia and other large zooplankton. This continues for two weeks. It is vital to maintain good environmental conditions for better growth and survival of the larvae. So, regular water exchange, feeding and thinning of stock density are important aspects to be taken care of. A stocking density of 1500/m^2 is considered to be ideal for first two weeks for better growth and survival under indoor captive conditions. After 20 days of rearing the spawn attain a size of 12-16 mm. At this stage they can be fed with total plankton, avoiding only Anisops and larvae of some aquatic insects. In another 10 days the fry grow to a size of 20 mm when they can be fed with supplementary feed consisting of rice bran, soybean flour, groundnut oil cake and fishmeal with protein level of 30-35 %. The difference in size groups is mainly due to consumption of food and at this stage utmost care should be taken to segregate the faster growing 'shooter' fry from the others at a regular intervals, otherwise there will be heavy losses due to cannibalism. The survival rate is very high when seed is reared in cement tanks (3 x 5 meters) with low water depth (75 cm) and fed with formulated feed. The advanced fry is further reared in big cement cisterns with a soil base. Raw cow dung is applied to develop natural food supplies for the fry and stocking density is kept @ 50-60 fry/m^2.

At this stage the larvae are very small and delicate, so they need a good rearing system as well as proper water management for optimum survivability. The accumulation of metabolites and unutilised feed in the rearing tanks deteriorate the environment and ultimately lead to oxygen depletion causing disease and morality. Therefore, around 50% of the water is exchanged at regular intervals. Feed consisting of agricultural by products and fish meal in fixed ratios serve as good feed. However, this fish will accept all kinds of feed ingredients although the best results will be obtained using with high quality feed. During the first two months of rearing seed attain a size of 35 to 40 mm and become ready for stocking.

Grow out culture

Grow out culture is taken up in larger ponds (400 –500m^2.). Fingerlings can be reared in stone lined ponds to check their escape due to 'climbing' behavior. *Anabas* is not able to scale the embankment if it is at an angle of 75° or more. However, stone lined ponds serve ideally. Pond management requires similar steps to those followed for carp farming. Climbing perch are reared in monoculture or with other air breathing fishes. In monoculture system they are stocked @ 5 to 6 fishes/m^2. Supplementary feeding is essential with regular monitoring of water quality. *Anabas* is primarily insectivorous, so fixing a hanging light just above the tank/pond/cage is a really good way to attract insect, which provide an additional source of food when they fall on the water surface.

Being an air breathing fish, climbing perch frequently come up to the water surface for another gulp of air and this behaviour renders them vulnerable to predation by birds. To avoid this loss, the pond should be covered with net or bird scaring devices. In an experiment conducted at CIFA, a pond when stocked @ 3 fingerlings/m^2 with an average size of 14.17g/9.31cm has registered a production of 1,279kg/ha/year. The fish attains marketable size (50- 60 g) in one-year. For harvesting the fish the pond has to be dewatered

completely and fishes are collectted by hand. Similar kind of results have been recorded in other trials when climbing perch has been cultured in ponds.

Cage culture of climbing perch

An attempt has been made to assess the production performance of this species in fixed and floating cages during its growout phase. Cages of 4.5x 1.5x 1.5m were fabricated using iron frames and nylon nets of 6mm (quarter inch) mesh size with an opening on the top for periodical checking and sampling. Three cages were kept floating using hollow drums, while two others were stationed on the bottom of the pond (0.04 ha). Periodic manuring of pond was carried out with raw cow dung @ 5,000kg/ha/year was carried out in monthly doses. Healthy fish were selected and acclimatised overnight in FRP tanks (500 l) before stocking in the cages. Stocking densities and culture period of the cages varied from 30-74 fishes/ m^2 and 140-375 days respectively. No supplementary feed was used during the experiment. Production output ranged from 0.3 to 1.0 kg/m^2 depending upon the density, culture period and survival, suggesting that this high value species has potential for farming in cage systems. This system prevents losses due to the migratory and climbing habits of the fish particularly during rainy season.

Conclusion

There is a saying about this fish that one farmer cultures the fish and other farmer harvests it. This is because the fish migrates from one pond to another, particularly with the onset of monsoon. This is probably one reason why farmers do not prefer to culture it, the second being lack of availability of sufficient quantity of seed due to poor survivability of its larvae. These issues have been well addressed by researchers of CIFA and we hope will encourage more farmers to undertake culture of this excellent fish.

Augmentation of fish production from small reservoir of Vidarbha: A success story

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Fishemen observing the difference in size of stocking material.

Reservoirs constitute the single largest inland fisheries resources in India in terms of potential area of fish production. Small reservoirs can play an important role in increasing fish production in the country provided that these vast resources are developed on the lines of culture-based capture fisheries. Maharashtra, being the third largest state in India, has a huge potential to increase fish production from reservoirs. The total water area of reservoirs of 20 ha and above is estimated to be around 236,000 ha. The average fish yield from small reservoirs of Maharashtra is on the order of 21 kg/ha/year, which is low compared to the national average of 50 kg/ha/year; which is again low as compared to other Asian countries. The same trend occurs in the reservoirs of Vidarbha and Marathwada region of the Maharashtra state.

Today, in spite of a high carrying capacity due to conducive climatic conditions, a good standing crop of plankton and high rate of primary productivity in small reservoirs, the production from small reservoirs of the Vidarbha region is quite low. The reason behind this is an arbitrary approach to stocking, non-adherence to sound stock management practices and a lack of awareness of the true potential of these resources. Therefore, there is an urgent need to create awareness amongst the rural fisher folks of Vidarbha through training and demonstrations at field level with emphasis on culture-based capture fisheries and to enhance inland fish production from these water bodies. This would play an important role in improving nutritional security, income and employment opportunities for the rural fish farmers of this region.

Screens installed to prevent entry of unwanted fishes prior to stocking.

With this aim a project was implemented by College of Fishery Science, Nagpur, Maharashtra State under the financial assistance from Rajiv Gandhi Science & Technology Commission (RGSTC), Government of Maharashtra, Mumbai, in the Vidarbha and Marathwada region of Maharashtra State. Under this project a few reservoirs of below 20 ha surface area were adopted for demonstration of improved reservoir culture practices so as to enhance fish production and create awareness amongst the rural population through field level training. This is a success story of a small reservoir of Vidarbha region, which due to efficient management practices and teamwork of members of fisheries co-operative society, brought social and economic changes to the lives of its members.

Background

The project reservoir was located in Shankarpur Village of Chandrapur District in Maharashtra State. The total water area of the reservoir in the monsoon season was 11 ha with an average depth of 4 m. The surface area of the reservoir decreased as the season progresses to a minimum of around 5 ha with average depth of 3 m. The reservoir was taken on lease for a period of one year by the members of a local fisheries co-operative society.

The reservoir used to be stocked with the seed of Indian major carps, procured from private fish seed suppliers. A practice of heavy stocking was followed after the heavy showers of the monsoon. The percentage of Indian major carp seed stocked in the reservoir was always questionable since the seed stocked was never 100 percent pure, containing some minor carp varieties along with weed fishes which found entry to the reservoir through this indiscriminate stocking. There were many small streams which ran into the reservoir through which many predatory and weed fished could also find entry to the reservoir. After the indiscriminate stocking, no feeding or feed management practices were adhered to, relying instead on the natural productivity of the reservoir. The reservoir was harvested as and when required and was being utilised as a capture fisheries resource rather than culture based fisheries resource.

In addition to fish culture activity, the reservoir was traditionally used for growing water chestnut (T*rapa bispinosa*). This water chestnut has a good local market in the Nagpur region of Vidarbha. The only advantage this reservoir was used for this purpose is that it completely dried during the month of summer i.e. from March to May, and complete harvesting was possible. Due to indiscriminate stocking and reduced water area in the month of May, the average weight of fish at harvest was 220-270 g after a culture period of 6-7 months. Thus, the members of the co-operative society used to produce an average annual fish production of around 9 tonnes which were sold at an average rate of Rs. 25 per kg (US$0.45) and thus generating average annual revenue of around Rs. 250,000 (US$4,500). In addition to this, the yield of 1 tonne of water chestnuts, sold at an average rate of Rs. 20 per kg, provided surplus revenue of Rs. 20,000 (US$360) per year. Thus the average annual earnings from this reservoir were approximately Rs. 270,000 (US$4,860) per year, which was far lower than the potential of water body.

Members of the fishermen co-operative society trained in improved management practices.

On-field demonstration of fertilisation practice.

Improving production

Meetings were organised with the members of co-operative society in January 2009, prior to the monsoons. Preliminary investigations on water quality parameters and estimation of primary productivity was conducted. Information on fish production in the reservoir was collected from the members of the cooperative societies and relevant social problems were also discussed. One of the major problems encountered was regarding release of water to the near-by fields for paddy cultivation, since paddy is a major crop of this region, thereby reducing water available for fish production. After thorough discussions, a detailed programme was chalked down with the members of the society and agreed targets were set.

Pre-stocking activities

As per the programme, society members initiated pre-stocking activities in May 2009 when the reservoir was completely dry. All the weeds, small shrubs and other unwanted materials were manually removed from the entire reservoir basin, after which the bottom was ploughed and levelled before the onset of monsoon. Cracks in the embankment were repaired to reduce water loss from the reservoir and screens were installed at all the inlets and outlets so as to prevent the entry of predatory and weed fishes from the nearby runoffs. At the onset of the monsoon, as the water started accumulating, an initial dose of 200 kg/ha of lime was applied to the reservoir. Prior to stocking the fish seed, the reservoir water was fertilised with a mixture of raw cow dung @750 kg/ha and groundnut oil cake @250 kg/ha, along with urea and super phosphate @50 kg/ha each, to boost the primary productivity. The water quality and biological parameters of the reservoir water were studied prior to stocking the fish seed.

Stocking

Yearlings of catla (*Catla catla*), rohu (*Labeo rohita)* and mrigal (*Cirrhinus mrigala*) with an average size of 13.5 cm (20g), 12.5 cm (18g) and 11.5 cm (10 g) respectively were procured from the Fish Seed Production Centre of College of Fishery Science, Nagpur District, Nagpur, Maharashtra State, India. The seed was stocked in the ratio of 4:3:3 and at a density of 5,000 yearlings per hectare considering the (minimum) pre-monsoon reservoir surface area of 5 ha in June 2009.

Feed and feeding management

Supplementary feeding was conducted with the mixture of de-oiled rice-bran and ground nut oil cake, both local crops of this region, in the ratio of 4:1. Daily feeding was done at the rate of 5% of body weight of fish. In the initial month of culture, feeding was by hand broadcasting wherein the decided feed ration was evenly distributed over the entire reservoir area. In the later months, small plastic bags with perforations were filled with required feed ration and were hung in the reservoir at equal intervals along the entire length and breadth of reservoir, from which fishes could draw feed as per requirement and thereby reducing the wastage of

Reservoir infested with water chest nut prior to stocking.

feed. Bag feeding began in August, while maintaining hand broadcasting to allow the fish to adapt to the bags. From September feeding was by bags only. The bag method was found to be more suitable and economical over conventional hand broadcasting, with reduced feed wastage and labour cost.

Water quality and health management

The water quality parameters of the reservoir water were regularly monitored and found to be within the optimum levels for the fish culture activity. Regular fertilisation of the reservoir water was done with raw cow dung, urea and single super phosphate as per plankton levels. Regular sampling was carried out to study the growth and health condition of the fishes. The health condition of the fishes was normal throughout the culture duration.

Harvesting and marketing

Partial harvesting of the fish stock commenced in February, wherein the fishes weighing up to 1 kg or more were harvested using monofilament gill net. Later on complete harvesting of stock was carried out in March 2010, wherein a production of around 16 tonnes was achieved. As a part of marketing strategy advised to the society members, harvesting was done mostly on the market days of the nearby villages. The members of the fisher's society directly supplied the harvested fish stock to the local vendors and retailers, thus avoiding the middle men and maximising their returns.

Outcomes

The fish production from the selected reservoir prior to adoption under the project was very low in spite of its high biological productivity. After adoption under the project, with proper management practices and scientific interventions the production level increased approximately four fold (Fig. 1).

Because of enhanced production and proper marketing strategy employed, the society members have realised the importance of intervention of scientific technology and proper management

Society members stocking the fish seed.

Stocking material transported to site.

practices which has helped them in gaining a handsome profit and elevating their standard of living to some extent.

Demonstration and training were organised to motivate the members of the fisher's co-operative society of nearby villages. These people have realised the change and have started adopting scientific principles for culture-based capture fisheries. Based on similar lines, the members of the fisher's co-operative society could harvest around 24 tonnes of fish in the year 2010-11 from the same reservoir (Fig. 1).

Acknowledgements

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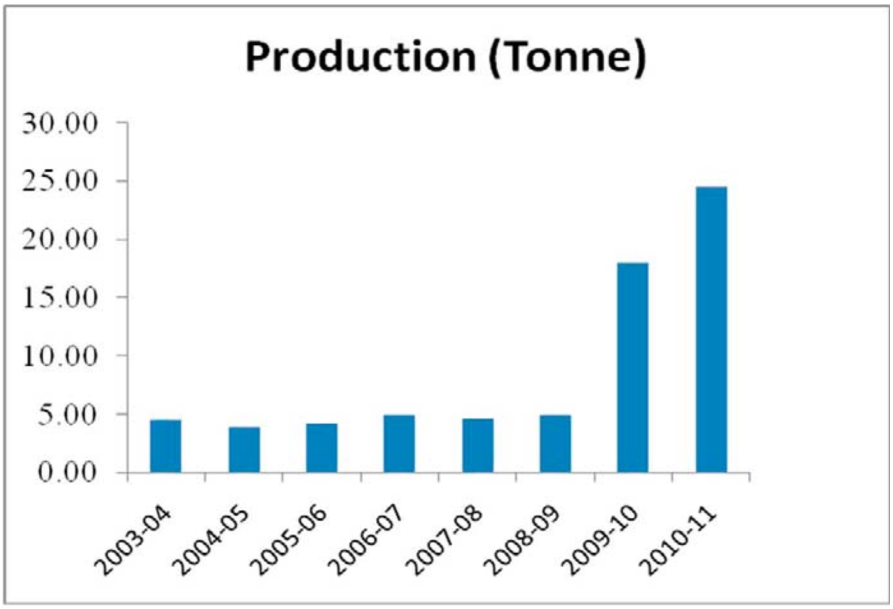

Figure 1: Year-wise production of selected reservoir.

View of selected reservoir after weed removal.

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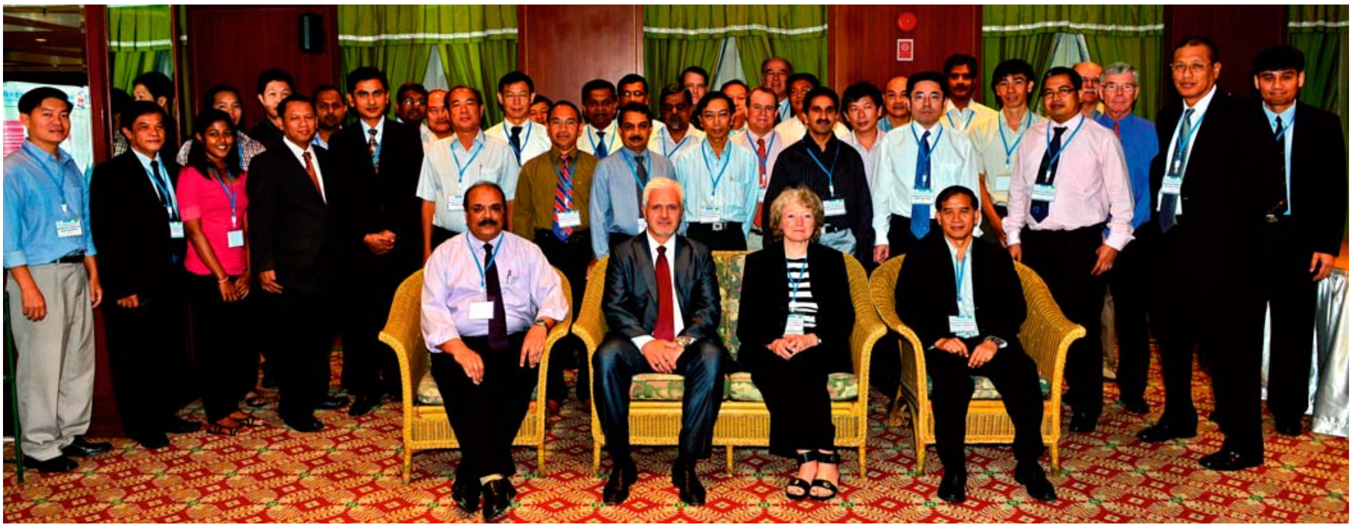
Aquaclimate Project gets thumbs up from regional workshop on climate change



Participants in the Regional Workshop on the Impacts of Climate Change in Fisheries and Aquaculture.

For the past three years NACA has been working with a consortium of partners on a project to strengthen the adaptive capacities of small-scale farmers to climate change. The aim of the "Aquaclimate" project, funded by the Norwegian Agency for Development Cooperation (NORAD), is to identify the likely medium-term impacts of climate change on important aquaculture systems and to develop adaptation strategies that will help farmers to cope with the changes.

The project has focused on five case studies that are important from a livelihood and/or food security perspective: Catfish farming in the Mekong Delta of Vietnam; milkfish farming in the Philippines; low intensity shrimp farming in India; improved extensive shrimp farming in Vietnam; and culture based fisheries in seasonal reservoirs in Sri Lanka. The project has mapped farmer perceptions of climate change through an extensive series of stakeholder consultations and developed climate change scenarios for the case study areas through local downscaling of mainstream climate change models. All of these systems are at substantial risk from climate change due to impacts such as sea level rise, saline intrusion into freshwater reaches of river systems, changes in rainfall patterns and more frequent storms and other extreme events.

As the project is drawing to a close, a Regional Workshop on Impacts of Climate Change in Fisheries and Aquaculture was held in Bangkok from 14-16 May to share the findings with senior policy makers from the region, gather feedback on the recommendations and to facilitate exchange of experience. The workshop was attended by the representatives of twelve countries as well as the Mekong River Commission, Southeast Asian Fisheries Development Center, WorldFish Center, the Secretariat of the Pacific Community and FAO. The workshop was opened with an inaugural address by Mr Erik Svedahl, Chargé d'affaires of the Norwegian Embassy in Bangkok.

Mr Svedahl noted that "The Aqua-Climate Project is probably the first and the most extensive on-site study that has been carried out in the region so far. The Aqua-Climate Project departs from other studies which have not explicitly considered communities and individual famers' adaptation capacities to climate change".

"I wish to emphasise here the need to continue this type of studies pioneered by the Aqua-Climate Project to better understand and manage the risks from climate change impacts in the region", he said. "One key message that Norway will take to the Rio+20 conference next month, is that climate-resilient food production should be encouraged in both agriculture and fisheries".

The outcomes of the project case studies were presented at the workshop. Participants were invited to discuss the findings, which included proposed adaptation strategies for each farming system, and to comment on a related series of briefs and extension materials separately targeting policy makers, scientists and farmer groups. "I appreciate that there are different styles of briefing material available for different stakeholder groups", said Dr Sommano Phounsavath, Senior Fishery Officer from the Laos PDR Department of Livestock and Fisheries. Mr Svedahl noted that "the guidelines for policy makers will be of significant assistance

Dr Brit Fisknes, Senior Advisor to NORAD's Department of Climate, Environment and Natural Resources.

in framing appropriate regional adaptation strategies and framing of policy... the project is well poised to contribute to short and long-term adaptive strategy recommendations to address environmental and social changes that are likely to arise from climate change impacts".

Participants also gave a presentation on their own climate change activities, which were discussed in a plenary session Chaired by Dr Brit Fisknes, Senior Advisor to NORAD's Department of Climate, Environment and Natural Resources. It was clear from the presentations that most countries and institutions see climate change as a high priority issue of great concern. However, clearly distinguishing climate change impacts from natural variability and other factors was acknowledged as difficult, since the effects are gradual and changes require long-term monitoring to quantify. While many climate change adaptation measures require a significant investment and a long lead in time to implement, convincing policy makers with a short term planning horizon to act on long-term threats was seen as difficult.

As the first study of its kind in aquaculture, the Aquaclimate Project was seen to have provided a catalyst for initiating research on climate change impacts in aquaculture for the region. "The project methodology is a very useful contribution", said Dr Peter Degen, Chief Technical Advisor to the Mekong River Commission's Fisheries Programme. A multi-disciplinary approach had been developed integrating remote sensing and climate modeling together with a very strong social science and stakeholder engagement component. "The project has generated substantial methodologies and results that will be carried through to WorldFish Scientists", said Dr Bill Collis. "The methodology developed under the project would be a useful model for conducting similar studies for Malaysian aquaculture", said Md. Fariddudin bin Othman from Malaysia's Fisheries Research Institute, a sentiment echoed by participants from Nepal, India and China.

National partners indicated that through their participation in the project they had gained valuable insight into approaches for conducting such an investigation. "Participation in the project has greatly assisted in our understanding of methodologies to conduct such an investigation", said Dr A.G Ponniah, Director of India's Central Institute for Brackishwater Aquaculture. "This will be used in our own institute's work".

Workshop participants indicated that there was an ongoing need for countries and institutions in the region to network, share their experience and research findings and to develop common methodologies to facilitate the integration and analysis of data collected by different research groups. NACA will facilitate further regional research cooperation through its ongoing Climate Change Programme and through formation of institutional partnerships and alliances with like-minded organisations.

The case study reports, policy briefs and other publications from the project will be published on the NACA website in due course. For more information about the project, please visit the Aquaclimate Project webpage at:

http://www.enaca.org/modules/inland-projects/index.php?content_id=10

NACA wishes to express its thanks to NORAD for providing the funding to make this project possible.

Developing climate resilient aquaculture: The Aquaclimate Project

NACA was privileged to have Mr Erik Svedahl, Chargé d'affaires of the Norwegian Embassy in Bangkok, deliver the inagural address to senior policy makers at the Asia-Pacific Regional Workshop on the Impacts of Climate Change on Fisheries and Aquaculture, convened on 16 May in Bangkok, Thailand. Mr Svedahl had some very interesting things to say concerning the need to develop climate-resilient food production systems, which are the subject of NACA's new Climate Change Programme. A transcript of Mr Svedahl's address follows below - Ed.

Country Delegates from the Asia-Pacific region, Partner institutions of the Aqua-Climate Project, Representatives from regional and international organizations, Ladies and Gentlemen, Good Morning.

I am very pleased to be here with you this morning to inaugurate this important regional event.

Fisheries and Aquaculture contribute significantly to the national GDP of many countries across the globe, including Norway. The Norwegian aquaculture industry is a relatively young industry which has evolved during the past 40 years. There has been a continuous growth in production since 1980, and last year the Norwegian production of farmed Atlantic salmon reached almost 1 million tons. The value of the Norwegian aquaculture production now exceeds the value from the fisheries sector and the development of the salmon farming industry is one of Norway's greatest success stories.

Today, fisheries and aquaculture plays a significant role in providing essential nutrients for about 3 billion people, out of which 400 million are in the poorest countries. Despite the significance of these sectors in the global economy and food security, development and sustainability of Fisheries and Aquaculture are facing immense challenges, one of which being the impact of seemingly inevitable climatic variability and change.

Climate change is a growing threat to food security in many regions of the world. Higher mean temperatures and extreme weather events such as drought and flooding, together with the increased prevalence of animal and plant diseases, threaten food production. Areas where food security is already poor and where the population is least equipped to adapt to such changes are particularly hard hit.

One key message that Norway will take to the Rio+20 conference next month, is that climate-resilient food production should be encouraged in both agriculture and fisheries.

The body temperatures of fish and other seafood species vary according to the water temperature. Climate change-induced temperature variations therefore have a strong impact on the growth and reproduction rates of marine species, and consequently on the spatial distribution of fishing and aquaculture activities and on their productivity and yields. Thus, climate change adds a further argument for developing effective and flexible fisheries management systems in an ecosystem context.

Scientific evidence for direct and indirect impacts of climate change on aquatic ecosystems and its effects on aquatic food production systems are now on hand. The two ways of tackling this problem are mitigation and adaptation. Mitigation of greenhouse gas emissions should be done hand in hand with better management of the risks from climatic change impacts and capacity building of individuals, households, communities and nations which enables them to cope with the potential impacts. Many organisations have initiated studies on the impact of climate change on fisheries and aquaculture; FAO, SPC, MRC, SEAFDEC, Asia-Pacific Fisheries Commission (APFIC), World Fish Centre, to name but a few.

The NORAD - MFA - NACA Aqua-Climate Project

The Aqua-Climate Project sponsored by the Norwegian Agency for Development Cooperation (NORAD) and the Norwegian Ministry of Foreign Affairs (MFA) and implemented by NACA and its partners, is probably the first and the most extensive on-site study that has been carried out in the region so far. The Aqua-Climate Project departs from other studies which have not explicitly considered communities and individual famers' adaptation capacities to climate change.

The Aqua-Climate Project revolves around the guiding principle that measures for mitigation and adaptation should be integrated into national economic and social development plans and harmonized at the policy and practical levels with other environmental management and socio-economic development activities. This requires partnerships, capacity building, innovative funding mechanisms and the involvement of a wide range of stakeholders, motivation at all levels, and political will.

The Aqua-Climate project comprises five case studies, which cover several different species, ecosystems, culture systems and social setups. The study sites spans across four countries in the region, namely, India, the Philippines, Sri Lanka and Vietnam.

The targeted beneficiaries of the project are the small-scale fish farmers who are mostly poor people who depend on aquatic resources for their livelihoods. Small-scale fish farmers constitute about 80% of the estimated ten million fish farmers in Asia. They represent a large economic sector in the Asia-Pacific Region and contribute significantly to the regions' food security. Much of the land and water bodies they derive their livelihoods from are marginal, degraded and/or under severe threat of degradation, and are therefore ecologically sensitive and highly vulnerable to climate change impacts. The communities targeted for the study have in general low capacity to cope with natural calamities and economic shocks, have relatively weak resilience, and are less able to protect themselves and their livelihoods from various threats.

Outputs of the Aqua-Climate Project

I understand that during the past two days you had intensive discussions on the outputs of the Aqua-Climate Project. I am very pleased to see the draft outputs displayed and I look forward to receiving a final copy of the report when it is ready.

The Aqua-Climate project has endeavoured to assess the potential impacts of climate change on small scale aquaculture sector in the near and long term in the selected study areas. The focus is on developing realistic future scenarios of impacts of climate change on aquatic resources and to assess the plausible adaptive measures for different aquatic farming systems and suggest appropriate management practices for such systems. Mapping of perceptions, attitudes, and general preparedness of various stakeholder groups – farmers', researchers' and policy makers' – to the looming threat of climate change is the major highlight of the Aqua-Climate Project.

I am very pleased to see on display guidelines for policy makers that will be of significant assistance in framing appropriate regional adaptation strategies and framing of policy. It is my understanding that the project is well poised to contribute to short and long-term adaptive strategy recommendations to address environmental and social changes that are likely to arise from climate change impacts. The project has underscored the need to improve management/governance mechanisms and decision support systems; capacity building; strengthen institutional partnerships and alliances.

I wish to emphasize here the need to continue this type of studies pioneered by the Aqua-Climate Project to better understand and manage the risks from climate change impacts in the region.

The Asia – Pacific Regional Workshop

The primary objective of the Regional Workshop today is to disseminate the knowledge and experience gained in the Aqua-Climate project to a wider community of scientists and decision makers and to strengthen regional collaborations to combat the 'climate challenge' faced by the fisheries and aquaculture sectors.

I am indeed very pleased to see Senior Level Representatives from NACA member countries, Regional and International agencies who have gathered here to share their experiences. The primary objective of this exercise is to place in context the significance of work carried out under the Aqua-Climate Project in relation to other similar studies in the region; and to develop a collective plan of action and approaches to further advance this "nascent" scientific discipline.

This collective plan of regional action should ultimately result in a climate resilient food producing sector, climate resilient aquaculture practices, and farmers' who are better equipped to cope with the vagaries of the climate change impacts.

I wish you all the very best for productive meetings ahead. Thank you.

Emergency regional consultation on shrimp early mortality syndrome, 9-10 August, Bangkok

Recently, an emerging disease known as early mortality syndrome (EMS) in shrimp (also termed acute hepatopancreatic necrosis syndrome or AHPNS) has been reported to cause significant losses among shrimp farmers in China, Vietnam, Malaysia and the eastern Gulf of Thailand. Outbreaks in Vietnam and Malaysia have caused severe economic losses and significantly lowered annual farmed shrimp production.

The disease affects both *P. monodon* and *P. vannamei* and is characterised by mass mortalities, reaching up to 100% in some cases, during the first 20-30 days of post-stocking culture. Clinical signs include slow growth, corkscrew swimming, loose shells, pale colouration and an abnormal hepatopancreas.

This degenerative pathology of hepato-Pancreas is highly suggestive of a toxic etiology, but anecdotal information suggests that disease spread patterns may be consistent with an infectious agent. The primary cause / pathogen (considering the disease to be infectious) has not yet been identified.

Considering the likely threat of great economic loss that EMS will cause in the region's shrimp industry, concerted action by every shrimp producing country in the region is urgently required to prevent the spread and/or occurrence of this disease. Farmers, on the other hand, should be made aware of this threat and requested to cooperate with the concerned agencies by promptly reporting any suspected mortalities among cultured shrimp that appear to be similar to the clinical description of EMS/AHPNS.

Please download the NACA Disease Advisory on EMS for further details about this emerging threat from:

- http://library.enaca.org/Health/DiseaseLibrary/disease-advisory-ems-ahpns.pdf

See also a poster 'Shotgun sequencing of bacteria from AHPNS: A new shrimp disease threat for Thailand', reproduced on the NACA website with the kind permission of Prachumwat et al. at:

- http://library.enaca.org/Health/DiseaseLibrary/ahpns-poster-nru-summit.pptx

Immediate action warranted

As a first step, NACA is widely disseminating a Disease Advisory to Competent Authorities (CA) and concerned stakeholders in member governments urging improved surveillance and reporting efforts on the part of all stakeholders including farmers. Only through surveillance, early response, contingency planning and disease preparedness, can countries minimise the impact of the impending threat.

Regional consultation and contingency planning

Given the serious impact of this emerging shrimp disease, NACA and the Australian Department of Agriculture, Fisheries and Forestry are also convening an emergency consultation to:

- Develop a regional emergency response and contingency plans to contain, control and prevent the disease.
- Improve surveillance, monitoring and reporting arrangements for EMS and a protocol for outbreak investigation.
- Develop a case definition and field level disease information card to improve awareness.
- Coordinate collaborative research to identify the primary causative agent.

The consultation will bring together around 50 people including 10 global shrimp health experts, the competent authorities of regional governments, international agencies such as the World Organization for Animal Health (OIE) and the private sector to develop a coordinated response.

The consultation will include detailed lectures on this emerging disease including gross signs, histopathological characteristics, production losses, suspected pathogens and causative agents, and case studies of outbreaks in affected countries, followed by open discussions. NACA will make audio recordings of the technical presentations available for download and streaming shortly after the consultation, in addition to available technical documentation.

For more information, please download the consultation prospectus from the link below. Enquiries may be directed to Dr Eduardo Leano, Coordinator for Aquatic Animal Health (email Eduardo@enaca.org) and Dr CV Mohan, R&D Manager (email mohan@enaca.org).

- http://library.enaca.org/announcements/2012/ems-prospectus.pdf

NACA wishes to gratefully acknowledge the financial support provided by the Australian Department of Agriculture, Fisheries and Forestry to make this consultation possible. We very much appreciate the timeliness of DAFF's support to the region.

Follow developments on EMS

The outcomes of the regional consultation will be made available at:

http://www.enaca.org/modules/news/article.php?article_id=1952

Audio recordings of the workshop technical presentations will be made available for download.

Regional study/workshop on adoption of aquaculture assessment tools for sustainability

The importance of promoting responsible and sustainable aquaculture practices at national and local levels is widely recognised. Planners, policy makers and manager are expected to consider environmental, social, animal health and welfare and food safety issues among others while developing national programs and activities to promote aquaculture to support rural development and empower small scale farmers. Various aquaculture assessment tools (e.g. import risk analysis, environment impact assessment, residue inspection, process and product certification) have been developed and used to support development of responsible and sustainable aquaculture.

Broadly speaking, aquaculture assessment tools could include methods, guidelines and processes that are used for planning, development, management and decision making. Some could be specific while others more generic. Some tools are guided by international agreements and instruments. Based on purpose, they can be classified as (1) tools for assessing risks in aquaculture (e.g. pathogen risk analysis, food safety risks, genetic and ecological risks), (2) tools for assessing risks in international trade (e.g. import risk analysis), (3) tools for assessing impacts (e.g. environmental impact assessment), (4) tools for assessing governance (e.g. codes of practice), (5) tools for management (e.g. BMPs, GAPs, Certification) (6) tools for socio-economic assessments and so on. Other tools could include communication tools, information tools, guidance tools such as the FAO Code of Conduct for Responsible Fisheries.

However, appropriate use of these tools by relevant stakeholders has been rather limited in Asia Pacific for various reasons. Following the recommendation of the recently completed APFIC regional consultative workshop on "Strengthening Assessments of Fisheries and Aquaculture in the Asia-Pacific Region for Policy Development and Management" (4-6 October 2011, Yangon, Myanmar), FAO, NACA and APFIC are collaboratively organising a regional evaluation study on adoption of existing aquaculture assessment tools. The project will also convene a regional workshop from 3-5 July 2012 in Pattaya, Thailand, to develop a strategy to promote wider application of aquaculture assessment tools in the Asia Pacific.

The specific objectives are:

- Assess the status of the use of various aquaculture assessment tools in selected countries in the region.
- Evaluate the applicability and effectiveness of existing tools for aquaculture development and

management and suggest possible modifications for better applicability in the region.

- Develop 8-10 country study papers and one regional synthesis paper on the application of aquaculture assessment tools.
- Formulate a set of regional strategy recommendations for promoting application of well established aquaculture assessment tools in aquaculture development and management in Asia Pacific through a regional expert workshop
- Produce a FAO/NACA/APFIC publication on the regional study.

Eight to ten countries from the region which are very active in aquaculture development will be participating in the workshop. These countries are Bangladesh, China, India, Indonesia, Malaysia, Philippines, Republic of Korea, Thailand and Vietnam. In addition, Australia and Republic of Korea will be invited to attend the workshop and share their experiences in application of aquaculture assessment tools. In addition to delegates from NACA and FAORAP, experts from FAO Rome, SEAFDEC AQD, WFC and the private sector will be invited to participate.

For more information, please download the prospectus from:

http://www.enaca.org/uploads/temporary/aquaculture-assessment-tools-2012.pdf

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Regional framework for cooperation on climate change

At the recent Asia-Pacific Regional Workshop on Impacts of Climate Change in Fisheries and Aquaculture, held under the "Aquaclimate" project, senior policy makers from the region agreed that a networking mechanism was needed to facilitate sharing of experience and data between governments and institutions.

Climate change is widely seen as a priority issue, particularly for agricultural sectors, which are a significant contributor to climate change impacts, but also highly important in terms of livelihoods and food security. Research activity to address climate change in agriculture is rapidly ramping up, both in terms of mitigating the impacts of farming and in the development of adaptation strategies to help farmers cope with the coming changes.

As climate change is a truly global issue, the development of a networking mechanism, institutional partnerships and alliances were seen as critical elements to a successful response. There was a need to improve communication not only within the aquaculture sector, but also to improve cross-sectoral sharing of information and experience. As research funds within the aquaculture sector are limited, there are significant benefits to be had from coordination of effort. It is also important to develop common methodologies to facilitate the integration and analysis of data collected by different research groups across the region.

NACA has undertaken to facilitate further regional research cooperation through its ongoing Climate Change Programme, which was approved by the 23rd Governing Council Meeting in March. The programme will endeavour to link and establish a network between like-minded organisations working towards sustainable and climate resilient aquaculture. More information about the programme will be posted on the NACA website as it develops.

Audio recordings available

Download or stream the technical presentations from the AquaClimate workshop as mp3 files.

www.enaca.org/modules/podcast

Recordings from other technical workshop are also available. Subscribe to NACA's podcast feed today!

www.enaca.org/modules/podcast/rss.php

Regional proficiency testing for aquatic animal disease diagnostic laboratories

Proficiency testing is an important mechanism for animal health diagnostic laboratories to test and improve their capabilities. Testing conducted by such laboratories helps underpin national health and quarantine programmes, and also plays an important role in facilitating international trade.

Participation in a recognised proficiency testing program is usually a requirement for formal laboratory accreditation. However, there is currently very limited access to proficiency testing programs for aquatic animal health laboratories in Asia. The NACA Regional Advisory Group on Aquatic Animal Health has previously noted that ad hoc proficiency testing programs have been run for a limited selection of diseases and countries, but there is limited or no access to any on-going laboratory proficiency testing programs.

Asia is the largest producing region in the world for aquatic animal products, including more than 90% of global aquaculture production by volume. In response to the need, a joint laboratory proficiency testing programme will be conducted for aquatic animal disease diagnostic laboratories by NACA, the Australian Department of Agriculture, Fisheries and Forestry (DAFF), Australian National Quality Assurance Program (ANQAP), and the Australian Animal Health Laboratory of CSIRO. The programme is funded by the Australian Government, through DAFF.

The objectives are to:

1. Strengthen Asia's regional capability to diagnose important aquatic animal diseases that impact on trade, industry sustainability and/or productivity.
2. Train participating laboratory personnel in diagnostic standards, and proficiency testing procedures, and to provide technical assistance to improve laboratory performance.
3. Establish a laboratory proficiency testing program that meets regional needs and which can be accessed following completion of the project (on a fee for service basis).

This programme will focus on aquatic animal diseases of significance to the Asian region. The program will provide access to proficiency testing services from an accredited provider (ANQAP), which is accredited as a proficiency testing provider by the Australian National Association of Testing Authorities, and will draw on the expertise of the CSIRO AAHL to develop required testing reagents and materials. Participants will include national/key aquatic animal disease diagnostic laboratories of NACA member countries plus two additional diagnostic laboratories with level III (molecular/PCR) diagnostic capabilities.

The first activity of the programme will be a workshop (hosted by NACA) which will be held in Bangkok, Thailand on 25-25 July 2012. The workshop will focus on providing participants with an overview on diagnostic standards, proficiency testing procedures, laboratory accreditation and to reach agreement on the panel of tests to be included in the program. Subsequent to the workshop, appropriate test materials (non-viable pathogen material within an appropriate matrix and at a variety of concentrations) will be developed. Pathogen material will be obtained, purified and rigorous quality assurance procedures followed for preparation of materials for a total of ten priority diseases of crustaceans, fish and molluscs. CSIRO AAHL has the expertise, experience and facilities (including biosecure facilities for processing exotic disease material) to undertake this work.

In years two and three of the programme, at least four rounds of testing will be offered to participating laboratories. The testing rounds will follow National Association of Testing Authorities (NATA) standards and provide participants with confidential reports on their testing proficiency.

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NACA is a network composed of 18 member governments in the Asia-Pacific Region.

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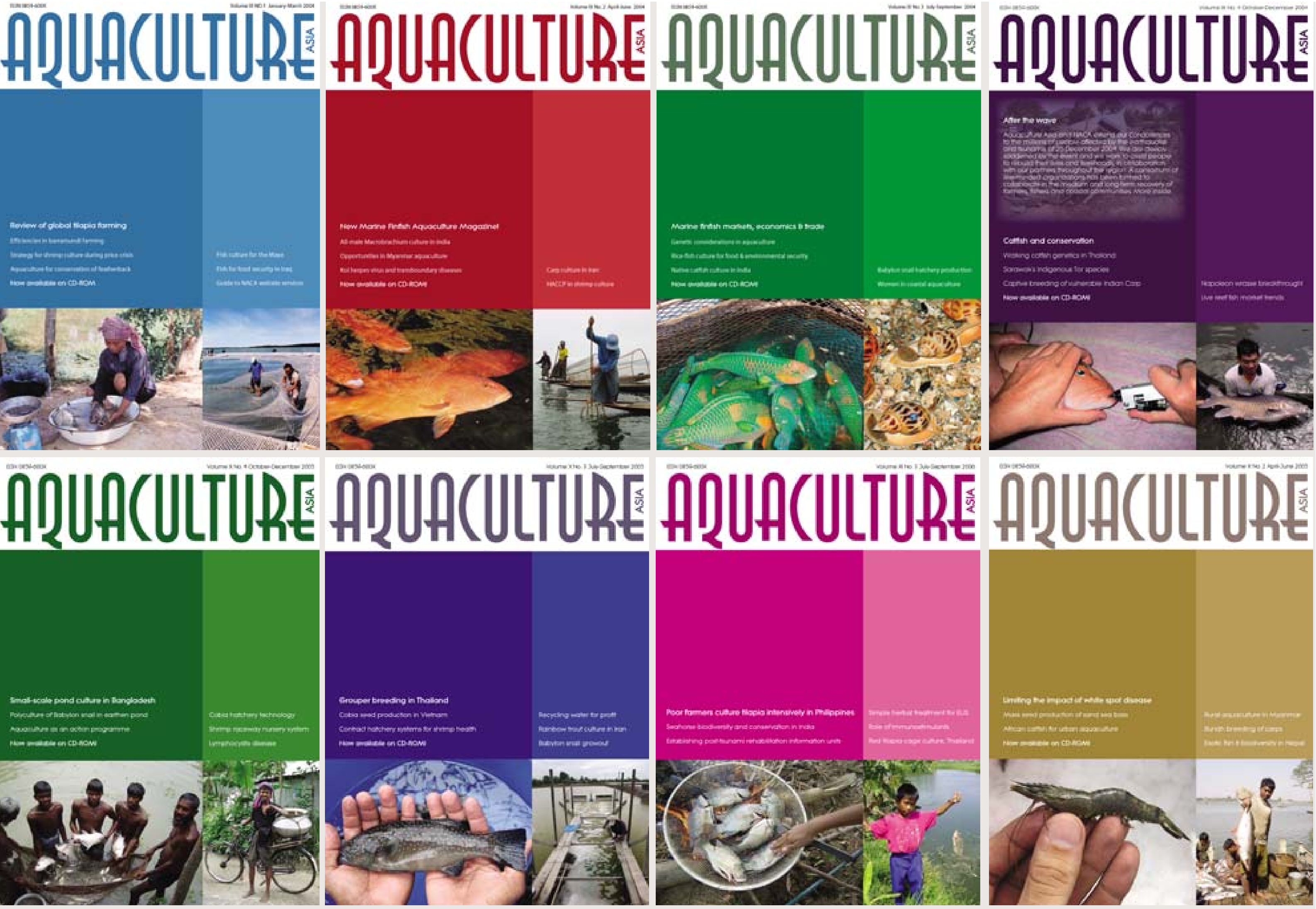

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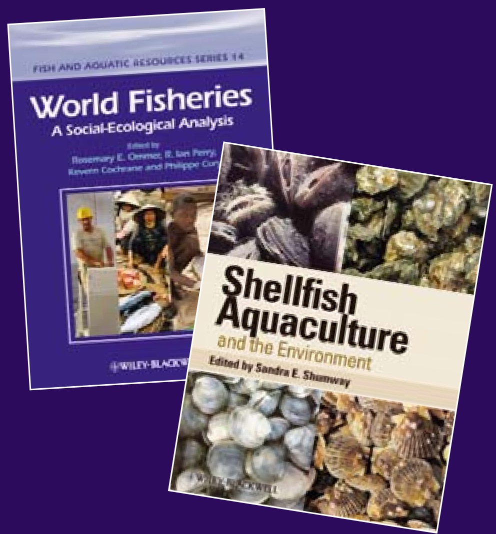

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