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

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Cooperatives: The future of small-scale farming?

Pick any emerging industry you like and consider its development over time. The pattern should be familiar: A few pioneers kick things off and achieve early success. A 'goldrush' ensues with large numbers of entrants piling in chasing (what looks like) easy money. This is followed by a production boom and a price collapse, at which point the uncompetitive tend to go out of business. The survivors pick up the pieces and expand their own holdings, gaining economies of scale. Slowly, the industry consolidates and settles into a new and somewhat less dynamic equilibrium.

This trend of competition and consolidation appears to be an inevitable economic consequence in the development of a new industry. It is, according to popular economic theory, both normal and good, in that it leads to cheaper prices and a higher standard of living for consumers.

The benefits of this cycle to producers are less clear. The social impacts associated with people going out of business are considerable. The price of failure and debt can be high, particularly among poor rural communities where there are few other livelihood options. Asian aquaculture is to a large extent characterised by large numbers of small-scale and frequently poor producers. How can these people compete effectively with larger, more industrialised operations in an increasingly globalised world?

One possible solution is for small scale farmers to emulate the pattern of consolidation through formation of farming cooperatives or 'clusters'. NACA has explored this approach over the last ten years or so, mainly working with small-scale shrimp farmers in India, Vietnam and Indonesia, and more recently with catfish farmers in the Mekong Delta. By working together, small farmers can wield greater market power when buying inputs for their farm or selling their product. They gain economies of scale and increase their negotiating power with government authorities, who find it much easier to deal with organised groups than thousands of individual farmers.

NACA has sought to use cooperatives as a practical mechanism to develop and implement better management practices among small-scale farmers. Many better management practices are things that require neighbouring farmers to coordinate their activities, for example in the timing of stocking, harvesting and discharging water and in obtaining healthy seed. The financial benefits of participating in the cooperative (and the potential impacts of non-compliance on neighbouring crops) result in considerable incentive as well as peer pressure amongst members to follow the cooperative's rules. Such self-regulation is both effective and sustainable when farmers gain a benefit from it.

NACA has recently begun expanding its work on better management practices to cover other commodities in the region including tilapia, snakehead, striped catfish and seaweed. I refer interested readers to the article concerning a project funded by the ASEAN Foundation in this issue.

Simon Wilkinson

AQUACULTURE ASIA

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Peter Edwards writes on

Rural Aquaculture

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The Dedanaw Project

Dedanaw village has extensive rice fields.

Background

Myanmar was hit by Cyclone Nargis in May 2008 with winds of 190km/hour and an enormous sea surge. It destroyed houses and even whole villages and caused massive flooding with an officially estimated death toll of 140,000 people and the livelihoods of 2.4 million people seriously affected. I outlined issues relating to small-scale aquaculture in articles in previous columns ('Myanmar revisited' in the January-March 2009 issue and 'Small-scale aquaculture in the Ayeyarwady Delta' in the April-June 2009 issue). Many agencies have been working since the disaster on the emergency distribution of food, non-food items and providing shelter, agriculture inputs and medical care to the victims in the affected areas to reduce their vulnerability and dependency on foreign food aid.

Among them the Ever Green Group (EGG), Social Enterprise Partnership for Development, a local NGO, has been facilitating the early recovery of the livelihoods of suffering families. EGG has a housing support project in Dedanaw village, Kungyangon Township, Yangon Division in the upper Ayeyarwady Delta about three hours drive south of the capital city Yangon and through this project we came into contact with small-scale fish farmers there. Following my second visit to the village I recommended that assistance be sought to help farmers to restart the aquaculture component of their livelihood portfolio. Staff from the national FAO office in Yangon, including those from the Emergency Rehabilitation & Coordination Unit (ERCU) set up to help Nargis victims subsequently visited the village and expressed interest in supporting the recovery efforts.

The Chairman of EGG, Zaw Zaw Han, submitted a proposal to FAO, Yangon, 'Recovery Assistance for Small Scale Aquaculture Project, Dedanaw Village, Kum Gyan Gone Township' which was subsequently funded by SIDA through FAO and implemented by EGG. The project with a modest budget of US$20,000 is being run from April 2009 to April 2010 and the beneficiaries are 27 small-scale farming households. I was invited by EGG in January 2010 to review the progress of the project and to suggest how to move forward which form the topic of this issue's column.

Dedanaw village

The village like most of the Ayeyarwady Delta comprises mostly extensive rice fields dissected by canals. There are a total of 700 households, 150 of which farm rice with the majority being landless, a typical pattern in the Delta. Fish farming was an established activity in Dedanaw village prior to the Cyclone with the knowledge of how to farm fish obtained by farmers from Twante, the major aquaculture area in the country to the west of Yangon. About 50 farmers in the village had constructed ponds in rice fields, dug with both family and hired labour, mostly initially to provide a source of water for domestic use and for watering rice seedlings but wild fish which entered unaided were harvested. Most of the ponds were dug about 10 years ago but the Government banned conversion of rice fields to fish ponds as discussed in my two earlier columns. Most of the ponds are not used today for domestic water as the water supply has been improved so most are abandoned ponds and used only to harvest wild fish.

On a previous visit to the village I was told by a villager that there were only four fish farmers in the village so imagine my surprise when I was later informed that 27 farmers are being assisted through the project to restart or develop pond aquaculture. On my latest visit I asked the same farmer about this apparent discrepancy and was told that the previous low number was that of farming households for which aquaculture had been a significant practice before Nargis. However, 27 farmers had renovated their derelict or idle fish ponds as the project provided them with assistance to get restart farming fish. Cyclone Nargis had flooded the village and washed away stocked fish and in some cases damaged the pond dikes. The rice farming villagers' first priorities following Nargis were to repair houses and to re-establish rice production, their major livelihood. Before the implementation of the project the fish farmers in the village had been unable to restart their fish culture businesses as they lacked funds for the start-up costs.

Large cattle introduced by the British over a 100 years ago to pull their cannon but used today to plough rice fields. Their manure is used to fertilise crops.

The project

The project is being coordinated by Zaw Zaw Han, Chairman of EGG. The technical aspects of the project were designed by Htin Aung Kyaw, National Consultant for ERCU, an Asian Institute of Technology (AIT) alumnus. Excellent advice on how to execute the project was provided by Rick Gregory, Fisheries Advisor for FAO, one of whose previous positions was Director of the AIT Outreach Program in Cambodia. Regular monthly supervision, monitoring and data recording of types and amounts of pond inputs and growth of stocked fish are being carried out by Win Maung Kyaw, Technical Specialist assisted by Ko Naing, a village farmer who serves as village-level Extension Agent.

U Aung Sint the first rice farmer to build fish ponds in the village on swampy land unsuitable for rice more than 25 years ago.

The main project objective is to restart aquaculture as a livelihood for rice farmers in Dedanaw village. The 'traditional' fish species cultured in freshwater in Myanmar are the Indian major carps (IMC) (mainly rohu with much smaller numbers of catla and/or mrigal) and common carp. As IMC grow well in relatively large ponds such as the 1-2 acre (0.4-0.8 ha) ponds owned by many farmers, the culture of the smaller and shorter life cycle species Nile tilapia was introduced for the many smaller ponds less than 1 acre (0.4 ha) in size. Nile tilapia is also a more appropriate species for the poorest rice farmers. This project is thus demonstrating how to farm the smaller Nile tilapia and is providing an opportunity to compare first hand their established carp culture system with that of the novel culture of tilapia.

Twenty seven fish farmers are involved in the project with a total of just over 50 acres (20 ha) of ponds. It is expected that over 50 tonnes of fish will be produced which will improve the nutrition of fish farming households as well as that of the local community as well as provide income for the fish farmers.

Project experiences are being documented and will be circulated to other organisations.

U Win Maung Kyaw project Technical Specialist (left) and Mrs Ki Ti Aung (right) a project farmer.

Approach

EGG followed a farmer field school type of approach to working with the fish farmers that involves training and communal learning through regular experience-sharing opportunities. Field sessions involved test netting and technology demonstration and are facilitating discussion of the performance of carp and tilapia fish culture systems.

The first project activity was to form a fish farmers group with a Chairman and Secretary and it is being encouraged to meet on a regular basis. Training was provided on a range of topics during alternate months through the first 8 months of the project, starting with pond preparation and stocking in June 2009. Three one day long training sessions were held for the farmers on pond fertilisation, general grow-out and tilapia nursing and grow-out. The stocking of the fish ponds required a high level of cooperation between the farmers. It was important that stocking took place early in the wet season (June-July) before predatory fish species had a chance to repopulate the prepared ponds.

The project provided diesel for the farmers to pump water into their ponds.

Feeding rice bran which was not provided by the project.

It was explained to the Dedanaw village farmers at the outset that the Project would not pay for draining their ponds, removing excess mud and aquatic weeds which filled most of the ponds, or repairs to the dikes. Only ponds that had a high and complete dike and which had been drained, de-weeded and had predatory fish removed would be eligible for project support. The costs of these operations were to be met by the fish farmers themselves. The Technical Specialist verified the status of each pond to prevent fish seed from being wasted through stocking in under-prepared ponds. The project provided lime for pond preparation, diesel to cover the costs of pumping water to fill the ponds prepared for stocking fish, fish fingerlings and the initial fertilisation of the pond to create productive conditions for stocking. The farmers were told that only when their pond was predator-free and potentially productive would free fingerlings be provided through the project. This strategy served to separate out the approximately 50% of the farmers in the village with abandoned ponds who would only be interested in a 'free ride' from those willing to devote their own limited resources to ensuring that fish farming would be successful.

The project agreed to restock at least one pond of each of the 27 fish farmers in the village who prepared their ponds for stocking. Farmers also selected the type of fish culture that they wished to conduct. They were given the choice of stocking rohu or tilapia. Farmers with both large and small sizes of pond could choose to stock both rohu and tilapia, respectively. The procurement and distribution of fingerlings obtained from Khayan, the main seed producing area of the country, was be done by the project Technical Specialist.

Farmers were provided with 10-12.5 cm carp rohu fingerlings, and/or 2.5-3.75 cm tilapia fingerlings which they were taught to nurse in a hapa suspended in the pond for 1 month to reach a size of 5.0-6.25 cm before they were stocked in the pond at a density of 0.5 fingerlings/m^2 for rohu and 3.0 fingerlings/m^2 for tilapia.

Farmers were provided with free chemical fertilisers to use in their ponds at the rate of 24.6 kg urea and 6.2 kg TSP/acre (0.4 ha)/2 weeks based on recommendations from the USAID-funded CRSP project based at AIT. No feed is being provided by the project as the farmers agreed to provide supplementary feed themselves for the fish.

No other inputs were provided under the project following stocking the ponds to increase the likelihood of sustainability at the end of the project. Farmers have to provide their own fertiliser and feed. Integration with existing livestock, especially ducks, was encouraged to provide manure to fertilise the ponds. One large high-quality seine net was provided to the fish farmer's group to facilitate harvesting fish by group members.

Figure 1. Gantt chart of project activities, July 2009-February 2010.

Activity	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1. Formation of fish farmers group	●								
2. Training course on preparation and stocking	●								
2. Preparation of fish ponds and verification	●								
3. Purchase and stock of fingerlings		●	●						
4. Training courses and farmer field schools		●		●		●		●	
5. Harvesting of fish begins									●

Findings

I visited 9 project farms with ponds, a third of the project total of 27 farmers. The farmers unanimously expressed satisfaction with, and appreciation of, the benefits provided by the project. However, most commented that the fish were not growing fast enough as their ponds required more fertiliser and supplementary feed that they could afford to purchase.

One farmer said it was possible to borrow money to buy more fertiliser and feed but at an interest rate of 5%/month, equivalent to an exorbitant rate of 60%/year; and this is probably only half the rate at which some farmers would be able to obtain credit from loan 'sharks'. Future projects as advised by one of the farmers should either loan the farmers fertiliser and feed to be repaid after final harvest and sale of fish; or provide low-interest credit.

According to detailed project records 23 farmers had a total of 33 ponds ranging in size from 0.1-4.0 acres (400m^2 – 1.6 ha) stocked with 10-15 g rohu in July 2009 that ranged in average size from 35-290g by December 2009, 160 days after stocking. Furthermore, 5 farmers, some of whom had stocked one or more ponds with rohu, opted to stock monosex tilapia in a total of 6 ponds ranging in size from 0.2-0.8 acres (800-3,200m^2) with 0.4g fingerlings in July 2009 and they had grown to an average size of 80-120g by December 2009, again 160 days after stocking.

The considerable range in fish growth was mainly due to variation in amount of fertiliser and supplementary feed used by individual farmers. Remember that the farmers were only given free fertiliser and not feed, and fertiliser was provided weekly only for the first month after stocking fingerlings although the initial dose was at double the weekly rate. Only about 25% of the farmers continued to fertilise their ponds when they had to purchase their own fertiliser. Some farmers also purchased rice bran as supplementary feed but usually insufficient to maintain high fish growth.

The farmers were unaware and were pleasantly surprised that chemical fertilisers could be used in fish ponds as their only previous experience had fertilising rice. Traditionally the farmers used mainly rice bran and occasionally oil cake as pond nutritional inputs.

The growth performance of tilapia was relatively higher and less variable than rohu which probably also reflects the selection of the new species, tilapia, by more adventurous and conscientious farmers.

Two of the farms visited had ducks which at the time of the visit were scavenging for food in the rice field. Partially housing the ducks over the fish pond is an effective way to fertilise the pond as one of the farmers with 170 ducks housed at night over a 0.3 acre (0.12 ha) fish pond or a duck stocking rate of about 12,000 ducks/ha had green pond water and the best growth of rohu among project farmers.

Some of the farmers had purchased and stocked a few grass carp to control vegetation in the ponds. Grass carp were smaller than rohu when stocked but after a few months were much larger in size.

Their degree of involvement in rice farming varied. Of the six farmers I enquired about their rice holdings, one household had none, a second only 2 acres (0.8 ha) and the other three sizable rice holdings of 14-23 acres (5.6-9.2 ha).

I reported on the only project family without a rice field in my two previous columns on the Delta. During my first visit all their fish had been washed out of their three 500 m^2 ponds on their 2 acre plot of land (0.8 ha) and their house had been destroyed by Nargis so they were living in a temporary

Feeding baskets.

Plankton-rich green water from partial confinement of ducks over the pond during the night.

Sampling rohu.

dwelling. At the time of my second visit Mr Hla Min who is a bus conductor and seasonal farm labourer and his wife Ki Ti Aung had rebuilt their house but still had insufficient money to purchase fish seed and feed and be able to restart the fish farming part of their livelihood portfolio. By the time of my visit this January the project had helped them to restart aquaculture. They had stocked two ponds with rohu and one pond with tilapia and were feeding rice bran as well as fertilising once/month. Mrs Ki reported that the main thing the project taught them was pond fertilisation which reduced the need to purchase costly rice bran.

In my previous column on small-scale aquaculture in Myanmar I reported on and photographed a landless family excavating soil from a 'borrow pit' on their small plot of land to raise the level of the house. The borrow pit could have been used as a fish pond but project staff informed me that the family was not interested in joining the project. This underscores the fact that it is difficult for the poorest households to spend their very limited resources on farming fish.

Ducks scavenging for feed during the day in the rice field.

A 350 g rohu from a well-managed project pond.

Feeding rice bran which was not provided by the project.

Sampling tilapia.

A 100 g tilapia from a well-managed pond.

A large abandoned pond.

The farmer who had only 2 acres (0.8 ha) of rice fields had three ponds with a total area of 3.1 acres (1.2 ha). He used to raise chickens and fish but they were both washed away by Nargis. Now he is developing fish culture as his main business. He inherited the land but worked as a rickshaw driver until he had saved enough to invest in poultry and fish.

I also observed a large abandoned fish pond of 3.5 acres (1.4 ha). When I enquired why such a resource was not being used to culture fish I was told that it belonged to a better-off rice farming family who also have 20 acres (8 ha) of rice fields. The farmer and his wife are getting on in years and their grown-up children have left the farm and are not interested in fish culture.

Some of the larger fish, some faster growing rohu and grass carp, had already been seined out and harvested in December after 5 months of growth. They were able to sell 350g rohu for kyats 1,700/viss (1.6 kg) or about US$1/kg.

I was told that the farmers had organised themselves into six farmer groups rather than one, each with a leader, to avoid problems, especially staging fish harvests to avoid flooding the local market with fish, thereby lowering the price. Clearly the project is working well and farmers reported that they would be able to continue farming fish without further support at the end of the project.

Rationale and future

The project was conceived as a pilot to provide learning opportunities within Dedanaw village for both farmers and project staff, with the intention of extending the experience later within Dedanaw Village (witnessing the success of the project should lead to interest by some of the other farmers in the village with abandoned ponds to farm fish), elsewhere in the Delta and in other areas in the country. Efforts are currently underway to locate other villages with abandoned fish ponds in the Delta and funding will be sought to replicate the successful project experience in other villages.

I also visited Khayan, the major fish seed producing area in Myanmar, to investigate the availability of seed for future expansion of aquaculture in the Delta. I was informed by U Aye Ko, the Leader of the Khayan Fish Farmers'Association that they would be able to supply sufficient fry and/or fingerlings. The total seed production last year was 1 billion 3cm and 700 million 10-15 cm fingerlings. They sell seed to nursery and grow-out farms throughout the country.

A small abandoned pond.

Many families depend on small-scale aquaculture in Yangon Division and northern Ayerwaddy Division and there is considerable potential for this activity to spread to new areas, particularly those with less than abundant wild fish stocks. In some areas, aquaculture is an important means of food and income generation, as well as providing significant employment opportunities for casual labourers. Very few organisations to date have supported the rehabilitation of small-scale aquaculture in Nargis affected areas although several have shown an interest in piloting aquaculture approaches.

As there is considerable wild vegetation on and around farms, grass carp should be stocked also in the ponds in polyculture with either carps or tilapia. Grass carp stocked at 12.5 cm can control growth of vegetation in the pond and after only 6 months is large enough to be harvested.

To maximise profit in fish culture it is necessary to effectively use pond space and volume by stocking large fingerlings in the grow-out phase, as was done in the project. However, some farmers should be taught how to nurse fry to fingerlings, perhaps in hapas suspended in the ponds as most of the ponds are too large to be prepared for nursing by small-scale farmers. As well as it being easier and cheaper to transport fry than fingerlings from the main seed producing area of Khayan near Yangon to the Delta for grow-out, nursing fry to fingerlings would thus become a livelihood option for some farmers.

The changing face of women for small-scale aquaculture development in rural Bangladesh

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Bangladesh is considered one of the most suitable countries in the world for freshwater aquaculture, because of its favourable resources and agro-climatic conditions. A sub-tropical climate and vast areas of shallow water provide ideal conditions for fish production. Over the last decade, there has been a dramatic increase in inland freshwater aquaculture production in Bangladesh, growing at an average annual rate of nearly 20%[1]. Around 400,000 ha of freshwater ponds and ditches are used for aquaculture and more than 900,000 households are involved in aquaculture activities[2]. Conditions are highly favourable for the rapid expansion of aquaculture. This is mainly due to the recent rapid advances in seed and feed production. The total annual fish production in Bangladesh was estimated at 2.44 million tons in 2007 of which 945,812 tons (39% of the total production) were obtained from freshwater aquaculture[3]. The main production systems for freshwater aquaculture in Bangladesh are extensive and semi-intensive pond polyculture of Indian major carps and exotic carps which accounts for 80% of the total freshwater aquaculture production. The remaining 20% are mainly from prawn, catfish, tilapia, small indigenous fish and rice-fish farming[2].

It is changing the face of rural Bangladesh through small-scale aquaculture development, and a large number of rural women are involved in various aspects of aquaculture activities. Traditionally, the work of women in rural Bangladesh is mostly confined to the homestead due to cultural, religious and social restrictions. Generally, household management in rural communities vest in the male head of the family and female members of the family depend upon the earnings of men. As such, almost all economic decisions are ordinarily done by men. There have, however, been more recent changes in the attitude of the people towards the role of women in various aspects of household decision making, household management, economic decision and income generating activities[4], and a number of activities associated with freshwater aquaculture increasingly involve women. The women have been involved in small-scale aquaculture in different stages of operation. They are active caretakers of fish in homestead ponds, nurseries, cages and even in rice fields. Despite the fact that their role in aquaculture growth has not been sufficiently recognised and remains inadequately addressed. It is therefore necessary to understand related issues and develop gender sensitive interventions in aquaculture for their empowerment.

This study seeks to broadly understand the role of women in small-scale aquaculture. It is assumed that women's empowerment can be enhanced through their active participation in aquaculture. The aim of this paper is therefore to describe linking women's empowerment and their participation in aquaculture. This description is based on published sources, together with the results of primary data collected in rural Bangladesh.

Methodology

The study was conducted in the Mymensingh area of north-central Bangladesh. Geographically, Mymensingh has been identified as the most important and promising area for freshwater aquaculture because of favourable resources and climatic conditions, including the availability of hatchery-produced fry, low-lying agricultural land, pond, warm climate, fertile soil, and cheap and abundant labour. The soil, water and climate support high levels of aquaculture production, and thus, about 40% of the country's aquaculture production comes from the greater Mymensingh area[5]. Small-scale freshwater aquaculture has benefited especially from sustained efforts in a major long-running development project, namely Mymensingh Aquaculture Extension Project (MAEP) - funded by Danish International Development Assistance. A large number of farmers including women received training in fish farming through MAEP. As a result, there has been a dramatic increase in fish production over the last few years.

A wide range of tools can be used for data collection to obtain a broad and in-depth understanding of women's participation in aquaculture. A combination of participatory, qualitative and quantitative methods were used for primary data collection (Figure 1). Data were collected for a period of six months from July to December 2007. The participatory rural appraisal tool focus group discussion (FGD) was conducted with women farmers (i.e. farmers' wives). A total of 20 FGD sessions were conducted in Phulpur sub-district under Mymensingh district where each group consisted of 8 to 12 women (total 192) and the duration of each session was approximately two hours. FGD was used to solicit an overview of women's participation in small-scale aquaculture activities. Questionnaire interviews with women were preceded by preparation and testing of the questionnaire and training of enumerators. A total of 100 women were interviewed in their houses and/or farm sites. Women were selected through simple random sampling. Several visits were made to selected women for observation of aquaculture practices. The interviews, lasting about an hour, focused on their involvement in aquaculture activities, constraints and socioeconomic benefits. Cross-check interviews were conducted with 20 key informants, including district and sub-district fisheries officers, local leaders, school teachers, researchers, policymakers and relevant non-government organisation (NGO) workers for the validation of collected information. Data from questionnaire interviews were coded and entered into a database system using Microsoft Excel software for analysis using SPSS (Statistical Package for Social Science) to produce descriptive statistics.

Carrying fish feed from the market.

Feeding the fish.

Helping with the harvesting.

The role of women in aquaculture

In the study area, the women are involved in various facets of aquaculture activities, including stocking of ponds, feeding of fish, pond management, fertilisation, liming, and

A girl with harvested fish - high value prawn (Macrobrachium rosenbergii).

fish harvesting and marketing. Based on a sample of 100 women farmers, it was found that women were involved in aquaculture activities with various degrees of participation (Table 1). According to the survey, the majority of women were regularly involved in feed preparation, feeding of fish, fertilisation, pond supervision and management, and fish harvesting. In general, women provide partial assistance to men in pond supervision and management, by applying feed,

A baby girl sorting fish with her father (today's girl tomorrow's woman fish farmer).

Aquaculture has improved economic power of rural women.

Aquaculture income has improved drinking water facilities.

lime and fertiliser. Most women reported that they managed the pond regularly in two ways: first, most routine operations such as fertilisation and feeding could easily be managed by women, and second, husbands were often busy in other work, away from the home for long hours, and hence the wife had to take the lead role in day-to-day operations. In several cases, harvest of fish for family consumption is done by women with the help of children. Husbands only help when they are at home or when the ponds water is too deep, requiring more specialised gear to be used for fish harvesting. Nevertheless, harvesting of fish for marketing is done by men with commercial harvesters. In that case, women are involved in post-harvest handling including sorting, grading and washing of fish.

Although the women are involved in various aquaculture activities, their participation has been generally limited to fish stocking, transporting and marketing. Men are generally involved in buying of fish fingerlings from hatcheries, stocking ponds and transporting harvested fish to markets. Nevertheless, some advanced women noted that they bought and transported fish feed, fertiliser and lime from markets, which is half a mile to three miles distant from their houses. According to key informants, the women are now more active in many aquaculture activities those were not previously involved.

According to the survey, fish production (an average 4,500 kg/ha/year) has increased 10-20% due to involvement of women. Job opportunities for women have increased since widespread of small-scale aquaculture in the Mymensingh area. The rapid development of the freshwater aquaculture industry has provided employment opportunities for women,

Icing of fish by a young girl.

meaning that they are now able to contribute to household income. Even women from the poorest households often work outside the home as paid labourers in fish hatcheries and fish feed industries for their family survival. A few women are involved in weaving fishing nets, a traditional occupation of women. These nets are used for fish harvesting, which has generated increased demand for nets. The result increase in the price of nets has increased their earnings.

Almost all interviewed women stated that small-scale aquaculture activities had increased their workload. The study revealed that women's average daily involvement in fish cultivation was 3.5 hours, ranging from 2 to 6 hours. The women were engaged in aquaculture activities for an average of 27% of their total daily working hours. The women stated that they would like to spend more time in aquaculture because of the high economic return. However, the main constraint was their household work obligations. Based on respondents' descriptions, a woman's day typically begins with cleaning the house; from the morning until late at night she has to wash dishes and clothes, cook food, look after children, carry out homestead gardening, poultry rearing, livestock feeding, fish farming and other agricultural works.

The women's involvement in aquaculture activities is further explored by examining correlations between their human capital and working hours (Table 2). The analysis shows significant positive correlations between involvement in aquaculture and age of women, education level, farming experience and training received. The analysis finds that the age of women is the weakest relationship to involvement in aquaculture among these capitals. In turn, there is a strong positive association between training received and aquaculture participation, followed by education level and farming experience. Nevertheless, there is a negative association between family size and women involvement in aquaculture, valued at - 0.37, significant at the 10% level.

Working together in fish harvesting.

Women come forward to participate in development activities outside their homestead.

Rural women are typically involved many household works beside aquaculture.

A girl with harvested vitamin-A enriched mola fish (Amblypharyngodon mola).

Table 1. Degree of participation by women in various aquaculture activities (n = 100).

Activities	Regular participation (%)	Irregular participation (%)	Seldom participation (%)	No participation (%)
Fish stocking	12	23	56	9
Feed preparation	67	28	5	0
Feeding of fish	82	12	6	0
Fertilisation	53	29	12	6
Liming	36	42	12	10
Pond supervision	55	41	4	0
Harvesting	62	21	12	5
Marketing	4	11	48	37

n: sample size of women farmers

Linking participation and empowerment

The role of women in small-scale aquaculture related activities is potentially very important for their empowerment. A conceptual framework has developed to show linkage between the participation of women in aquaculture and their empowerment (Figure 2). The women involvement in aquaculture provides three basic improvements: economic, nutritional and social benefits, those are assumed to be interlinked in order to empower women. The households of women have improved their income through increased profitability in fish farming. According to the survey, almost all women reported that they have improved their socioeconomic conditions through involvement in aquaculture activities. Such improved conditions can be described on the basis of qualitative indicators, including food consumption, sanitary and drinking water facilities through tube-wells, improvement of housing structures and children education. Study results suggest that women have broadly improved their standard of living, purchasing power and ability as an economic actor. Women respondents cited several examples of how the standards of living of their families have improved since their participation in aquaculture. Most households reported that they have improved their housing conditions, nutritional benefits, health and sanitary facilities, drinking water facility, children education and recreational items including cell phone, television and radio. Income from fish production offers to engage women in poultry farming, livestock rearing and homestead gardening to supplement their income. Income also provides the opportunity to increase security for coping with uncertain situation, such as illness of household members and natural disasters (i.e. floods, heavy rain and cyclones).

Trading fish at an urban market.

It is recognised by the family and society that women play a significant role in small-scale aquaculture development in the study area. Aquaculture activities of women at village level have enhanced their position in families. Almost all women interviewed noted that their position has improved due to such involvement. They now tend to play a stronger role in economic decisions for the management of their households, including those concerning education of children, attending social functions, inviting guests and attending religious functions. Women's participation in aquaculture has changed the attitudes of family members, including their husbands, mothers-in-laws and other female relatives as their aquaculture activities willingly offer help in meeting their household responsibilities because of increased income through increase fish production. During field visits, it was observed that improved women's status has improved child nutrition because women with greater status have better nutritional status, are better cared for themselves, and provide higher-quality care to their children. According to key informants, the participation of women in aquaculture has increased rural women's mobility and access to markets. They can also get access to better health services, educational opportunities and financial services.

Women's empowerment: Reality or dream?

The empowerment of women could be the principal strategy to upgrade their status. The most effective ways of empowering rural women and enabling them to move out of poverty will depend on local economic, cultural and political conditions[6]. Moreover, women's empowerment depends on a range of factors including psychological, cognitive, economic, social and political dimensions[7]. Women's empowerment may give them greater equity, mobility, more control over resources and political awareness, and thus, reduce incidents of domestic violence[8,9]. The empowerment status of rural women in Bangladesh can be significantly improved by increasing their involvement in income generating activities including aquaculture[10]. Nevertheless, the participation of women in different aspects of aquaculture activities is strongly affected by social, cultural and religious norms. Due to rapid development of small-scale aquaculture in rural Bangladesh, the women are now breaking through the traditional norms and coming forward to participate in the development activities outside their homesteads.

Access to aquaculture resources is one of the elements of women's empowerment. Resources may be economic (e.g. pond, land and credit), political (participation in local government and community decision-making) and social (education and training)[11]. Poverty alleviation in rural areas is significantly related to women's increased access to productive resources[12]. Access to productive resources for women enhances knowledge on farm management and income generation, develops bargaining and decision making power, improves children's schooling and health, increases self-confidence and social networks[13,14]. Rural women's empowerment can be enhanced through forming social capital by various development activities which could increase productive resources under women's control[11]. The women

Table 2. Human capital of women and correlation to participation in aquaculture.

Variable	Measure	Mean value	Correlation (r value)
Age	Years	32	0.34**
Literacy	Percent	29	0.65***
Family size	Persons	5.8	- 0.37*
Farming experience	Years	5.2	0.59**
Training received	Percent	17	0.71***
Single (*), double (**) and triple (****) denote significant at 10%, 5% and 1% levels, respectively			

Table 3. Strategies for empowering women to be actively involved in aquaculture activities.

Key Strategies	Women's empowerment
1. Education	Increase overall knowledge, help decision making, control over resource, more involvement in economic activities including aquaculture
2. Training	Increase technical knowledge on aquaculture, help farm supervision and management, increase farm production
3. Awareness	Self-confidence in aquaculture activities, motivation and inspiration to active participation in aquaculture
4. Credit	Widen economic activities in aquaculture, help to gain independence and improve social status
5. Information	Poverty alleviation through aquaculture, sustainable livelihoods in aquaculture and other income generating activities, human rights, etc
6. Group formation	Participation in local institutions and political process, exchange and sharing knowledge, conflict resolution, bargaining power and gaining freedom

Figure 1. Methodology followed for field works, data collection and data analysis.

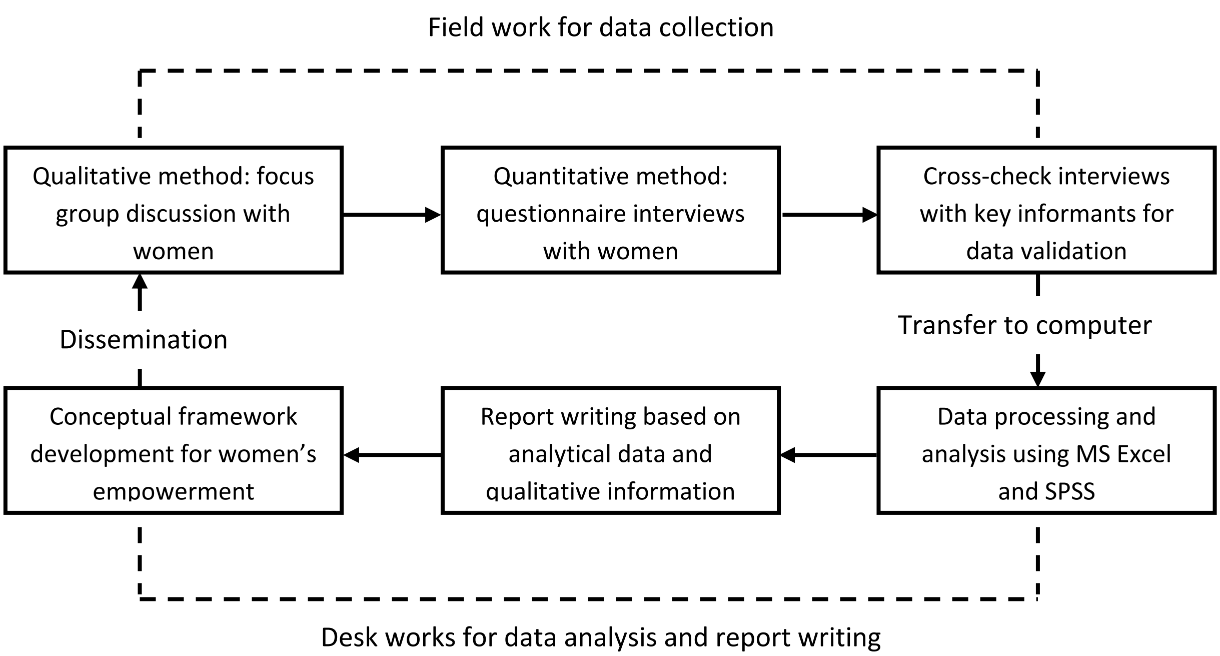
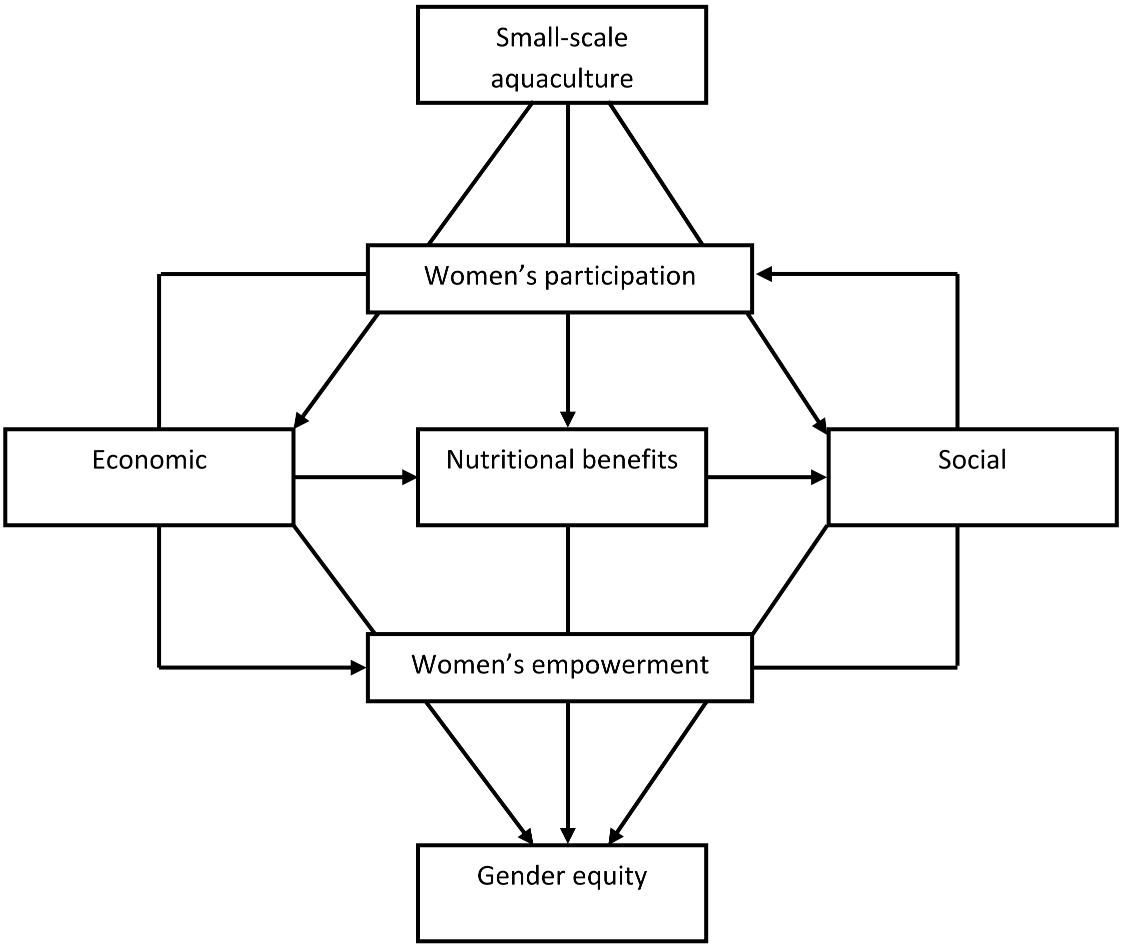


Figure 2. A conceptual framework for empowering women through their participation in aquaculture.



of rural households negotiate their livelihoods by obtaining access to land, pond, labour, capital, knowledge and market, which leads to enhance family well-being and sustainable use of resources[15].

While there is great potential for increasing family incomes through engaging in aquaculture activities by women, a number of factors might constraint to their active involvement. Despite their tremendous contribution to fish production, rural women are underestimated and overlooked in development strategies. Although women and men are by constitution equal in Bangladesh, the reality is different. There is a gross disparity between women and men in every sphere of life. The underlying problem lies in the sexual division of labour, in which females perform mainly unpaid labour in the home and males perform largely paid labour outside the home. Moreover, the lack of technical knowledge in aquaculture, heavy household tasks and socio-cultural constraints such as mobility restriction hinder women's participation in aquaculture activities. As a result, the level of participation in aquaculture by women in general remains below expectation. There is therefore huge scope to involve women in aquaculture. The active participation of women would have a crucial and positive impact on the social and economic well-being that will ultimately help in reducing poverty and empowering them. If the status of men and women are equalised, women may be empowered, and thus, women's empowerment may operate for improving household incomes through involvement in aquaculture activities. Table 3 provides some of the strategic measures for empowering women through their involvement in aquaculture activities.

Conclusions

Increased economic activities leading to income generation opportunities for the rural women are the most important benefits that have resulted from small-scale aquaculture development in rural Bangladesh. Women's growing participation in aquaculture has been a significant indicator of increased empowerment at the household level as well as society. With increased participation in aquaculture, women's socioeconomic conditions within the households and communities have risen significantly. This has begun to change giving women increased decision-making power on household management and income generating activities. However, poverty reduction should be prioritised in the government's intervention programmes for women's development based on dignity and equality to reduce gender discrimination as poverty is the main cause of disparity. With poverty very much a rural phenomenon, women's active participation in aquaculture is crucial to facilitate economic growth and reduce poverty in Bangladesh.

There is much scope for increased participation of women in aquaculture production. Education, training and capacity building are necessary for empowering rural women. Training might increase their knowledge and skill and may create opportunities of employment and increase income earning for improving their participation in the family decision making process which in turn empower the rural women in their family and society. With the support of local and national governments, NGOs and international organisations, the participation of rural women in aquaculture can be increased through well-planned projects which put emphasis on manpower development at the grassroots level. It may also necessary to establish institutional and policy support, financial support as well as extension services to women for active participation in aquaculture activities.

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Strengthening capacity of small holder ASEAN aquaculture farmers for competitive and sustainable aquaculture

Globally aquaculture is recognised as the most rapidly growing food production sector with an average growth of 8%. More than 90% of the global aquaculture production is contributed by Asia and more than 90% of this production is reported to be produced by the small scale aquaculture farmers. However, globalisation is changing the way commodities are traded and small farmers are largely unorganised, sometimes being illiterate or not adequately literate enough to deal with the increasing restrictions being imposed, they are confronted with many challenges. The ASEAN foundation has the mission of helping farmers of ASEAN countries to improve their livelihoods by improving not only husbandry practices, but also enhancing their entrepreneurship that would help them to improve their livelihoods.

In ASEAN countries, aquaculture is an important activity and millions of small farmers are engaged in this activity to earn their livelihood. Fish being a major animal protein source in ASEAN countries, greater importance is attached to ensure healthy fish and its products availability to all sections of the population. Recognising the importance of aquaculture in the region the ASEAN Foundation has supported the project "Strengthening the capacity of small holder ASEAN farmers for competitive and sustainable aquaculture" through NACA to accomplish the ASEAN vision of 2020. The project has the objectives to improve the competitiveness of ASEAN aquaculture small holders in the domestic, regional and global markets, to improve sustainability of their farming systems, to make them adopt responsible farming practices and improve their profitability.

Five ASEAN countries, namely, Cambodia, Indonesia, Philippines, Thailand and Vietnam were chosen as the representative countries for implementation of the project. Following the inception workshop, based on the interest expressed by each of the countries, following five commodities have been chosen in five different countries

In Cambodia, snakeheads contribute to the food and economy of people immensely. These group of fishes were cultured in cages and ponds for several decades by feeding them with small fishes. In 2005, Cambodia, banned the culture of this species as all farmers were using seeds collected from wild and fed them with fresh fish caught from wild. In order to develop better feed management practices and explore the culture of snakeheads using other feed resources, Cambodia has chosen snakeheads as the commodity.

Indonesia has made a very good progress in breeding of groupers and sea bass and several small farmers are engaged in culturing these species both for local as well as export market. As the livelihood of several farmers is dependent on the culture of these species, Indonesia preferred to work on groupers and sea bass as the commodities.

Tilapia being the most rapidly growing and widely cultured commodity, Thailand expressed its interest to work with farmers engaged in farming of tilapia in cages as well as ponds. Among the 573,090 farms engaged in fish culture, nearly 39% of the farms are actually involved in tilapia culture and tilapia farms are growing at an average of 5% per year.

Sea weed cultivation has contributed immensely in providing livelihoods to several farmers in Philippines. It is reported that there are over 160,000 families engaged in sea weed cultivation and the country has earned over 72 million USD in export during 2005. However, with the increasing quality requirements in the international markets, farmers are facing many challenges in the declining environmental qualities that are contributing for the increasing crop failures and declined profitability. To address these problems Philippines decided to work with farmers engaged in sea weed farming.

Vietnam has demonstrated its entrepreneurial approach in developing market for various aquatic products. The country is earning over 4 billion USD from aquatic products export and shrimp constitutes a major component of the export. Although, shrimp farming is continued to be practiced widely in the country, like in many other countries, the activity has been affected by the disease problems. Hence, Vietnam chose to work with shrimp.

Needs assessment

Each of the participating country carried out detailed needs assessment of the farmers dealing with the commodities they had identified. Focus group discussions, structured surveys and the secondary information collection from various agencies involved with the commodity in each country provided the issues that need to be addressed to build the competitiveness of farmers. However, there were common elements in all the commodities and these remained same in all countries, irrespective of the commodities.

As the farms are generally small and the scale of operation being limited, to reap the greater benefits from the markets, farmers need to be organised. This will help to increase volume of commodity availability for the buyers and also get the best possible price. When the farmers organise themselves in to groups, efficiency of the service delivery can be increased and farmers can also procure various materials in bulk. The benefits are many, but the challenge is to organise them in to groups and ensure sustainability to the group with good leadership.

Lack of capital is an issue in all countries and in respect of all commodities. The availability of capital at the right time to the farmers with easy terms of reference is the major problem. Although banks in all the countries have priority to lend money to farmers, the procedures involved being complex, farmers tend to borrow money from other sources with high interest rates when possible or otherwise, they restrict their activities.

Market access is frequently an issue. Farmers do not have the right information on the market in almost all countries, though in some countries like Thailand, there is not so much difference between the farm gate price and price of fish in the wholesale market. In general, farmers become obligated to middlemen who finance the culture operation when farmers need money and at the end, buy the product with bigger discounts coupled with several other extraction methods. In some countries like Indonesia, the price of groupers between farm gate and the retail market is nearly 100%. Farmers can derive enormous benefits by organising themselves into groups to obtain the best price.

Excepting for the local farmer to farmer exchanges of information that have been occurring more informally, farmers are confronted with the challenge of obtaining the necessary market information and technical issues that are essential to be successful. Existing traditional government support systems in most countries, though they make an effort to reach the farmers, because of the inherent problems, have not able to provide the required level of information that is required by farmers who are also widely scattered and unorganised.

Most importantly changing export market requirements on various sanitary measures being imposed by importing countries are hardly understood by farmers. They need education on better farming practices that are environment friendly and help to produce commodities that are healthy for acceptance in the international markets.

Training of trainers program

Based on the needs assessment carried out by all the participating countries, a training of trainers program was designed taking in to consideration of several needs brought out through the study. The training not only looked at greater depth on the technical necessities identified, but also helped train participants on how better management practices that can be evolved for each of the species that are being dealt with by different countries. Examples were drawn from the practical experience of NACA in developing such best management practices for shrimp in India and Indonesia and pangasius in Vietnam were shared with the participants. In all the species cultured, the biggest technical problem confronted by the farmers is the disease. As better management practices aim in part to reduce the risk of disease, participants were given examples from shrimp on how the most dreaded viral diseases can be prevented by organising farmers into groups, obtaining healthy seed from the hatchery through adoption of strategies that include even the selection of brooders and checking their health, followed by checking of the larvae by using advanced techniques like nested PCR, ensuring stocking of seed by the group of farmers at a time, taking precautionary measures in case of outbreak of disease to prevent its spread, etc. In India, Indonesia and even in Vietnam this disease problem could be prevented by the adoption of the above stated better management practices.

Feed is the major input cost in all the aquaculture systems. With the increasing feed cost and the declining feed prices, if the farmers do not adopt proper feeding practices, profitability declines drastically. It is because of this farmers not only need to have good knowledge on feeding practices, but also have the ability to produce homemade feeds that can reduce the costs substantially. Commercial companies have now come up with feeds that are specific to species and have succeeded in improving food conversion ratio by improving the quality of feed. However, as the cost of the feed of these commercial feeds is always on increase, wherever possible, farmers can produce homemade feed to reduce cost of production. Water quality is another major factor that has been affecting all cultured organisms and suggestions were made on how to maintain good quality water.

Market issues being a key factor, participants were educated on dealing with volatility of the market and planning their culture taking in to consideration of market targeted and produce products that can fetch the best price in the market. In order to have information on markets as well as other aspects of technology, information technology plays critical role. Examples from India, Indonesia on how the farmers have been able to use the information technology to address various problems was presented. In addition, a detailed account on using different internet communications to obtain technical information and solve were demonstrated. In India, shrimp farmers have been able to organise themselves and establish direct link with buyers in USA and this has helped farmers to get premium prize for the shrimp produced by small farmers.

Organising farmers into groups and the enormous benefits that they can derive from disease prevention, production of quality product through mutual sharing and caring, access to markets, information and even credit, impressed the participants. The guidance and support necessary for the farmers in the early stages for the formation of groups and adoption of democratic process to develop their own rules and regulations through participatory process and election of office bearers were identified as the key factors for the success of the organisation. Gender being a key issue, participants were enlightened on how a gender balanced approach can empower both men and women in the community. The Thailand Department of Fisheries being recognised for its role in addressing gender issues was used as an example on how the sustained efforts can bring solutions to the major problems.

The training program also provided an opportunity for the participants to present their findings and the strategies they wish to adopt to address the problems confronted in respect of the commodities that they are dealing. A plan of work on how they will proceed in respect of developing training manuals for each of the commodities was discussed and agreed upon.

Participation of the ASEAN Executive Director in the closing ceremony and his eloquent presentation on how ASEAN is aiming to bring common vision among the ASEAN countries and also assisting large number of farmers who form back bone of the ASEAN economy helped participants to understand the importance of the work they are carrying out. He appreciated the progress made by the project and indicated that if the project outcome demonstrate the greater benefits, the Foundation will explore ways to support the activities to get the desired output. Hence, he requested the participants to make use of the knowledge attained to address the problems encountered in the field and aim at getting the results that would be worthy to scale up.

Development of training manuals

Based on the knowledge gained and the skills acquired in the training of trainers workshop, participants worked in close partnership with various stakeholders and have prepared the draft manuals necessary for each commodity. The manuals specifically aim at addressing the issues identified by farmers and build their capacity to evolve better management practices, besides addressing other issues through group approach. Using these draft manuals as the basis trainings have been conducted in all the five countries. The training manuals are expected to be revised based on the input provided by farmers to make them user friendly.

Training of farmers in different countries

Seaweed cultivation

As already stated, large number of farmers are engaged in sea weed cultivation in Philippines. Farmers are able to make good profits when they are able to harvest crop successfully and get good price in the market. The major problem of farmers is only getting good information on the market price, but also getting credit during the culture operation to meet the livelihood expenses. Maintaining the quality of the harvested sea weeds through proper drying process is another major problem. Further when the seaweed are infected with the disease, getting the disease free planting material has been a major challenge.

Taking the above points in to consideration, training manual has been designed to evolve best management practices that can help farmers to produce good crop of sea weeds and obtain the best price in the market. In a five day training program held in November, 2009, with the participation of fifty farmers, they learnt about the best farming practices with the involvement of trainers from the processing sector, researchers dealing with the sea weed diseases, extension specialists, etc. After two days of class room discussion, farmers spent time in the field to learn about the practical aspects of seaweed cultivation and processing.

These farmers have been organised in to groups and assisted to use the knowledge and skills acquired in the field. As the MCPI Corporation involved in seaweed processing is also involved in the project, it is hoped that the farmers would get the best benefit from the industry perspective.

Snakehead culture

Farmers on the Great lake of Cambodia have initiated the cultivation of snakehead *Channa striata* in cages using homemade feed. Fisheries Administration has granted permission for the farmers to conduct the experiment with a view to evolve new culture methods that will help to reduce the usage of trash fish. Farmers are now using trash fish unsuitable for human consumption along with large quantity of good quality rice bran rice bran and silk cotton leaves powder. The proportion of these feed ingredients would vary based on the cost and availability in the market. Farmers have reported good growth of fish on the feed and the trials are in good progress. Although pellet feed specifically designed for snakeheads is now marketed, it is yet to found acceptability by farmers because of cost and food conversion efficiency.

It is also important to record here that farmers have been able to breed the snake head successfully and produce small amount of seed. Farmers are confident of producing the seed locally, if the government lifts the ban on its cultivation and allow people to cultivate.

Training for two batches of farmers comprising twenty farmers from Siem Reap and another twenty from Pursat province has been planned. In the training conducted in Siem Reap in Dec, 2009, farmers shared the knowledge they have generated in seed production and growing fish successfully using the home made feed. Experts in the training assisted farmers to understand the developments made in the production of seed, nutritional requirement studies and how to make made feed can be prepared using different feed resources.

In the group discussion held involving both husband and wife of the cage farmers, they identified lifting of Government ban on cultivating snakehead as the most urgent necessity. In the absence of such a rule that facilitates them to carry out the culture, farmers are subjected for exploitation. In addition, farmers recognised credit availability as the second urgent necessity to enable them to withstand the financial shortages and plan marketing of fish when the price would be high.

Farmers have agreed to establish themselves in to a group and work collectively to develop best aquaculture practices for the culture of snakeheads. Based on the results obtained, the government will be appraised with a view to also farmers to undertake culture of snakeheads using homemade feed.

Groupers and sea bass cultivation

Twenty farmers involved in grouper and sea bass farming participated in the two day organised in Lampung in the Marine Fish Culture Station in December 2009. Farmers discussed the best ways to cultivate fish in cages to meet the market standards. Although at present they use largely trash fish for cultivation, they are gradually realising the benefits of using pellet feed, mainly to prevent disease problems. As the culture period for groupers take long time, small farmers are facing the problem of credit and they often depend on the middlemen to borrow the required amount under an agreement that grown up fish would be sold. Because of these obligations, farmers do not get the best price they deserve to get and hence the need for them to get organised themselves in to group and initiate saving related activities was discussed.

These trained farmers are expected to be given follow up support to establish the group and help them carry out the activity. As there is huge difference in the farm gate price and the international retail price, it is hoped that farmers would be able to benefit largely from such an effort.

Tilapia cultivation

As the farmers in Thailand are facing major disease problems in the cultivation of tilapia both in ponds and cages, the training focused on building the capacity of farmers in preventing disease problems in tilapia cultivation by adopting good practices. When the disease occur, steps that need to taken to prevent the spread of disease were taught to farmers. Lead farmers who participated in the training provided inputs on the design of the training manual to their requirements. Farmers have indicated that the manual, in addition to being a reference material, it should serve as record book. Farmers have also suggested to produce the posters on various aspects of culture of tilapia so that they can utilise the same in training farmers. Existing training materials in the Department of Fisheries would be modified to suit the necessities.

Extension specialists also trained lead farmers on the effective communication methods to help farmers have the required level of confidence in the field.

Shrimp cultivation

Some of the self organised groups in Vietnam have been successful in growing shrimp successfully without any disease problems. These farmers have evolved the good practices that will help in the disease prevention and even in case, there would be a disease outbreak, sufficient measures have been developed to prevent the spread of the disease. As the farmers are organised in to group and follow well established norms like stocking healthy seed and all stocking almost at the same time in an area, use of pellet feed instead of trash fish or use the well proceed homemade feed, prevent unnecessary exchange of water, dissemination of information to all other farmers in the area in case of the disease outbreak, etc.

In contrast to the above, in several areas, farmers not being organised are confronted with many challenges with frequent crop failure or very low yield. For example, farmers in Ninh Binh Province are faced with such crop failures and an effort is made through this project to educate farmers on how the problem could be eliminated by following the best practices. In the training, farmers were educated on the need for group formation since the spread of disease will be rampant, if there is no coordination among farmers. Starting from preparing pond properly to stock seed, obtaining tested and disease free seed for stocking, feeding either pellet feed or well cooked homemade feed to prevent the virus introduction through uncooked trash fish, periodic checking of the seed for health and on how to manage the disease in case of disease occurrence, etc were taught to farmers.

A large number of women participated in the training program along with men. In the group discussion, men and women identified the activities they can carry out efficiently. Further, women were also categorical in stating that all the activities men can do, they also can do in shrimp farming. As the work is divided between men and women, each continue to specialise in their area of operation, but if necessity demands, each can carry out all the activities. However, it was identified that both men and women should be trained to enable them to carry out the activity in the family as a team.

Following the training, based on the expressed desire of farmers, a field trip for the selected group of farmers was organised top see the shrimp farming activity in Ham Ninh commune in Quang Binh province. The farmers could see themselves on how the shrimp farming can be carried out successfully by getting themselves organised into a group. Each farmer in the group is successfully harvesting two crops of shrimp with tiger shrimp cultivation being taken up high saline season followed by the white leg shrimp in the monsoon season. Farmers could learn about the type of coordination needed in shrimp farming to prevent disease and how quality inputs can be obtained by organising in to groups.

Farmers have planned to form group in Ninh Binh province and undertake shrimp farming following the good practice of Ham Ninh commune. Farmers from Ham Ninh Commune have promised to help the farmers in Ninh Binh to establish the farmer groups and initiate the activity. All this would depend largely based on the leadership and it is hoped that, having seen the success with the follow up support, they would initiate the activity on the similar lines.

The Vietnam team has also developed a good pictorial guide on the benefits of forming farmer organisation. This manual would be useful to all countries in educating people on establishing farmer groups.

Conclusion

The project has been able to accomplish most of the anticipated outcomes owing to the active interest and support extended by the participating countries. As all the commodities identified by different countries are significantly important from the trade, the project has focused on building the capacity of people in meeting the market requirements both domestically and internationally. Access to information is key not only for the successful culture of the aquatic products, but also for profitable marketing. Since buyers require the product in bulk, if farmers become organised, they can have better bargaining power.

In the coming months, project is expected to provide support for the formation of groups and help them begin best aquaculture practices. All these experiences will be shared among all the ASEAN countries in the workshop scheduled to be held in August in Vietnam.

Carp seed production at rural front in Orissa, India

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The availability of quality seed is prerequisite for rapid expansion and growth of aquaculture. However, uncertainty in timely seed supply is one of the major constraints. Considering its significance constant efforts have been made to produce large quantity of carp seed every year in increasing trends. For instance, the total fry production in India was estimated at 632 million in 1986-87 which had increased to 18.5 billion in 2002-2003 and in 2005-06 it was over 22.6 billion. Quantified data on larger size fingerlings and/or yearlings are not available, although it is much needed for grow out culture.

Fish seed production includes egg to spawn production for 3 days, spawn to fry nursing for 15-20 days, fry to fingerling rearing for 60-90 days and fingerling to yearling rearing for 8-9 months. Thus the carp seed may be categorised at its final size into spawn (6-8 mm size), fry (20-25 mm size), fingerlings (100-150 mm size) and yearlings (100-200 g weight).

Mass production of carp eggs in a spawning pool.

The distribution system of carp seed is complex and dynamic. Though some of the entrepreneurs produce and supply the fish seed to end users often as a part of complex networks, their supply remains erratic in other part, particularly in rural sectors[1]. The gap between demand and supply of quality seeds, by and large, remains a daunting task in rural aquaculture development. This can be mitigated, if village farmers produce quality carp seed in their ponds to not only make the access of locally produced and nursed quality seed to the fish farmers but also stimulate and support neighbouring farmers to adopt fish culture within their situation. Earlier studies indicate that paucity of carp spawn compelled village farmers to stock their ponds with riverine fish seed[2] and due to lack of technical support and basic infrastructure facilities; carp breeding was rarely adopted by farmers[3]. In view of this various attempts have been made to demonstrate carp breeding[4-8], spawn to fry rearing and fry to fingerling rearing[6, 9-22] and fingerling to yearling rearing[21] in rural area. Despite pointed extension focus in this regard, the sustainability aspect of the production of carp seed by the farmers still remains a missing link. Present communication summarises the carp spawn production and seed rearing management by the fish farmers of Orissa by citing examples of some selected cases.

What is rural carp seed production?

Rural carp seed production may be defined as "carp seed production by small-scale households or communities using mainly extensive and semi-intensive management appropriate to existing resource base for their own use and/ or improving their family income" or "carp seed production using technologies adapted to locally available and limited resources of households". Rural carp seed production is not very capital intensive or input intensive and contributes to rural livelihoods. It is different from more commercially carp seed production systems or entrepreneurial carp seed production.

Evolving rural to entrepreneurial carp seed producers

The system of carp seed production process is a continuum and it is very difficult to strictly divide rural from entrepreneurial fish seed producers. In fact, many farmers who have been involved in subsistence level carp seed production increased their production over the years, with the more inputs and better management skill, resulting in enlarging their resource base and gradually becoming entrepreneurial. For example, a farmer who used to stock spawn in unprepared pond because of not knowing the technique of pond preparation, when came to know, followed the technique strictly and got better recovery and more income. Thus over a period of few years he could afford more inputs and intensifies his management and becomes entrepreneurial seed producer. It is more desirable to make the resource poor farmers entrepreneurial farmers in rural area. Such evolution is already taking place with the time. For instances, farmers of Sarakana village evolved as carp seed entrepreneurs from traditional carp seed producer.

Spawn production in rural area

Common spawn production

In rural areas generally carp spawn are generally produced twice during June-August and January-March of the year, following the adaptive breeding methods.

Pond breeding: Common carp brood fish are reared in composite fish culture ponds. In season, clean aquatic weeds such as *Hydrilla* / *Najaj* or water hyacinth are placed in pond's corners or inside floating bamboo frames in the evening hours. During late night to early morning fish breed naturally and eggs are attached to aquatic weeds. Since water hyacinth is floating, the eggs get attached on the roots only. The egg loaded aquatic weeds are collected in morning hours and kept for incubation in hatching hapas or directly spread in well prepared nursery ponds. However, in nursery spread eggs the spawn survival is very poor than hapa hatching. This method has certain disadvantages like: difficult to estimate eggs, egg predation by pond animals, poor egg fertilisation etc.

Release of carp spawns in incubation pool.

Hapa breeding: Brood fish are reared either in separate ponds or in composite fish culture ponds. Brood fish are netted out to segregate mature males and females. They are weighed and kept in breeding hapa containing suitable egg collectors in evening hours. Generally 3-4 kg *Hydrilla*/ kg female fish is used as egg collector. Males and females are kept in ratio of 1:1 by weight. They breed naturally in hapa after 6-8 hrs. In less suitable condition fishes are injected with inducing hormones to ensure breeding. After spawning, the females are weighed to estimate the egg release. About 12-15% of the weight difference goes towards faecal matter of fish and rest weight difference is due to egg release in ovary. One gram weight difference in ovary provides an estimate of 700 egg release. Egg attached 2-4 kg *Hydrilla* is spread per inner hatching hapa. Depending on water temperature, hatching takes place in 2 days and inner hatching hapas are removed in 3 days. After 4-5 days, spawn are collected for stocking in nursery ponds[23].

Hatchery breeding: Some of the village hatchery owners use breeding pools for common carp spawning. They use nylon threads or plastic threads or plastic nets or *Hydrilla* or water hyacinth as egg collectors. Egg incubation is carried out in hatching pools.

Indian and exotic major carp spawn production

Hapa breeding: In remote villages brood fish are grown in composite fish culture ponds. During monsoon season they are netted out and fully mature males and females are selected. Breeding hapas are fixed in composite fish culture ponds having common carps. Presence of common carp, prawns and crabs cause severe damage to carp eggs in breeding hapas. Hence, to avoid hazards of loss of viable eggs, the breeding hapas are fixed inside the net enclosure[5,7]. Generally for one female two males are used. Intra-muscular and/or intra-peritorial injection is administered to brood fish during June-October. Females are injected with PG extract or glycerine extract of PG twice but males are injected only once. First dose is given in the evening hours to female @ 5-6mg/kg and second dose after 4-6 hours of first injection @ 8-16 mg/kg. Males are injected at the time of second dose of female @ 4-5mg/kg male. Presently synthetic hormones (ovaprim or ovatide) are used as inducing agents in rural areas[7]. Both the males and females are injected only once.

These synthetic hormones are administered @ 0.2-0.5 ml/kg female and 0.1-0.2 ml/kg male. After 4-6 hours of injection fish spawn. Fertilised eggs are identified and quantified at comma stage of embryos and hatching are done using hapa hatching device. Spawn are collected after 72-80 hours of hatching by filtering with inner hatching hapa with the spawn recovery of only 24-44% of the fertilised eggs[7,8]. The low recovery of spawn from hapa hatching device could be due to a combination of factors such as cutting of hapas by crabs and/or large freshwater prawns, entry of unwanted fishes in hatching hapas[8], presence of predatory cyclopoid copepods in hatching hapas[4,24] and sudden change in water temperature, depletion of DO content, water bloom and cyclonic weather[7,8,25].

Hatchery breeding: For hatchery breeding, brood stocks are maintained in separate ponds by stoking 1-3t/ha brood fish under scientific management. Brood fishes are injected with inducing hormones as mentioned in hapa breeding. In rural area the spawning is done in breeding hapa and/or spawning pool but hatching is done in incubation pools. Two-three year old carps weighing 2-5 kg are the best for hypophysation. "Eco-hatchery" is used by the village entrepreneurs. It includes overhead tank, spawning pools, egg collection chamber, incubation pools and spawn collection chamber. An overhead tank is generally made on the roof of single or double storied building and a water holding capacity of 5000 litre can supply water to spawning and incubation pools. Depending upon the requirements, the sizes of spawning pools vary. Spawning pool is 8-9 m diameter and 1.0-1.5 m deep with the provision of water circulatory system and shower. Farmers use 20-30 kg female per spawning pool and produce 250-400 litres of carp eggs in one operation. These eggs are incubated in 3-5 hatching pools. Incubation pools are 3-4m inside diameter and 1 m deep. Generally 1 egg is incubated in one ml water. During egg incubation, farmers maintain water flow @ 2.5 l/sec. initially, @ 2.0 l / sec at twisting movements of embryos and @ 3.5 l/sec after hatching to get better spawn recovery. Farmers harvest 800,000 to 1,000,000 spawn/pool/operation. KVK/TTC, CIFA designed and fabricated portable FRP carp hatchery in 1989 with the maximum spawn recovery of 3,000,000 lakh / operation/pool[26], now modified and commercialised by CIFA and it is used by the village entrepreneurs to produce carp spawn. From hatchery breeding farmers get 80-95% recovery from the viable eggs. By adopting circular carp hatchery some of the rural fish farmers changed into entrepreneurial seed producers.

Success cases of carp spawn production

Carp spawn production at Sarakana: Farmers from the Sarakana village started carp spawn production in 1987 with common carp and produced 3.5 lakh spawn in hapa - breeding. Gradually they learnt the induced breeding techniques of Indian major carps and exotic carps in hapa17. Carp spawn production increased to 1,440,000-8,555,000 up to 1995. The spawn recovery was poor and ranged between 24-44%[8]. To mitigate the problems of poor recovery of spawn in hapa, they have been motivated by KVK/TTC, CIFA to construct a cemented circular hatchery in 1995 which resulted higher spawn recovery of 74-85% from 1996 onwards. This resulted in producing 15,750,000-31,950,000 spawn of *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Cyprinus carpio*, *Ctenopharyngodon idella* and *Hypophthalmychthys molitrix* annually[8]. To meet the market demand of carp spawn in

Carp fry production in rural area.

the region, they ploughed back their hard earned money to construct another carp hatchery with higher production efficiency. As a result of which they are able to produce 100-150 million carp spawn annually. This suggests that traditional seed production in rural area transformed into entrepreneurial seed production by utilising the improved technology. They produce carp seed not only to meet the market demands but also earn handsome income and employment.

Carp spawn production at Kantapada: Farmers from Kantapada village initiated carp spawn production in 1996 using hapa breeding device. With spawn recovery of 25-40% of viable eggs, they produced 40, 50, 67and 42 lakh spawn during 1996, 1997, 1998 and 199925. After realising the poor spawn recovery, farmers constructed one circular carp hatchery and now they are producing 40-60 million carp spawn annually.

Carp spawn production at Bhatapadgarh: Carp breeding was started with hapa breeding with the technical guidance of CIFA, Kausalyagang in stored rain water in ponds constructed at hilly terrains during 2002[27]. Farmers have been trained through participatory approach in carp breeding skills. During skill learning farmers could produce 1,100,000 carp spawn with 20-40% recovery in hapa breeding. Meanwhile, they constructed one commercial carp hatchery during 2003 and made it operational through the technical guidance of the author in 2004. Now farmers are producing 50-110 million spawn of *C. catla*, *L. rohita*, *C. mrigala*, *C. carpio*, *L. calbasu*, *C. idella* and *H. molitrix* every year at the hilly terrains to meet the regional demand.

By seeing the economic profitability in carp spawn production, many of the neighbouring farmers and entrepreneurs have constructed carp hatchery to produce carp spawn to meet the local carp seed demand.

Carp fry and fingerling rearing in rural areas

In rural area, spawn to fry nursing is carried out in smaller ponds of 0.02-0.05 ha (0.5-1.0m depth). In same perennial ponds fry, fingerling and/or yearlings are reared in succession during June-July, August-November and December-June respectively. Alternatively the ponds are stocked with carp fry and rearing of fingerlings and yearlings are continued in succession. For rearing larger size carp fingerlings 0.05-0.1 ha with an average depth of 1.0-2.0m are preferred. Ponds shaded by trees are rendered unproductive by reduced sunlight. Accumulation of leaf litter and an excessive organic load in the pond further deteriorates water quality, adversely affecting carp and carp food organisms[28]. At times, masses of foamy brown/white frog eggs, which tend to fall into ponds during rains, caused a proliferation of tadpoles[8]. Therefore, marginal trees and bushes are cleared before launching the seed raising programme. Pond embankments are renovated with the provision of secured inlet and outlet. Since backyard ponds are shallow and small, aquatic weed clearance is completed manually by rural farmers. Predatory animals/ fishes and weed fishes are eradicated by de-watering and drying the ponds or application of suitable piscicides. Raw cattle dung is applied as basal manure in ponds. To enhance the fertilisation effect liming is done. For sustained production of natural fish food organisms a mixture of de-oiled cake, cattle dung/ bio-gas slurry and single super phosphate or a multiplex pre mineral mixture and vitamins are used in liquid forms before 4-5 days of spawn stocking[29].

Fry are harvested and/or thinned in phases according to the local demand, allowing an extended period of rearing (14-44 days) in rural area. Prolonged retention of fry in nursery ponds adversely affects the fry survival. Fry recovery is 20-40%[3, 8,10,12,19]. Stocking spawn at shallow water depth (35-45 cm) followed by phased increase of water level at 3 - 4 days intervals, results higher fry recovery of 50-70 %[8,29]. Fortification of micro-nutrients in artificial feeds is also enhances the growth and survival of fry[16]. A commercially available multiplex pre-minerals mixture with vitamins accelerates plankton production and fry survival in nursery ponds[8]. In case ponds are used for fry rearing, fry are harvested by repeated netting on day 15-20 of stocking. At times, two crops of fry are taken. After fry harvesting, the ponds are fertilised with the mixture of above manure to produce adequate natural fish-food organisms. On day 2 or 3 of fertilisation, the fresh fry are stocked along with residual fry in such a way to maintain the density of 300,000-500,000/ ha. Later a mixture of above fertilisers is applied in liquid form at weekly or fortnightly intervals. Fingerlings are also fed traditionally and harvested by repeated netting after three months of rearing.

Success cases of fry and fingerling production

Fry and fingerling production at Sarakana village: Farmers from the Sarakana village started carp fry raising in one pond of 0.08ha and produced only 220,000 fry and 40,000 fingerlings[17]. High profitability in fry and fingerling rearing work encouraged the farmers to invest money for creating more facilities by constructing two other ponds in 1988 and produced 384,000 fry and over 100,000 fingerlings[8]. Since then every year the farmers expanded their activities by excavating new ponds and at preset 23 ponds of 0.02-0.1ha each are available for fry and fingerling production. Now they are producing 4,300,000-6,000,000 lakh fry and 440,000-570,000 fingerlings every year.

Fry and fingerling production at Kantapada village: In this village fish seed nursing was initiated in 1983 by using 12 nursery ponds. Ponds were prepared and stocked @ 30-50 lakh spawn/ha. The fry were harvested after 30-45 days with the recovery of 15-30%. With the time farmers acquired scientific management practices and expanded rearing area to 20 ponds (2.0 ha) gradually[25]. Farmers are harvesting carp fry within 12-20 days with the recovery of 35-60%. Multi cropping of fry production is also done. They are able to harvest 3,000,000-7,600,000 fry annually. The same ponds are used for fingerling rearing with the production of over 300,000-600,000 fingerlings every year.

Fry and fingerling production at Bhatapadagarh village: Terrace type a series of 17 nursery and rearing ponds (0.05-0.17ha) are constructed with a network of inlets and outlets systems during 2003 to store huge quantity of water flowing in from the hilly terrains[27].These ponds were prepared by manuring, liming and insect control and stocked with carp spawn @ 3,000,000-6,000,000/ha. Ponds were harvested after 20-30 days of rearing with the recovery of 20-60% yielding about 5,900,000 fry from July to September in 1 or 2 crops. After developing confidence in economic profitability, the farmers also started using even large size ponds of 0.5-0.7ha for stocking carp spawn at shallower depth followed by phased increase of water level[29] for commercial fry and fingerling production. They are producing 6,000,000-15,000,000 fry and 100,000-800,000 fingerlings of catla, rohu, mrigal, calbasu, common carp, silver carp, and grass carp every year for supply in the region.

Large sized fingerling and yearling production

Yearlings are produced traditionally in village ponds. When farmers fail to sale their fingerlings and they continue to rear them up to May-June. Before monsoon, when ponds are prepared for next fry rearing crops, farmers harvest stunted fish for consumption as they are grown with reduced nutrient uptake. But now a days with the increased awareness of yearlings significance as stocking materials, it is being sold at pond site for grow out fish culture. When stunted fingerlings are kept on a high quality diet they grow rapidly leading efficient body weight[21]. Some of the village fish farmers produce yearlings and/or stunted fingerlings with improved management on commercial scale. In this, the fingerlings stocked in well prepared ponds at high density July-August. Yearlings are also reared by stocking appropriate carp fingerlings along with residual stock of fingerlings. During culture period ponds are fertilised monthly once. Fingerlings are fed with the mixture of ground nut oil cake and rice bran in the ratio of 1:1 by weight @ 4-6% of the body weight. Complete harvesting of yearlings is done by repeated netting from May-June. Adopting this management the farmers of Kantapada and Bhatpadagarh are producing 3-5 tonnes of yearlings every year.

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A sustainable mountain paddy-fish farming of the Apatani tribes of Arunachal Pradesh, India

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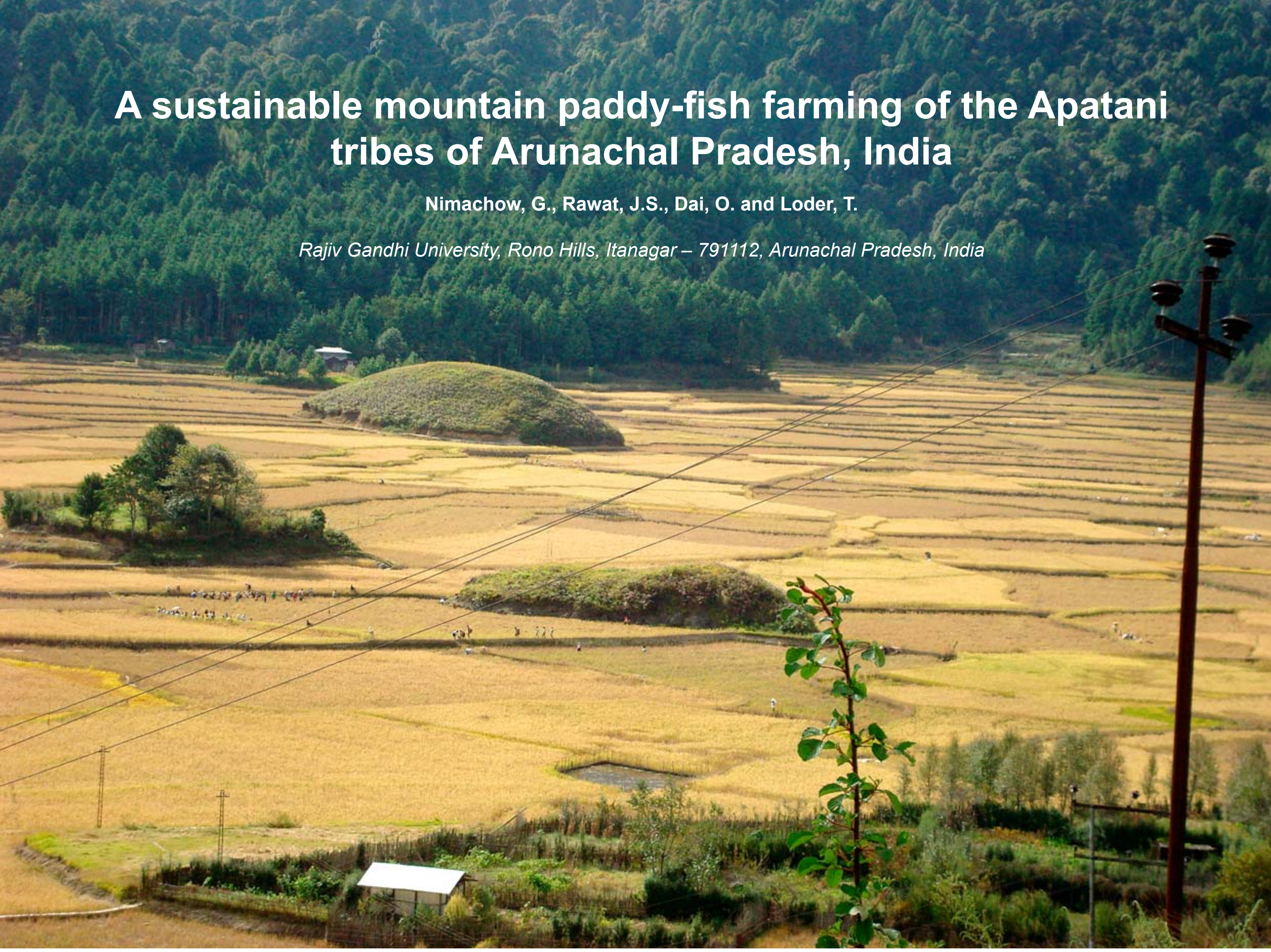

Efficient land utilisation.

Integrated paddy-fish farming systems can be found in parts of China, Japan, Indonesia, Philippines, Vietnam, Malaysia, Thailand, Myanmar and India. In some cases these systems date back virtually to when man started paddy cultivation. These systems generally involve some form of on-farm waste recycling technique or multiple usage of resources that enhance production capacity, helping to improve farmer's socio-economic conditions and often benefiting the ecology as well. Integrated paddy-fish systems can aid intensive production of rice and fish protein with greater efficiency than they can be grown in isolation, as the by-products of one system component becomes the input for other[1].

With 26 major tribes and 110 sub-tribes, Arunachal Pradesh is well-known for its ethnic diversity and a wealth of traditional ecological knowledge. The efficient management and sustainable use of agro-ecosystems by the Apatani tribe of the Ziro Valley in lower Subansiri District is unmatched when compared to the other adjacent tribes of Arunachal Pradesh, which largely depend on a low productivity slash-and-burn economy. Apatanis are well known for their integrated system of rice and fish culture (Aji-ngyii) in the valley[2], which has become an additional source of income and important economic avenue of the Apatani farm families[3]. At the same time fish culture in paddy field may sometime cause health risks if the input of pesticides in the paddy crop is not properly managed[4]. Similarly, although common carp culture in rice fields is quite advanced in Japan[5], it has had serious setbacks because of pesticide use in paddy cultivation[1].

The paddy-fish culture of the Apatani, however, is a purely an organic farming practice and is distinctly characteristic of Apatani agro-ecosystem[2]. UNESCO has, therefore, proposed Ziro valley as a World Heritage Site for it's for its ancient custom, forming the basis of the eco-preservation efforts. This article describes the integrated paddy-fish farming of the Apatani Tribes of Arunachal Pradesh.

Background of Ziro Valley

Located at the altitude of 1572 meters Ziro valley has about 32 km^2 of cultivable area, the rest being covered with hills and mountains unsuitable for wet rice cultivation. As per the 2001 census, the total population of Apatani tribes was about 26,650 with a density of 948 person km^{-2}. The annual rainfall fluctuates from 2,240mm – 2,910 mm with the maximum rainfall during the months of June and July. The minimum and maximum temperature during summer is 6.3°C and 28.1°C respectively and that of winter is 1.0°C and 18.4°C[3] respectively. The air has mountainous soils with high water holding capacity suitable for paddy cultivation.

The land and water resource utilisation system developed by Apatanis is essentially necessitated by the limited land resource available for large population base. The Apatanis are densely concentrated in the Ziro valley. The population density of the Ziro valley, as shown in Table 1, is more than hundred folds than that of state's density and also much higher than the average for the country. In the year 1961 it was 415 persons km^{-2} against 4 persons and 142 persons km^{-2} of the state and country respectively. The population density of Ziro valley had doubled by 1991 where as that of state and country doubled by 1981. Interestingly, the 0.03% area of the Ziro Valley to the total geographical area of Arunachal Pradesh is supporting 2.26% population of the state.

Looking at the distribution scenario of landholding size and number of farmers, as evident in Table 2, farmers with marginal (very small) holdings make up almost half of the farming population in Ziro Valley. In contrast, the rest of the district and state have more than 50% medium-sized farmers. On the other hand medium size landholdings in Ziro valley are only 17% of farms and the large size landholdings are a low 0.8% of holdings compared to the district and state figure of 5.1%. The paucity of the arable land has compelled the Apatanis to evolve and indigenous technique of intensive farming and efficient method of land and water management. The Indian Council for Agricultural Research for North East Himalayan region has demonstrated sustainable agriculture through paddy-cum-fish culture in Manipur. The Apatanis of Ziro valley have also developed their own techniques of rearing fish along with paddy to meet both the requirements of rice as well as fish as an important part of their diet.

Land, water and nutrient management

The Apatanis have developed a multipurpose water management system, which integrates land, water and farming systems by protecting against soil erosion, conserving water for irrigation and paddy-cum-fish culture[6]. It is managed by diverting streams originating in the forest into a single canal to which each field is connected with bamboo or pinewood pipe[7]. The streams are trapped into a major channel and again redistributed to numerous secondary channels to convey water in each and every field plots. The water is conveyed from one terrace to another through the bamboo or wooden pipes put above 15 – 25 cm above the bed to ensure the proper water level. In order to contain soil erosion, bio-fencing is installed alongside of the main canals. The irrigation systems are managed by a group of farmers led by *Bogo Ahtoh* to ensure proper supply and sharing of water[2].

Wooden pipe to convey water in another terrace.

Paddy fields terrace are developed with size ranges from 235 to 2740 m^2 which are levelled uniformly to ensure the uniform water height. In order to hold the water level dykes or bund, supported by bamboos and wooden clips, are constructed in the fields. The width of the dykes ranges from 0.6 m to 1.4 m and height varies between 0.2 m to 0.6 m. No ploughing is done in the field to retain the soil fertility and land is prepared with the help of spades. The household's waste water drained to the irrigation canals provides good source of manure in the field. Soil nutrients are also maintained through recycling of agricultural wastes, paddy straw, rice husk, ash, weeds, etc. After the harvest free cattle grazing is allowed to add green manure. In addition, the decomposed leaf litter leaching from the forest floor is collected in separate pipes connected to the main canal so that it goes on to the plots.

Table 1. Population & density (people/km^2) of Ziro Valley vis-a-vis Arunachal Pradesh & India

Year	Apatani		Arunachal Pradesh		% to state	India
	Population	Density	Population	Density		density
1961	10,793	415	336,588	4	3.21	142
1971	12,888	496	468,511	6	2.75	177
1981	16,580	638	631,839	8	2.62	216
1991	22,526	866	864,558	10	2.61	267
2001	24,650	948	1,091,117	13	2.26	324

Source: Census of India (1961, 1971, 1981, 1991 & 2001), Government of India.

Table 2. Landholding wise number and proportion of farmers

Holdings	Apatani Valley		Lower Subansiri		State's
	Number	%	Number	%	Total (%)
Marginal	1,360	47.5	2,323	20.01	19.24
Small	990	34.6	2,678	23.07	19.33
Medium	489	17.1	6,017	51.82	55.65
Large	23	0.8	592	5.10	5.75

Sources: 1. District Ag. Officer, Lower Subansiri & Agricultural Census 1995-96.

Paddy-fish culture

People believe that tali nguyi (*Channa* sp.) and papi nguyi (*Puntius* sp.) fishes were naturally available in the paddy fields. Usually, these fishes are caught by opening the outlet of bunds so that the volume of water becomes lesser in the field. Indigenous trap prepared from bamboo is placed in the outlets to catch the fishes. The remaining fish in the field are caught by indigenous baskets, nets, etc. Such natural occurrence of fish in paddy fields led the Government of Arunachal Pradesh to start paddy cum fish culture in Apatani valley during 1964-65 on experimental basis. The experiment started with 23 plots of paddy fields covering an area of 10 acres and was found remarkably successful*8*. The Paddy fields are

Paddy harvesting and digging trenches side by side.

suitable for fish culture because these fields have strong dykes or bunds locally known as agher for preventing leakage of water and retaining it to the desired depth and also to prevent the escaping of cultivated fishes during floods. On the bunds, sarse (millet) is cultivated which is a common practice among the Apatani people. Therefore, no portion of paddy plots remains unutilised.

Apart from the naturally available tali ngiyi (*Channa* spp.) and papi ngiyi (*Puntius* spp.) fish species, there are other varieties of fishes like ngilyang ngiyi (*Schizothorax* spp.), tabu ngiyi (eels), ribu (*Nemaucheilus*), ngiyi papi (dorikona or weed fish) found in Kiley River draining the valley. The Government of Arunachal Pradesh had introduced aji ngiyi (common carp or *Cyprinus carpio*) in the paddy fields of the people. Presently, this is the most frequently reared fish species in the region. Currently, species such as kuri mass (*Labeo gonius*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), *Barbonymus gonionotus*, etc. are also stocked along with common carp. But the success rates of these varieties are much less than the common carp. The reason may be unfavourable climatic conditions of the Ziro valley for these varieties of fish. Fish rearing in field is reported by the farmers to be beneficial in multiple ways. These fishes feed on small insects like water beetle, larvae, and others harmful to the paddy. In turn the waste material of fish works as manure to paddy plant. Fish such as the grass carp feeds on paddy leaves and hence it damages the crops. So this variety of fish is being stocked when the paddy is grown well above water level.

The people categorise their fields as *zebi aji* (soft field) and *aller aji* (hard field). Generally in soft fields the pyapin (*Oryza sativa*) variety of paddy is grown and lesser numbers of common carp are reared for once in a year. Due to the softness of the field, there is a risk of roots being damaged by fish. Hence, only one batch of paddy and fish are reared. On the other hand, in hard fields, two batches of fish are reared in a crop season. The first batch of fish is stocked during late March to early April before the transplantation of paddy saplings. These fishes are harvested in mid June and the second batch is put in the month of July which is harvested in the month of September. A long multi-purpose trench is prepared along the middle of the paddy field. When weeding the paddy field fish are kept in the trench. When there is no rain, hot weather, etc the stagnant water of the field become warm. However, the water in deep trench provides cool hideouts for the fishes. While harvesting the fishes, water is completely drained out from the paddy field. Fishes are bound to concentrate in the trenches from where they are caught easily using the traditional traps. Such trenches dug out just after the harvest of paddy or even during the harvest. Different traditional species of *Oryza* are grown in the paddy-fish system locally known as *ampo*, *mipya*, *layi* and *misang amo*. They mostly cultivate *amo*, *mipya* and *layi* varieties of paddy which are indigenous in nature. *Missang amo* is a variety of paddy that have been taken from the neighboring Nyishi tribe. *Mipya* is early variety and harvested in the early part of July whereas *Empo* is a late maturing variety ripe at different periods and harvested in the month of October. *Mipya* is at the verge of extinction due to more emphasis on other varieties for higher productivity and quality.

The average weight attained by the fingerlings at the time of harvest ranges from 130 to 400 g. Based on the conservative estimates of village elders a hectare of land on an average yields about 200 kg of fish. The excellent efficiency of the fish production is despite high mortality of fingerlings[9]. The fishes form an important part of diet of the Apatanis and fetches them subsidiary income with low inputs. Paddy-fish systems help poor and small farmers having too small holding for crop production and a few heads of livestock to diversify their farm production, increase cash income, improve quality and quantity of food produced and exploitation of unutilised resources[1]. It has been observed that until now paddy-fish culture is not been carried out on a larger scale or on full time commercial purpose thus leaving a good scope for improvement. This practice has potentials of becoming commercially vibrant only if the people and the government works towards its development. Such an important culture can also be disseminated among other surrounding tribes. The success of paddy-fish culture in the area can be used in the form of illustration to the farmers belonging to other different ethnic groups for sustainable mountain agriculture. This would enhance the economic prosperity of the rural people. By now almost every tribe in the state has started wet rice cultivation in the available cultivable lands. Thus, paddy-rice practice can be encouraged initiated in those fields. It is a relatively easy, low-cost and low-risk entry point for rural farming communities to improve their livelihood and household income without jeopardising the sustainability of rice production[10].

It was realised from the present study that increased population leads disintegrating/fragmenting of cultivable land. Therefore, the available land can be managed in such a manner that it will yield both paddy and fish together at a time to meet the need of food and capital simultaneously.

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From "Tragedy of Commons" to "Wisdom of Conservation"

"That which belongs to everyone
Is not taken care of by anyone"
was Aristotle's serious apprehension
About common property resource exploitation

Came in 1968, Economist Garret Haddin's assertion
Through his "Tragedy of Commons" proposition
That unless we care for and take immediate action
To prevent resources' over exploitation
There won't be any resource left for consumption

A team of Canadian scientists have already forecast a grim situation
For world's marine fish stock position
That if not reversed the current pace of destruction
By 2048 all world fish stocks would face extermination

With growing concern for dwindling fish stock condition
Came in 1982 a collective global opinion
Through FAO's World Conference deliberation
To steer the world towards aquatic resource conservation

Snowballing subsequently,
The idea got a definite shape and improvisation
And culminated in
Rio de Janeiro's 1992 Earth Summit's discussion

With emphatic world opinion
Generated through UNCLOS resolution
Finally came into force in 1995
FAO's Code of Conduct for Responsible Fisheries and its draft circulation

Let every nation arise and realise
And take concrete preventive action
To channelize the wisdom of fish conservation
To ensure the availability of fish for future generation!!

S.M.Shivaprakash.

The economic impacts of WSSV on shrimp farming production and export in Iran

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White spot syndrome virus (WSSV) occurs worldwide and causes high mortality and considerable economic damage to the shrimp farming industry. WSSV, which was first discovered in Southeast Asia around 1992, is currently the most serious viral pathogen of shrimp worldwide. It causes up to 100% mortality within 7 to 10 days in commercial shrimp farms, resulting in large economic losses to the shrimp farming industry[1]. Shrimp culture has been a booming business since the beginning of the 1990s, and worldwide production was 1 million metric tonnes in 2002[2], increased to almost 2.4 million tonnes in Asia by 2008[3]. The shrimp farming industry is an important source of economic development and provides well-paid employment in poor coastal areas[4].

From the 1990-1995, potential areas for shrimp culture development were surveyed in Iran, comprising some 2,000 km of coastline and more than 110,000 ha of cultivable area. Prior to 2001, more than 7,000 ha of shrimp ponds had been constructed and 11,000 ha were under construction. The main native species produced under semi intensive systems was the Indian white shrimp (*Penaeus indicus*). However, since outbreaks of WSSV farmers have changed to white leg shrimp (*Litopenaeus vannamei*) in Khuzestan and Bushehr provinces. Shrimp culture development has taken place along the coastal areas of the Persian Gulf and the Gulf of Oman, where the soils are alkaline and infertile and the water is alkaline (37-42 ppt). Salinity increases up to 47-50 ppt in the ponds and air temperature reaches 50°C. These are generally considered harsh conditions, but the Indian white shrimp and white leg shrimp not only survive but seem also to thrive very well.

The sustainability of shrimp farming has become a major concern among the small-scale coastal farmers in Iran, as the sector has experienced widespread disease problems for four or five consecutive years. In 2002, an outbreak of disease of cultured Indian white shrimp occurred in semi-intensive farms in Abadan (Khuzestan province), southwestern Iran, where it caused losses of almost 100 percent of production. Later WSSV disease occurred in all shrimp sites in Bushehr province, where it severely affected small-scale farms practicing high stocking density, resulting in great economic loss. In 2007, an outbreak of disease of cultured Indian white shrimp occurred in semi-intensive farms in shrimp site of Goater (Sistan and Baluchestan province), southeastern Iran.

Production and export of shrimp play a dominant role in the fisheries economy in southern Iran; the shrimp sector was the second largest contributor to fisheries export earnings. Per ha production increased from almost 500 kg in 1993 to 2,300 kg in 2002. Since 2003, the effect of WSSV has caused a decline of per ha production in shrimp farming in Iran. In 2005, yield in Bushehr had declined to almost 1,000 kg / ha*5*. Besides the reduction in export income, the

Abadan shrimp site, photos by Dr Afsharnasab.

disease outbreaks that took place in 2002, 2005, and 2007 also caused liquidity problems among farm operators. Many shrimp hatcheries, shrimp farms and shrimp processing factories could not make bank payments on their loans. This led lenders, especially the Agriculture Bank, to come up with a loan rescheduling programme for shrimp farmers.

Shrimp culture development in Iran

In Iran, shrimp farming started about 15 years ago and it has undoubtedly seen great experience over this time. Shrimp farms are located along the 2,000 km coastline in the southern parts of Iran from Abadan (Khuzestan province) in the southwest through Bushehr province, Hormozghan province and finally to Goater (Sistan and Baluchestan province) in the southeast, near the border of Pakistan. Since 1991, the Fisheries Organization of Iran has initiated development of marine shrimp farming in the southern coast provinces. Initial trials were carried out with FAO/UNDP assistance in the years 1991-92, producing post-larvae of local species such as *P. semisulcatus*, *P. merguiensis* and *M. affinis* and reviewing favourable areas for shrimp culture. The development of shrimp culture in the region attracted considerable investment and expanded very fast, however there is still a long way to meet the goals of the national development plan. Though the potential of shrimp culture to expand may be apparent, it may be constrained by market demand and producer profitability. From 1992-2002 the sector had undoubtedly seen great success, but since 2002 production has declined due to the impact of WSSV.

Provincial production

As Table 1 shows, production rose from less than 20 tonnes in 1993 to more than 7,600 tonnes in 2001 before declining to 6,000 tonnes in 2002[6], with a recovery to 9,000 tonnes in 2004 and further declines in 2005 and 2007[5]. In Khuzestan province, shrimp farming production increased from less than 10 tonnes in 1993 to the highest level of production of more than 2,050 tonnes in 2001. In 2002, an outbreak of WSSV disease caused loss of all production. Over the four years from 2003 - 2007, all governmental effort including introduction of new species of white leg shrimp increased production to 70 tonnes. In Bushehr province, shrimp farming production increased from less than 1 tonne in 1993 to 5,600 tonnes in 2004. In 2005, an outbreak of WSSV disease caused losses of great economic loss and production declined to almost 475 tonnes. Introduction of white leg shrimp increased production to 1,623 tonnes in 2006 and 876 tonnes in 2007. WSSV did not affect the Hormozgan province, though, where the production trend is almost constant. In Sistan and Baluchestan province, shrimp farming production increased from less than 1 tonne in 1993 to 2,500 tonnes in 2006, In 2007, an outbreak of WSSV disease caused losses of great economic loss and production declined to almost 16 tonnes in 2007 (Table, 1).

Shrimp farming production and exports

The area of shrimp farming rose from 2 ha in 1992 to more than 3,660 ha in 2001 before declining to 2,650 ha in 2002[9], increasing again to 3,600 and 4,270 ha in 2003 and 2004 respectively (Figure 1)[5]. Since 2005, the areas of operating farms have again started to decline and fell to almost 1,000 ha in 2007. However, more than 7,000 ha of farms were constructed and more than 11,000 ha were also under construction, although the active area did not increase more than 4,250 ha. Over the 1993-2004 periods, the number of farms increased from 12 farms to 310 farms, declining to almost 200 farms in 2006-2007. The average area of operating ponds per farm was less than 3 ha in 1993 and increased to almost 14 ha over the 2003-2006, declining dramatically to less than 6 ha by 2007 (Figure 2). Since 2001, farm gate price has declined almost 40% (Figure 3) and some companies have left the industry. In Iran, the inflation rate averaged between 12 to 24 percent over the 1997 to 2007 periods. The inflation rate was also negatively affected shrimp industry and caused for losses of companies.

Throughout the end 1990s, the shrimp sector grew dramatically in response to global demand. Iran produces 9,000 tonnes of farmed shrimp in 2004[6]. However, over the years 2002-2007, the exportation of cultured shrimp has

declined, due mainly to disease outbreaks. In 2000, 2003 and 2004, from both captured and cultured shrimp Iran earned (US$22.9 million, US$32.6 million and US$32.8 million) by exporting 7,860 tonnes, 6,630 tonnes and 7,680 tonnes of frozen shrimp respectively, while in 2005, 2006 and 2007, Iran exported only 1,920 tonnes, 2,980 tonnes and 2,290 tonnes and earned (US$7.2 million, US$13 million tonnes and US$8.7 million)[5,7,8].

Conclusions and recommendations

Since 2002, WSSV disease has caused losses of production and export income of shrimp farming industry in three main shrimp farming areas of coastal southern provinces in Iran. Overall, small-scale shrimp farmers in the coastal area in all southern provinces are presently in a poor state. The flow of capital between the shrimp farmers and related financial support activities has almost stopped. Measures need to be taken to assist shrimp farmers and other related industries such as hatcheries, feed factories and processing factories; otherwise this potentially valuable sector will disappear from this area. Recommendations include:

- Extension activities, which need to be within the farmers' reach. An informed extension service and a routine reporting system should be in place. Co-ordination of experts, extension workers, investment agencies and farmers is urgently required.

- Farm management and management strategies should be adopted at the conception of the shrimp farm, including pond preparation, the use of fine screens at inlets, maintenance of standard stocking densities and implementation of a water management system. In the

Table 1: Shrimp farming production in four coastal provinces over the 1993-2007 in south Iran.

Province	1993	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007
Khuzestan	8.6	35	114	491	850	2054	0	26	21	0	17	70
Bushehr	0.6	63	296	1,062	1,955	3,334	3,788	3,585	5,600	476	1623	876
Hormozgan	6.6	32	106	205	850	1,213	872	1,737	2,004	1,284	1,560	1,538
Sistan and Baluchestan	0.5	5	3	69	355	1,023	1,300	2,114	1,278	1,800	2,500	16
Total	16.3	135	517	1,858	4,010	7,624	5,960	7,462	8,903	3,560	5,700	2,500
Sources: Salehi, 2003, PDD, 2002, 2004 & 2005 and Fisheries of Iran, 2008.												

case of imported brood stock and post-larvae, proper checking should be carried out before importation is also allowed.

- Network building, including a co-operative network to address shrimp diseases should be further developed that includes research, extension, field investigation, information exchange and preventative measures.

- If it is possible, alternative income generation activities should be supported and provisions should be made for small-scale shrimp farmers and hatchery centers to explore, and engage in, alternative activities.

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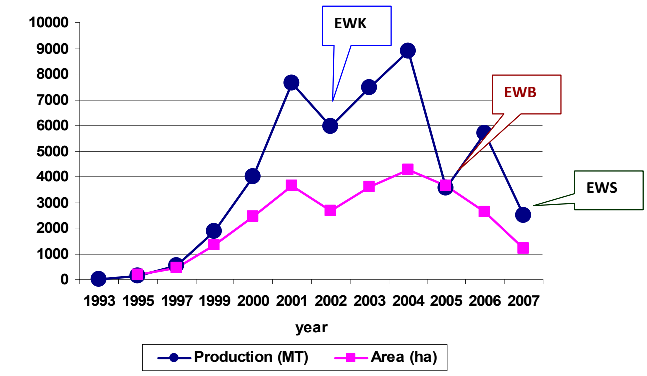
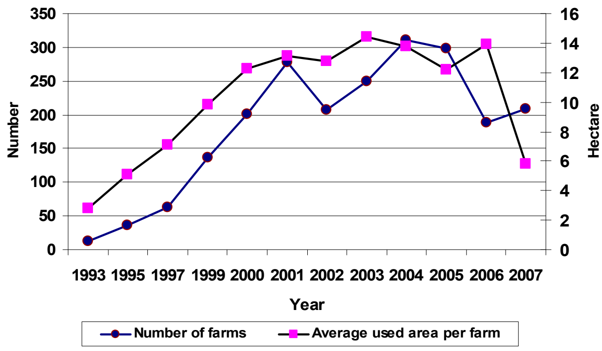
Figure 1: Area and production of shrimp farming from 1993-2007 in Iran.



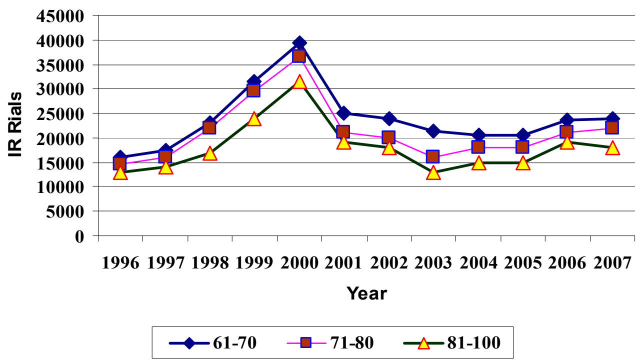
EWK= Effect of white spot syndrome virus in Khuzestan Province, EWB= Effect of white spot syndrome virus in Bushehr Province, EWS= Effect of white spot syndrome virus in Sistan and Baluchestan Province. Sources: Salehi, 2003, PDD, 2002, 2004 & 2005 and Fisheries of Iran, 2008.

Figure 2: Number of operating farms and average area of ponds per farm from 1993-2007 in Iran.



Sources: Salehi, 2003, PDD, 2002, 2004 & 2005 and Fisheries of Iran, 2008.

Figure 3: Farm gate price IR Rials per kg. of shrimp production from 1996-2007 in Iran.



Sources: Salehi, 2002 & 2003 and Fisheries of Iran, 2008.

Marine Finfish Aquaculture Network

Current practices of marine finfish cage culture in China, Indonesia, Thailand and Viet Nam

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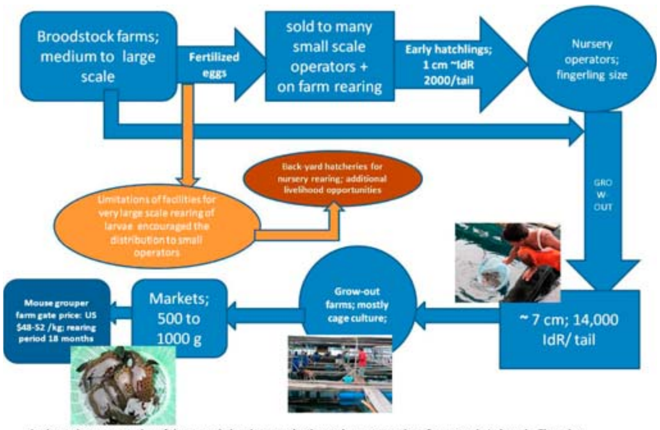
The regional project *Reducing the dependence on the utilisation of trash fish/ low value fish as feed for aquaculture of marine finfish in the Asian region* is being implemented in China, Indonesia, Thailand and Viet Nam under the auspices of the Technical Cooperation Programm (TCP) of the FAO of the UN. The Lead Technical Officer for the project from FAO is Dr. Mohammad Hasan, Fishery Resources Officer, FIRA, Department of Fisheries and Aquaculture of the FAO. The regional activities are coordinated by the Network of Aquaculture Centres in Asia-Pacific, headed by Professor Sena S De Silva. The article has been prepared based on the contribution from the country national project coordinators and has been edited by Mohammad Hasan and Sena S De Silva.

In contrast to most aquaculture practices, there is a steady increase in the diversity of marine finfish species farmed in the Asia-Pacific region. In the last two decades there have been a strong demand for high-value live reef fish in Asia, particularly by the live food fish restaurant trade (LFFRT) in China, Hong Kong, Singapore and Taiwan Province of China and also the rest of Southeast Asia, driven by improved economic conditions. Marine fish cage culture is now replacing capture fisheries for much sought after reef fish species, such as groupers, snappers and wrasses. Also the capture fisheries of such species tended to use destructive fishing gears, and this together with increasing fuel costs have resulted in a decline, and also a general reluctance of the public, to consume wild caught reef fishes.

In the early stages of the farming of important reef food fishes there was a high degree of dependence on wild caught seed. The supply of wild caught seed for cage culture, which also involves destructive fishing practices and quarantine risks makes it neither reliable in quantity nor quality. Closing the life cycle of some of the important farmed species, and the commercialisation of these practices, has gradually led to a very significant increase in the use of such seed stocks in the farming practices in the region. Some of the important species, the farming of which are based on hatchery reared seed stocks, albeit to varying degrees, are orange-spotted grouper (*Epinephelus coioides*), Malabar grouper (*E. malabaricus*), humpback grouper (*Cromileptes altivelis*), giant



A schematic representation of the stages in hatchery production and nursery rearing of groupers in Indonesia. The prices quoted are for mouse/ humpback grouper in Indonesian Rupiah

grouper (*E. lanceolatus*), tiger or brown-marbled grouper (*E. fuscoguttatus*), seabass (*Lates calcarifer*), snubnose pompano (*Trachinotus blochii*), Russell's snapper (*Lutjanus russellii*), and cobia (*Rachycentron canadum*).

On the other hand, marine finfish farming is still predominantly dependent on the direct use of trash fish/low-value fish, and remains a contentious issue on many grounds such as resource use, environmental pollution, irregular supply, poor feed conversion efficiency (high FCR) and energy/oil costs for capture. The ongoing FAO/NACA project on "Reducing the dependence on the utilisation of trash fish/ low value fish as feed for aquaculture of marine finfish in the Asian region" is expected to address these issues through a direct involvement of farmers in reducing the perception that the trash fish/low value fish perform better than pellet feeds. It is expected that the farmer based trials will lead to a transition phase from the use of one feed form to the other, and consequently contribute to overall sustainability of this sector in Asia, and preservation of the livelihoods of the farmers and trash fish suppliers. Indeed, the project will attempt to address whether the use of trash fish/ low-value fish directly as a feed is more detrimental than the use of commercial feeds. Accordingly, participatory trials for comparisons between commercial pellet feeds and trash fish in marine fish cage culture are being conducted in Zhanjiang, Guangdong Province in China; Lampung in Indonesia; Phuket, Phang-nga and Krabi provinces in Thailand and; Nha Trang, Khan Hoa Province in Viet Nam, supplemented with relevant livelihood surveys of fish farmers and trash/ low value fish suppliers.

This presentation is the first of a series, and attempts to evaluate the current mariculture practices in operation in the four countries participating in this project.

Marine fish culture operations in Asia

The marine finfish production in these four major producing countries dealt with here have significantly increased over the years and currently accounts for 394,580 tonnes, valued at nearly US$ 512 million, with China being the largest producer. The above production however, is achieved mostly through small, farmer owned / leased, operated and managed practices, as in most aquaculture practices in the Asia-Pacific region.

In Asia, there has been a considerable development of small-scale or backyard hatcheries for marine finfish species, as is the case for shrimp, that have only a couple of larval rearing tanks. These hatcheries use simple but effective technologies to produce seedstock of a range of marine finfish species for cage culture. The key for commercially successful hatcheries in Taiwan Province of China is to share the fertilised eggs among the small-scale hatcheries for mutual benefit. As grouper species usually spawn over a million eggs at any one time, it is often difficult for a hatchery to complete the larval rearing cycle by self due to a strong demand for live feed production, space and other facilities and intensive requirement of skilled labour in nursery rearing. Often the spawning time and frequency is unpredictable, and therefore mass production of live feed such as rotifer, *Chlorella*, *Tetraselmis* etc. for feeding hatchlings for one or more spawns at a time is often difficult. This small-scale model is similar to the grouper network developed by NACA which is now developing in ASEAN countries particularly in Indonesia and Thailand. The simplified and inexpensive technology of small-scale hatcheries also minimises the risk on heavy mortality caused by disease transmission, poor management by unskilled workers and other physical factors (e.g. power disruptions, shortage of feed and other supplies).

In China, medium-scale hatcheries are found mainly in Hainan Island while large-scale enterprises are found on mainland. Most farms are small to medium scale (10-100 cages per farm) with increasingly developed large-scale offshore cages. Traditional cages were generally developed from small-scale operations (4-20 cages) and subsequently expanded to medium size (20-100 cages) until becoming crowded and hence there are limitations of suitable space for operations.

Over 80% of hatcheries in Indonesia, particularly in Bali are small-scale. Fertilised eggs are produced by large-scale hatcheries that maintain broodstock and distribute eggs to many small-scale hatcheries for larval rearing and nursing using simple technology. Such small-scale hatcheries also have the capability to switch production between species such as for example between mouse grouper, tiger grouper, milkfish and shrimp depending on price and demand. Grow-out operations in cages in Indonesia is generally more medium-scale (20-100 cages) than small-scale (less than 20 cages) and large-scale (over 100 cages). As an island country, investment on cage farming is high due to requirements for more rigid structures suitable for deep water but the water quality is excellent.

Commercial seabass hatcheries in Thailand also supply fertilised eggs to small-scale hatcheries for similar reasons as above. In Thailand, small-scale or backyard hatcheries also engage in nursing of 1 cm Asian seabass fry produced from hatcheries, or wild caught grouper fry up to stocking size for cage culture. These operations are also capable of shifting between species, ranging from marine shrimp, freshwater prawn, seabass, grouper, etc. according to price and market demand, which is strong evidence of the resilience of these small-scale operators to meet the challenges of the market fluctuations. Cage culture in Thailand is mainly a small-scale operation which is commonly located inshore or in mangrove creeks, not far from farmers' houses for easy management by owners, security and saving of labour costs. Other advantages are that these offer convenient sites, savings on transportation and less mortality for partial harvest and supply to live fish markets in the main cities and tourist

Table 1. Aquaculture productions and values of economically important marine fish in 2007 (FAO, 2009).

Country / species	Quantity (tonnes)	Value (US$ 1,000)
China		
Japanese amberjack	11,528	13,603
Cobia	25,855	30,508
Groupers	42,854	50,567
Yellow croaker	61,844	72,976
Red drum	49,291	58,163
Flounder	66,549	78,528
Japanese seaperch	100,574	119,683
Total	358,495	414,028
Indonesia		
Asian seabass	4,417	6,802
Groupers	6,370	12,294
Total	10,787	19,096
Thailand		
Asian seabass	15,700	42,444
Groupers	3,000	18,433
Total	18,700	60,877
Viet Nam*		
Groupers	766	4,020
Snappers	1,069	5,005
Seabream	3,805	7,229
Asian seabass	750	1,875
Cobia	208	1,681
Total	6,598	17,934

** Data from Statistics Centre, Ministry of Agriculture & Rural Development, Vietnam.*

Inshore cages in Xe Cuan Bay, Hainan, China. Each raft with the living quarters is owned and managed by one family, and the main species cultured are grouper, pompano and cobia (Photo: S.S. De Silva).

spots. Over 80% of marine cages are small-scale (4-20 cages) while the rest are medium-scale (20-100 cages). Large-scale cage culture is always limited by insufficient fingerling supplies, irregular demand of the domestic live fish market and unreliable export markets. Many small-scale farmers also use gill nets to trap small fish to feed their farmed stock in order to reduce costs.

Over 30,000 small-scale cages have been reported in Viet Nam, with many in Halong Bay where they are well protected by strong winds and wave action. In the middle of the country, cages are more medium-scale which requires more investment for rigid structure against typhoons and storms.

There is evidence to suggest that small-scale operations run by owners / family for both hatchery and cage culture, are more suitable under the prevailing conditions than large-scale enterprises which are operated by paid workers. When problems occur, production can be discontinued, even for a long period without much economic suffering. Such family businesses are in contrast to large-scale, sophisticated operations, in which the cost of wages, power, supporting facilities and other overheads such as interest on bank loans, still has to be borne during closure periods. Periodic discontinuation of operations is, in fact, necessary for aquaculture in order to facilitate reconditioning, drying and disinfection of tanks, aeration and water system as well as outbreak of disease cycle in grow-out cages. In essence the above observations on marine finfish culture are very similar to that reported for shrimp culture in the region.

Culture practices in China

Since the late 1980s, Chinese mariculture has been growing very rapidly with a large increase in species and expansion of culture areas due to the government's open economic policy. Over one million traditional (mostly wooden) cages still account for the majority of marine cages along coastal provinces, e.g. Fujian (54%), Guangdong (15%), Zhejiang (10%), Shandong (7%), Hainan (5%) and others (9%). These traditional cages are small to medium-scale with a simple design (3-5m x 3-5m with 4-5m depth), made of locally available materials for the frame (bamboo, wooden board, steel pipe) and for floats (plastic container or drum and polyurethane foam) similar to other Asian countries. Cages are connected together to form a large floating raft in order to reduce the effects of wave action and strong currents. Cage rafts are commonly equipped with a mincer, high pressure pump, freshwater pipe, electricity and accommodation facilities for owner and workers.

Inshore (traditional) cage culture has been facing constraints, particularly in areas most conducive for cage culture, with good water exchange and easy access to services, due to limitations on suitable areas for expansion, typhoons, environmental pollution and disease outbreaks. Self pollution caused by accumulation of metabolites of fish and feed waste in crowded cage areas, leads to eutrophication and disease outbreaks. Therefore, offshore typhoon resistant cages are being developed to solve the above problems and to create new job opportunities for thousands of fishers who can no longer survive through fishing. The Chinese government and the relevant authorities strongly support this development both through policy and financing. Since the late 1990s, offshore cages from Norway, USA, Japan have been introduced and modified to suit local conditions and the economic situation in China.

Accordingly, large floating and submersible circular cages made of high-density polyethylene (HDPE) are now locally produced at a very cheap price (less than US$ 15 per m3). Circular cages generally withstand the rough sea conditions better because the HDPE frame is more flexible than wooden and or metal frames. It can be submerged up to 4-10 m below the sea surface within 8-15 minutes if typhoon conditions prevail. Due to higher stocking density and production, farmers are able to maintain economic viability even though the profit margin is less. The reduction in sale price of the fish also attracts more consumers in both domestic and potential export markets. However, the expansion of offshore cage culture is also limited by the availability of hatchery bred seed stocks because the demand of fingerlings for stocking per cage is much higher than traditional inshore cages. The feed cost is still high because suitable pellet specific for different fish species has not yet been developed. There is also likely occurrence of high feed loss through the net in strong current conditions of deep sea for slow feeding species like grouper. The common species for stocking in offshore circular cages are cobia and giant grouper which are fast growing hatchery bred species.

Offshore (1 to 1.5 km from shore) cages in Zhanjiang, China, culturing mostly cobia and giant grouper.

As China has a large marine area covering both temperate and subtropical waters, there are more than 65 species that are being cultured, but these are in different stages of development. In south-east China, the large yellow croaker (*Pseudosciaena crocea*), groupers and cobia (*Rachycentron canadum*) are the most important cultured species, while Japanese flouder (*Paralichthys olivaceus*) dominates in the northeast. On the other hand, the Japanese seaperch (*Lateolabrax japonicus*) and red seabream (*Pagrosomus major*) are important to both regions. A few species have also been introduced and include red drum (*Sciaenops ocellatus*) from the US and turbot (*Scophthalmus maximus*) from Europe. Those species except groupers are commonly bred in commercial hatcheries. The high valued grouper species which have been successfully bred in hatcheries, include Hong Kong grouper (*E. akaara*), yellow grouper (*E. awoara*), orange-spotted grouper, Malabar grouper but the volume of seed produced by hatcheries in Hainan, Fijian, Guangzhou (Daya Bay), etc, has not been able to meet the demand for seed stock for cage culture. Traditionally, fish are fed with minced trash fish/low valued fish as much as 3% to 5% biomass daily. Trash fish is sourced from deep sea trawlers. Trash fish/low valued fish prices vary from US$ 0.20 to 0.53/kg and is not fresh as in other countries. Generally, there is a shortage of trash fish/low valued fish during summer and winter. Therefore some farmers buy commercial fish powder, starch, corn, soybean, wheat and other ingredients and mix it with fish oil, water and vitamins to produce a farm made feed.

Table 2. A comparison of a number of relevant parameters between inshore (traditional) and offshore cages (Chen et al., 2006).

	Traditional	Offshore
Survival rate of fish (%)	70	>90
Cage volume (m^3)	<100	>1,000
Capacity against wind (km/hr)	<100	>110
Capacity against current (m/s)	<1	<1.5
Capacity against wave-height (m)	2	>6
Life span of cage (year)	<3	>10
Suitable site	Sheltered inshore areas	Offshore
Yield (kg/m^3)	Around 5	>20

Table 3. Summary of practices of marine fish cage culture in China (SD - stocking density; HS - harvest size; CP - culture period; FGP - farm gate price).

Species	SD /m^3	Seed sources	CP (month)	HS (kg)	Survival (%)	Production (kg /m^3)	FGP (US$/kg)
Groupers	50	Hatchery, wild, imported	8-14	0.5	40	15	10
Snappers	50	Hatchery, wild	8-12	0.5	70	15	6.4
Pompano	60	Hatchery, imported	6-10	0.5	80	20	3.5
Cobia	7	Hatchery	8-12	3	85	15	3.5-4.5
Asian seabass	45	Hatchery, imported	6-10	0.6	85	20	2.5
Seabream	40	Hatchery, wild	8-12	0.5	75	10	5.8

There are four main types of feed in use including trash fish, moist diets, farm made feeds and artificial diets. There have been many locally produced formulated feeds for common marine fish but the results for grouper culture show that they are not as efficient or economic as trash fish. Though farmers have accepted these feeds (US$ 0.75-0.85/kg) for cobia, pompano and seabream culture, the FCRs are still high. The daily feed ration for marine fish depends on ambient water temperatures. In winter and spring, it is generally reduced by 2-3 times than in summer and autumn.

Medium-scale cages (40 to 80 cages operating at any one time) in Lampung, Indonesia.

Culture practices in Indonesia

Indonesia has a major development potential due to its vast potential areas, mostly inshore sheltered bays etc. for mariculture. Production of the high value species makes a significant contribution to export earnings, domestic food supply and aquatic resources conservation. Mariculture, brackishwater pond culture, freshwater pond culture, cage culture, culture in floating net cages and paddy field culture accounted for 20.0, 41.0, 22.9, 3.3, 4.7 and 7.7 percent, respectively of the total aquaculture production in the country. Grouper and other high valued marine carnivorous species contributed much to this increase in aquaculture production.

There are a number of marine fish species widely cultured in cages such as mouse or humpback grouper (*Cromileptes altivelis*), tiger grouper, Asian seabass (*Lates calcarifer*), primarily driven by the commercial success in artificial breeding of such species in Lampung and Gondol (Bali) hatcheries, followed by uptake of the technologies by private hatchery operators. Mouse grouper fingerlings of are also valued in the marine ornamental trade which is commonly exported to USA, EU, Singapore, Hong Kong and China. Recently, leopard coral trout (*Plectropomus leopardus*), giant grouper, orange-spotted grouper, camouflage grouper (*E. polyphekadion*), pompano, Napoleon wrasse (*Cheilinus undulatus)*- a CITES listed species , and golden trevally (*Gnathanodon speciosus*) have also been produced in government hatcheries and growout trials for these species are being conducted by Indonesian fish farmers.

A stationary trash fish trap, a traditional method of fishing, in Lampung, Indonesia. In Lampung Bay these are fairly common, and in the recent years these have been further modified and made mobile in a manner similar to purse seine operation dragged by two boats.

Over 125 marine finfish hatcheries are now operating in Bali, Lampung and East Java. These hatcheries have the capability to switch to species depending on market demand, such as in the case of milkfish and mouse grouper. However, still the culture of orange spotted grouper, Malabar grouper, dusky tail grouper (*E. bleekeri*), red snapper (*L. argentimaculatus*), rabbit fish (*Siganus* spp.) is mostly dependent on wild seed stocks, collected in Sumatra, Java and Sulawesi.

Large-scale cages (> 200 cages operating at a time), Lampung, Indonesia.

Small-scale cages in Phang-nga canal, Thailand.

Marine fish cage culture in Indonesia is carried out in many areas as there are several well sheltered bays and water quality is generally good compared to other countries in Asia. Cage culture can be found throughout Indonesia, including the islands of Sumatra, Bangka, Bengkulu, Lampung, Kepulauan, Seribu, Banten, Java, Lombok, Kalimantan and Sulawesi. Most cage farms in Lampung are relatively medium and large-scale operations (80-120 cages) and well constructed with wooden walkways, often shaded, house (accommodating 6-10 workers) and equipped with electricity, freshwater supply and high-pressure pumps for net cleaning. Fish are held in net cages typically 4-18 months depending on the size of the cultured species. There have been a few commercial pellet feeds (such as Comfeed, Matahari, Cargil, CP, etc.) developed for marine fish culture with the price around US$ 1.0-1.2/kg but the results are still not economically profitable and generally not well accepted by the farmers. In most parts of Indonesia trash fish / low valued fish is sourced through fish traps and or small-scale gill net around cage farming areas and these are still readily available at a relatively low price (US$ 0.1-0.2/kg) and in a fresh condition. In other areas or during storm season, the price of trash fish of the same quality may rise up to US$ 0.3-0.5/kg. In general, in Indonesia, the sourcing of trash fish / low valued fish for mariculture operations provides many thousands of jobs.

However, there are constraints to cage culture including access to markets, fluctuation of prices, irregular hatchery supply, lack of suitable feeds for grow out and diseases particularly viral nervous (VNN) and iridoviruses.

Culture practices in Thailand

The main cage culture species in Thailand are Asian seabass, orange-spotted grouper, tiger grouper, areolate grouper (*E. areolatus*), Malabar grouper, dusky-tail grouper, coral trout, giant grouper, red snapper and cobia. Seabass, orange-spotted grouper, tiger grouper, leopard coral trout, giant grouper and cobia have been successfully bred in hatcheries to varying degrees while the rest are still reliant on wild seed collection. In Thailand, marine fish farming is practiced in the coastal areas along the Gulf of Thailand and the west coast (Andaman Sea). Due to better water quality and water exchange, the Andaman coast has a greater potential for future development but there are less sheltered areas. Seabass cages are mainly located along the river mouths or canals because this species can tolerate lower salinity or even freshwater.

The preferred size for stocking in cages in Thailand is over 10 cm since mortality is reasonably low. Therefore, it is necessary to nurse both hatchery bred and wild caught fingerling (1-2.5 cm) in small net cages (1x1x1.5 m^3), earthen ponds (800-1,600 m^2) and concrete tanks (5-10 ton) in small-scale (backyard) hatcheries prior to stocking in cages.

There are two types of fish cages including stationary (mainly for seabass) which is suitable for shallow water, not deeper than 2.5 m along the river, canal and lake with less than 1 metre tidal fluctuation, and floating which is commonly located in deeper water of coastal area.

Stationary net cages are anchored at four corners by wooden or bamboo poles and is not movable. Floating cages located at the mouth of rivers and canals use low cost materials such as wooden or bamboo poles for the frame while cages in open water use wooden board or steel frame. Polyurethane foam covered by mosquito net is more common for making float of cage than plastic drum due to its lower cost.

Table 4. Summary of marine fish cage culture practices in Indonesia (SD - stocking density; HS - harvest size; CP - culture period; FGP - farm gate price).

Species	SD/m^3	Seed Source	CP (month)	HS (kg)	Survival (%)	Production (kg/m^3)	FGP (US$/kg)
Tiger grouper	15-20	Hatchery	9-12	0.5-0.7	80-90	7.5-8.0	8-10
Red snapper	15-20	Wild, hatchery	9-10	0.5-0.6	80-90	7.5-10.0	3-4
Coral trout	15-20	Hatchery, wild	12-14	0.5-0.7	70-80	7.5-8.0	18-20
Mouse grouper	12-15	Hatchery	18-20	0.4-0.6	60-80	6.0-7.0	45-48
Cobia	3-5	Hatchery, imported	10-12	4.0-5.0	80-90	8.0-10.0	3.5-4.0
Asian seabass	15-20	Hatchery	9-10	0.5-0.6	70-90	7.5-10.0	3

Table 5. Summary of procedures adopted in nursing of marine fish fingerling to juvenile in Thailand.

Nursery type	Stocking density (pc/m²)	Stocking size (cm)	Nursing period (days)	Harvest size (cm)
Net cage	300-500	5.0	60-75	12.5-15.0
Earthen pond	25-100	2.5	75-90	10.0-15.0
Concrete tank	50-100	1.0-2.5	60-75	5.0-10.0

Table 6. Summary practices of marine fish cage culture in Thailand (SD - stocking density; HS - harvest size; CP - culture period; FGP - farm gate price).

Species	SD/m³	Seed sources	CP (month)	HS (kg)	Survival (%)	Production (kg/m³)	FGP (US$/ kg)
Tiger grouper	5-7	Hatchery	10-12	0.4-0.7	70-75	1.8-3.7	9.0-10.5
Orange spotted grouper	5-7	Hatchery, wild	8-12	0.4-0.7	70-80	1.4-3.9	5.0-7.0
Cobia	1-2	Hatchery	12-15	5-8	80	4.0-12.8	3.0
Red snapper	5-7	wild	8-10	0.5-0.7	80	2.0-3.9	4.5-6.0
Asian seabass	5-7	Hatchery	6-8	0.6-1.0	80-90	2.4-6.3	3.5-5.0

Locally developed commercial floating pellets including CP, Thai Union, Chaipatana, etc, are used for grow out of some of marine fish species and are available at US$ 1.2-1.4/kg but farmers still believe that growth performance and profit margins are not as good as feeding with trash fish / low valued fish (US$ 0.30-0.40/kg). Trash fish are usually chopped by machine to save labour cost. There are many problems in grouper culture including lack of a reliable seed supply, disease outbreaks, and high investment for improving cage structure, lack of trash fish, good pellet and export market.

Culture practices in Viet Nam

Viet Nam has the potential to significantly increase the development of the marine fish-culture industry due to the strong export market. The total finfish aquaculture production from cages was over 6,500 tonnes in 2007. The main areas for cage culture production in 2007 was in the north, e.g. Quang Ninh Province (4,200 tonnes from 9,000 farms) and Hai Phong (1,900 tonnes from 7,280 farms). There were more than 40,000 cages which mainly farmed lobster and also produced marine fish, more than 1,000 tonnes in Khan Hoa and nearby provinces in central and southern Viet Nam. The main marine finfish species used in cage culture are orange-spotted grouper, tiger grouper, green or greasy grouper (*E. tauvina*), glass-eyed perch (*Psammopeca waigiensis*), seabream, cobia, red snapper, seabass, pompano and red drum (*Scianops ocellatus*), and seed stocks are obtained from both government and private hatcheries. There has been considerable investment in hatcheries, particularly by the government and enterprises from Taiwan Province of China, from where fertilised eggs at early stages of development are usually imported. The cultured species that are still dependent on wild caught fry include Malabar grouper, dusky-tail grouper, areolate grouper, Hong Kong grouper, yellow grouper (*E. awoara*), crimson snapper (*L. erythropterus*), red snapper and rabbit fish (*Siganus* spp.). Wild caught fingerlings are also exported by boat to China (including the mainland, Hong Kong, Taiwan Province of China and Hainan Island) but the quantities have gradually decreased.

Most cage farms are located in fishing villages where they can easily obtain, relatively cheap supplies of fresh trash / low valued fish. Large-scale Norwegian circular cages for cobia using imported feed from Canada (EWOS) and Chile (BioMar) have been developed in Nha Trang and followed by locally developed large cages in Nghe An and Vung Tau. The fry were originally imported from Taiwan Province of China and later produced locally. However, cobia culture is encountering problems with low prices and limited markets. Although Viet Nam has more than 30 feed mills producing a substantial amount of feeds for aquaculture there is no domestic production for feed for marine finfish. Therefore, most of feeds are imported from Norway (EWOS) for cobia and grouper, from Thailand (CP) for seabass and Taiwan PC for cobia and grouper. More than 90% of marine fish farms still use trash fish (US$ 0.4-0.5/kg) caught by small fishers and delivered to cages daily by boat as fresh feed and moist feed.

There are still several constraints including hatchery development, nursery technologies, feed development, disease control, health management and market expansion impeding mariculture development in Vietnam. As more than one million tonnes of trash fish is currently used as direct feed in aquaculture in Viet Nam, it is urgently needed to develop artificial feed to prevent the shortage of trash fish in the future.

Medium-scale cages in Nha Trang, central Viet Nam.

Markets for marine fish

Small-scale cages in Nha Trang, central Viet Nam.

Live food fish trade in Asia is still very much a growing sector due to the boom in tourism, improved incomes, improving transportation means and strong and traditional preference for live and fresh fish. Reduction in retail prices brought about by the increase in aquaculture productions also attracts more consumers. Over 10,000 tonnes of high valued live marine fish were imported both by air and sea from Australia, China, Indonesia, Malaysia, Philippines, Taiwan Province of China, Thailand, Viet Nam and Maldives to the largest market in Hong Kong which is also an important distribution centre to China.

China is the largest producer and consumer of marine fish in the world. In line with the country's rapid economic development, the market demand for marine fish in China is very high, especially the demand for live high valued species, catering to the live food fish restaurant trade. Directly imported high value live coral reef fish or brought in via Hong Kong are mainly targeted for high-end seafood restaurants in major cities such as Shanghai, Guangzhou and Beijing. The world's largest wholesale markets in Shanghai and Guangzhou play an important role in distribution of seafood throughout the country. Marine fish are transported both by air and by land. China is also the largest live fish exporter in the world, particularly finfish (seabream, basses, grouper) and eel to Japan, Hong Kong, Korea and Macau.

In Indonesia, the regional trade of adult fish and fingerling is considered to be economically important, particularly its exports to Taiwan Province of China, Hong Kong and Singapore both by boat and by air. The major species for export include leopard coral trout, humpback grouper, tiger grouper and orange spotted grouper. Domestic consumption of live fish is not much but it is improving, particulary in Bali, Jakarta, Yogyakarta, Medan and Surabaya.

In Thailand, seabass market is mainly live and chilled forms for local consumption and is exported to Singapore and Malaysia by land but live grouper is mainly exported only by air to Hong Kong, Taiwan Province of China and mainland China. Export species include orange spotted grouper, tiger grouper and leopard coral trout. However, Hong Kong considers Thai grouper as low grade product (pale color and muddy taste) due to their culture in low saline water or mangrove creeks. Shipment by air also burdens the cost for Thai exporters as they cannot compete with fish transported by sea from Viet Nam, Taiwan Province of China or even Indonesia. Thailand used to export millions of hatchery bred seabass and wild caught grouper fry to Hong Kong, China (through Hong Kong) and Taiwan Province of China. Since they have been successfully bred and mass cultured in those importing countries, it was not necessary to import both fry and adult fish from Thailand anymore. Though there are few problems on hatchery and culture practice, seabass culture still faces major constraints due to the lack of export markets of both live and frozen fish. Farmers also consider not be economically profitable to grow large size seabass (1.5-3.0 kg) for export of frozen fillets due to stunting on reaching 1.0 kg.

A strong export market is the driving force for the growth in aquaculture in Viet Nam. Exported species include orange spotted grouper, greasy grouper, areolate grouper and Malabar grouper. Because of Vietnam's relative proximity to large markets in Hong Kong, Taiwan Province of China, Hainan and western / southern China, live fish are mainly traded by boats which is more cost effective, and commands a decisive advantage over other ASEAN countries. There is also a growing demand of live or chilled fish in the domestic market as personal income have been improved substantially over the years after Viet Nam has adopted market economy.

To expand marine fish as a global commodity to the huge frozen market in other regions, it is necessary to develop suitable species, particularly fast growing and low production cost species in order to produce fillet or frozen whole fish

Table 7. Summary practices of marine fish cage culture in Viet Nam (SD - stocking density; CP - culture period; HS - harvest size; FGP - farm gate price).

Species	SD/m^3	Seed Sources	CP (month)	HS (kg)	Survival (%)	Production (kg/ m^3)	FGP (US$/kg)
Seabass	20	Hatchery, wild	8	1.0	76.5	10-15	2.5
Red drum	20-30	Hatchery	12	0.8-1.0	70-80	15	NA
Cobia	2.5	Hatchery	12-18	8.0-10.0	80	15-20	3.5-4.5
Groupers	13.8	Hatchery, wild	12-15	0.6-0.8	60-80	8-15	7.0-8.8
Red snapper	6.3	Wild	10-14	0.8-1.0	70-80	5.0-15	4.1
Pompano	15.6	Hatchery, wild	10-14	0.8-1.2	80	15	3.5-5.8

which yield lower price than live or fresh fish, similar to salmon, tilapia, catfish and shrimp. Cobia and giant grouper are the candidates but it is necessary to lower the feed cost and to promote them in international markets, particularly in US and EU supermarkets and in restaurant chains. Meanwhile, governments and relevant authorities should also promote domestic consumption similar to the success of *Penaeus vannamei* in China and Thailand. Though the profit margin of the domestic market is smaller it is more s than export markets, which always encounter problems of competition in production and price fluctuations due to extraordinary events.

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Effects of different trash fish with alginate binding on growth and body composition of juvenile cobia (*Rachycentron canadum*)

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The cobia (*Rachycentron canadum*) is a carnivorous fish. It can grow with good feed conversion efficiency in offshore net cage systems from fingerling to marketable size (4–6 kg) in one year with high survival and its white flesh is suitable for sashimi[1].

In cobia farming, trash fish are used as the main source feed for cobia grow-out. Farmers usually put trash fish direct into the cages. This causes a loss of nutrients out of the water environment leading to increased feed conversion ratio (6 – 8) and the risk of environmental pollution[7,8,13]. In addition, the difficulties in storing and variable nutritional quality are the main constraints for cobia culture[16]. In Vietnam, the pellet feeds has been developed and used in cobia culture, but due to difficulties in feed supplying and high prices so the farmers still tend to use trash fish in cobia farming because of stable supplies and low prices[13]. However, the low lipid content in trash fish can affect the lipid concentration of cobia thus reducing the quality of products and market acceptance.

Alginate has been used as binder in feeds for aquatic animals for a long time, when the use of wet or moist feed was common[10,11]. It has previously been shown that feed containing alginate stimulates the immune system resistance to diseases in red seabream, Pagrus major[9]. This study was carried out to determine effects of using trash fish with alginate binding on feed utilisation and body composition of juvenile cobia.

Materials and methods

Formulating moist diets

Three species of trash fish: A – anchovy; L – lizardfish; C - cardinalfish) and those combinations (50 % A + 50 % L; 50 % A + 50 % C and 50 % L + 50 % C) were formulated into six diets. Raw fish was ground and extruded by an extruder. Sodium alginate was used as a binder for all moist diets at a concentration of 3%. After extrusion, the moist diets were submersed in 10% $CaCl_2$ solution to gel through the strong binding of calcium and alginate for 10 minutes. Feeds was sealed in vacuum packed bags and stored frozen (-20°C) until feeding.

Fish rearing

Juvenile cobia were bought from a commercial farm in Nha Trang - Vietnam. Fish were acclimated with a commercial diet (45% crude protein, 16% lipid) for two weeks before starting of the trial, and then fish (mean weight 29 g) were randomly distributed to each of 18 tanks with 10 fish per tank. Fish were fed to satiation in 30 minutes, twice daily at 08:00 and 16:00. The feeding trial lasted for six weeks. Temperature and salinity in tanks were monitored daily, while pH and ammonia and oxygen were monitored once every three days. Animals were kept under natural photoperiod conditions. During the experimental period, temperature was 28 - 30°C, salinity was 28-30 ‰, pH: 7.5-8.5, ammonia was lower than 1 mg L^{-1} and dissolved oxygen was not less than 5.0 mg L^{-1}.

Sample collection and analysis methods

At the end of the six week feeding trial, fish in each tank were individually weighed and sampled for muscle analysis 24 hours after the last feeding. Three fish from each tank were randomly sampled and frozen at -30°C for whole body composition analysis. Crude protein was determined using the Kjeldahl nitrogen method and calculated as N x 6.25. Lipid content was determined gravimetrically following ether extraction. Total ash contents were calculated gravimetrically following ignition of samples in a muffle furnace at 550°C until constant weight. Dry matter was calculated by oven drying at 105°C until constant weight.

The parameters were calculated as follows:

- Weight gain (WG %) = 100 × (final body weight − initial body weight)/initial body weight
- Survival (%) = 100 × (final amount of fish)/(initial amount of fish)
- Specific growth rate (SGR) =100 × ln(final weight/ initial weight)/days of the experiment
- Feed conversion ratio (FCR) = feed consumed (g, DW)/ body weight gain (g)

Results were expressed as mean ± standard of deviation (SD) and group mean difference were compared using one–way ANOVA. When there were differences, the group means were further compared with Duncan's multiple range test. All computations were performed with SPSS 17.0. A significant level of $P < 0.05$ was employed at all cases.

Results

Results of growth and feed conversion ratio of the juvenile cobia fed different trash fish are shown in Table 1. The different diets had significant differences on weight gain; specific growth rate; feed conversion ratio and survival

of juvenile cobia ($P < 0.05$). The weight gain and specific growth rate were highest when using the C diet and had significant difference with other diets. The results showed that cardinalfish was most suitable for cobia farming in Vietnam.

Whole body proximate composition of cobia was presented in Table 2. Different trash fish significantly affected on crude protein, crude lipid and moisture of cobia ($P < 0.05$). There was no difference in ash concentration of cobia among groups. Compared with body composition of cobia at beginning trial, crude protein, lipid and ash concentration of cobia decreased while moisture concentration increased at the end of experiment.

Discussion

A recent study in Viet Nam concluded that there is rapidly increasing demand for trash fish for aquaculture. In 2003, there were over 175,790 tonnes of trash fish that was used in aquaculture[13]. In cobia farming, trash fish was used as main feed for cobia farming. Farmers usually put trash fish direct to the cages. This causes a loss of nutrients out of the water environment leading to increased feed conversion ratio (6 – 8)

Table 1. Weight gain, specific growth rate (SGR), feed conversion ratio (FCR) and survival of the cobia fed experimental diets

Diet	Initial weight (g)	Weight gain (%)	SGR (%/day)	FCR	Survival (%)
C	29.93 ± 0.81	421.67 ± 44.89b	3.93 ± 0.21b	3.17 ± 0.06a	83.33 ± 20.82b
L	30.73 ± 0.64	222.32 ± 24.03a	2.78 ± 0.18a	3.27 ± 0.30a	76.67 ± 5.77ab
A	30.00 ± 2.00	216.69 ± 7.95a	2.74 ± 0.06a	4.87 ± 0.25c	83.33 ± 5.77b
A:C	29.83 ± 1.66	226.81 ± 23.81a	2.82 ± 0.18a	3.36 ± 0.11a	73.33 ± 15.28ab
L:C	29.71 ± 2.15	243.30 ± 29.71a	2.93 ± 0.21a	4.18 ± 0.07b	56.67 ± 11.55a
A:L	28.41 ± 1.23	215.83 ± 27.93a	2.73 ± 0.21a	4.33 ± 0.28b	73.33 ± 5.77ab

Data in the same row with different superscripts differ at P < 0.05.

Table 2 Whole body proximate composition of the cobia fed experimental diets

Diet	Crude protein (%)	Crude lipid (%)	Ash (%)	Moisture (%)
Initial	22.42 ± 0.82	8.44 ± 1.06	4.93 ± 0.42	65.52 ± 0.77
C	16.76 ± 0.57b	4.43 ± 0.37bc	3.80 ± 0.64	73.24 ± 1.00b
L	16.06 ± 0.48b	3.57 ± 0.47abc	4.05 ± 0.54	75.12 ± 0.40 bc
A	16.10 ± 1.14b	3.25 ± 0.77ab	3.92 ± 0.28	74.07 ± 1.79 bc
A:C	16.66 ± 1.09b	3.04 ± 0.33a	4.04 ± 0.23	75.85 ± 0.49c
L:C	16.46 ± 0.64b	4.54 ± 0.05c	4.49 ± 0.30	70.10 ± 1.22a
A:L	11.34 ± 1.17a	4.28 ± 1.22abc	4.44 ± 0.05	75.23 ± 1.37bc

Data in the same row with different superscripts differ at P < 0.05.

and the risk of environmental pollution[7]. According to Tacon[12], the alginates with low soluble calcium could be used as effective and low-cost binding agents for raw trash fish or moist combination. In the present study, trash fish is bound by alginate before feeding. This reduces the amount of nutrients lost to the environment and improves the feed conversion ratio of juvenile cobia (3.17 – 4.87). Similar results were also noted by some other authors[5,6].

Juvenile cobia.

Lipid is an important nutrient in diet as the source of energy and essential fatty acids[15]. The diets has high lipid content can lead to decrease feed consumption and reduce the utilisation of other nutrients resulting to reduced growth[4,14,15]. However majority of culturing cobia is consumed as sashimi1 so it is desirable to increase the lipid content in muscle through feeding high lipid diets. This was reported by some authors[2,14]. In present study, the lipid concentration in cobia at the end of experiment are 3.04 - 5.84 %, it is lower than lipid content of cobia before experiment (8.44 %). According to Huy[7] using trash fish that had low lipid content in cobia farming caused lipid reducing in muscle of cobia, thereby reduced quality and price of products. The growth performance of juvenile cobia in present study was better than cobia that used pellets feed but the results of body proximate composition of cobia indicated that trash fish could be suitable for cobia farming but its lipid content need to be improved before feeding for cobia.

This study shows that using trash fish with alginate as binder could have excellent opportunity to improve the utilisation of the resources and feed costs in places where natural conditions are suitable. It would be interesting to examine the effects of these diets on growth, intestine morphology and body composition of cobia for longer period of time.

Acknowledgments

The study was funded by the Norwegian Agency for Development Cooperation (SRV-2701 project). The authors would like thank the Institute of Aquaculture Research and the Nha Trang Institute of Technology Research & Application for supplying facilities and collaboration in this study.

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NACA Newsletter

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April-June 2010

Expert Workshop on Inland Fisheries Resource Enhancement and Conservation in Asia

Participants in the workshop at Pattaya, Thailand.

Over the past few decades inland fisheries resources have come under increasing pressure from water engineering projects, pollution and overfishing. This has lead to an alarming decline in the natural populations of many important inland fish species in Asian countries, with implications for the economic welfare and nutrition of millions of people that are dependant on these resources, for the environment, and also for the aquaculture industry that depends on the genetic resource base.

Regional collaborative efforts are required to facilitate assessment of current inland fisheries resource enhancement and conservation practices, and there are transboundary coordination issues for countries that share rivers.

FAO and NACA convened an expert workshop to review inland fisheries resource enhancement and conservation practices in Pattaya, Thailand, 8-11 February. Experts from 10 Asian countries attended the meeting to share experiences and lessons learned. The papers and synthesis from the workshop will be published by FAO in due course, but in the meantime high-quality audio recordings of the workshop presentations are available for download from the NACA website in MP3 format. You can also stream them from our server if you prefer to listen to them online.

Country presentations on inland fisheries enhancement and conservation practices are available for Bangladesh, China, India, Indonesia, Republic of Korea, Myanmar, Nepal, Sri Lanka, Thailand and Vietnam. To download / listen to the presentations, please visit:

http://www.enaca.org/modules/news/article.php?storyid=1867

The Secretariat is pleased to announce that NACA will be offering audio recordings of key technical presentations for free download as a matter of course from now on, to increase the accessibility of this material throughout the region. A 'podcasting' feed is also in development.

Reviews in Aquaculture: Special issue on the Use and Exchange of Aquatic Genetic Resources

The new journal 'Reviews in Aquaculture' has published a special issue on the use and exchange of genetic resources of cultured aquatic animals and the articles are available for free download.

The papers in this issue are the result of a consultation NACA facilitated on behalf of the Commission on Genetic Resources for Food and Agriculture (CGRFA) of FAO, which was conducted in April 2009, in Chonburi, Thailand.

The issue also contains a synthesis paper on aquatic genetic resources that was tabled at the twelfth regular session of the CGRFA in October, 2009, Rome.

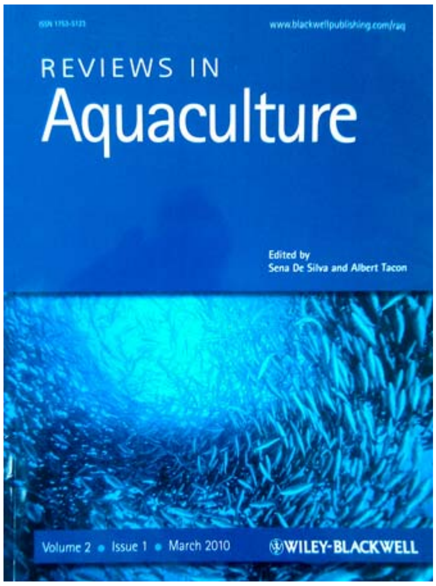
This is the first time that aquatic genetic resources have been included in the portfolio of the Commission, giving recognition of the growing importance of the sector for sustainable food production. Contents of this issue include (PDF articles):

- Editorial - Use and exchange of aquatic genetic resources in aquaculture: information relevant to access and benefit sharing
- Use and exchange of aquatic resources relevant for food and aquaculture: common carp (*Cyprinus carpio* L.)
- Use and exchange of salmonid genetic resources relevant for food and aquaculture
- Use and exchange of genetic resources of Nile tilapia (*Oreochromis niloticus*)
- Use and exchange of aquatic genetic resources for food and aquaculture: *Clarias* catfish
- Patterns of use and exchange of genetic resources of the striped catfish *Pangasianodon hypophthalmus* (Sauvage 1878)
- Use and exchange of genetic resources of penaeid shrimps for food and aquaculture
- Use and exchange of genetic resources in molluscan aquaculture
- Use and exchange of genetic resources of emerging species for aquaculture and other purposes
- Chinese abstracts

The issue may be accessed / downloaded from:

http://www.wiley.com/bw/journal.asp?ref=1753-5123

Other issues of Reviews in Aquaculture are also being made available for free download during the journal's start up phase, so keep an eye out for more to come.



Dr Ayyappan becomes the Director General of ICAR

Dr S. Ayyappan has been appointed to the post of Director General of the Indian Council of Agricultural Research (ICAR), with effect from 1 January 2010. With this appointment. Dr Ayyappan also becomes the Secretary of the Department of Agriculture Research and Education (DARE).

ICAR, one of the largest R&D institutions dedicated to agricultural research has 5,000 scientists working in 45 institutes, 17 National Research Centres, 4 Deemed Universities, 6 National Bureaus, 25 Directorates and Project Directorates, 569 Krishi Vigyan Kendras, 44 state agricultural universities across the country and one Central Agricultural University at Manipur.

Dr Ayyappan obtained his B.F.Sc and M.F.Sc degrees from College of Fisheries, Mangalore and PhD from Bangalore University. In his distinguished career of over 30 years, he has headed two ICAR institutions namely CIFA and CIFE, before becoming the Deputy Director General of Fisheries in ICAR in 2002. He is a well known scientist and has contributed immensely to the development of fisheries and aquaculture in India.

Dr Ayyappan is well known to the NACA family of 18 governments in Asia Pacific. He has served NACA as its TAC and GC member for several years. NACA is very pleased and proud that a fisheries scientist has reached the highest position in the ICAR system in a big country like India. On behalf of member countries, NACA Secretariat wishes Dr Ayyappan all the best in his future endeavours.

CIBA training course - capacity building on entrepreneurship development in coastal aquaculture

Coastal Aquaculture inter-alia offers scope for a variety of entrepreneurial activities that can generate value or contribute to the economy, such as identifying and exploiting new species, processes or markets. Identifying potential entrepreneurs and giving them an enabling environment is the role of government and other development departments that seek to support entrepreneurship in coastal aquaculture. To take initiative in this direction, the Central Institute of Brackishwater Aquaculture (CIBA) of the Indian Council of Agricultural Research (ICAR) conducted a national level training course on 'Entrepreneurship Development in Coastal Aquaculture' from 26-31 October 2009 at its campus in Chennai, with funding support from the National Fisheries Development Board. Twenty five participants comprised of three main groups (i) officials from the Departments of Fisheries of various maritime states, (ii) personnel from non-governmental organisations and (iii) potential entrepreneurs participated in the training course.

Training at a crab hatchery.

Entrepreneurial avenues in seven areas of coastal aquaculture sector were identified and included in the training module. The seven areas were: Seed production of shrimp, crab and finfish; farming of shrimp/ prawn and finfish; ornamental fish farming; shrimp and finfish feed production; disease diagnostics & analytical services; domestic fish marketing and ICT aided technical and marketing consultancy.

Training at a fish hatchery.

Identifying and developing new products, processes and markets were given emphasis in the training course. The training adopted a tripartite learning approach. The first technical part of the module dealt with the technical aspects of the entrepreneurial activity providing scientific aspects of the enterprise, the second economic part dealt with project preparation for credit support with economics principles and bankers' perspective and the final enabling part provided the institutional support available in the form of capacity building and technical consultancy, promotional schemes, regulatory guidelines, success stories and interactive sessions with bankers, promotional agencies and entrepreneurs and field visit to various entrepreneurial units/enterprises. The trainees indicated in their feedback that the approach taken was very useful in combining technical, economic and institutional aspects of learning and expressed that the course was an exciting experience. The government officials and the NGOs felt that the training had helped them to play a 'enabling role' in identifying and facilitating potential entrepreneurs. The potential entrepreneurs indicated that the training would help them to develop their own business enterprises in aquaculture.

Training at a shrimp farm.

Those who wish to participate in the training course dealing with entrepreneurship development in coastal brackishwater aquaculture may contact the Director, Central Institute of Brackishwater Aquaculture (ICAR), 75, Santhome High Road, R.A. Puram, Chennai-600028, India through e-mail to: director@ciba.res.in.

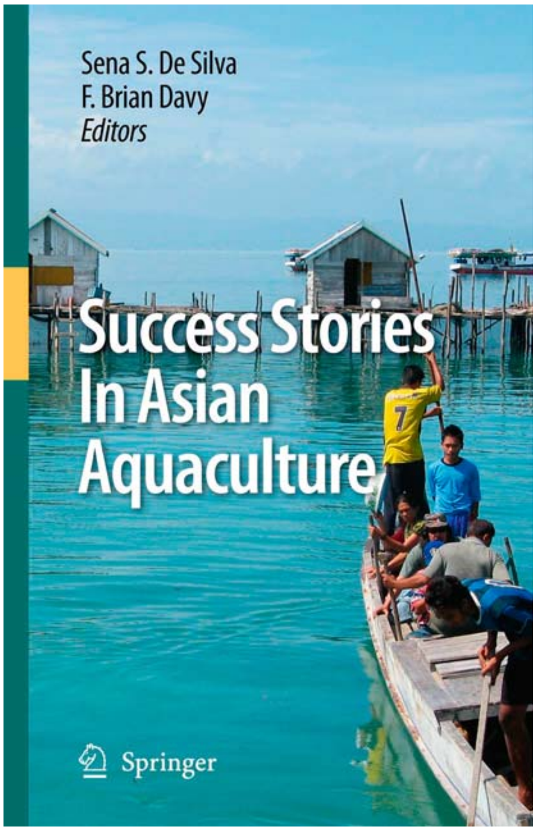
Success Stories in Asian Aquaculture – now available for free download!

We are pleased to announce that NACA's new flagship publication Success Stories in Asian Aquaculture is now available for free download from the NACA website, as foreshadowed in previous newsletters.

The stories in this book reflect the unique nature of Asian aquaculture, providing first-time insight into how and why it has become so successful. Overall, the book demonstrates how the resiliency, adaptability, and innovation of small-scale aquaculture farmers have been crucial to this success. It also places aquaculture development in Asia into a wider global context, and describes its relationship to natural systems, social conditions, and economics. The book is unique in its in-depth presentation of primary research on Asian aquaculture, and in demonstrating how aquaculture can have a lasting positive impact on livelihoods, food security, and sustainable development.

This book will appeal to a wide range of readers. The introduction and conclusion give an excellent general overview of Asian aquaculture, and the individual case studies provide a wealth of new information for specialist readers. Researchers, development workers, and decision-makers, in particular, will be interested in how the Asian experience might be used to strengthen aquaculture development more generally and in other parts of the developing topics of Latin America and Africa.

Success stories in Asian Aquaculture is edited by by Sena S. De Silva, Director General of the Network of Aquaculture Centres in Asia-Pacific, and F. Brian Davy, Senior Fellow at the International Institute for Sustainable Development in Canada.



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http://www.springer.com/environment/aquatic+sciences/book/978-90-481-3085-6

Giant Prawn 2011

Giant Prawn 2011 will be held as a component of next year's Asian-Pacific Aquaculture 2011 conference, 17-20 January, in Kochi, India. Giant Prawn 2011 will be a landmark opportunity to review the status of freshwater prawn farming worldwide and discuss the future of this $2 billion industry. The meeting will include field trips to freshwater prawn farming sites on 21-22 January.

The scientific programme for Giant Prawn 2011 consists of a three-day invited paper session (18-20 January), plus a one-day parallel session for contributed papers on freshwater prawn farming (date to be announced later). Speakers include Nesar Ahmed (Bangladesh), Janet Brown (UK), Michael Frinsko (USA), Ilan Karplus (Israel), Spencer Malecha (Hawai'i), Peter Mather (Australia), C. Mohanakumuran Nair (India), M.C. Nandeesha (India), Uthairat Na-Nakorn (Thailand), Michael New (UK), Nguyen Thanh Phuong (Vietnam), K.R. Salin (India), Amir Sagi (Israel), James Tidwell (USA), Wagner Valenti (Brazil), Patricia Moraes-Valenti (Brazil), Md. Abdul Wahab (Bangladesh) and Miao Weimin (China).

Discussions about the contributions of several further invited speakers are on-going. The topics to be presented in the invited session of GP2011 include biology, genetics, grow-out and hatchery rearing technology, health management, and post-harvest handling, marketing and economics.

Selected GP2011 papers will be considered for a special issue of the journal Aquaculture Research after the conference. The parent Asian-Pacific Aquaculture 2011 meeting will also provide the usual rainbow of conference topics and social events, together with an important exhibition. Those who attended the last event organised by this chapter in Kuala Lumpur will already know how successful it was.

GP2011 will be a very important event for all those involved in freshwater prawn farming, research and marketing. Mark your calendars and make your travel plans for January 2011 now!

Peer reviewed publications

For a complete list of peer reviewed publications, visit http://www.enaca.org/content.php?page=peer_reviewed_publications.

Microsatellite DNA markers revealed genetic population structure among captive stocks and wild populations of mrigal, *Cirrhinus cirrhosus* in Myanmar

Aung, O., Nguyen, T.T.T., Poompuang, S. And Kamonrat, W. (2010), Aquaculture 299(1-4): 37-43

We investigated genetic diversity and population structure of mrigal in Myanmar using microsatellite DNA markers. A total of 211 individuals from five wild populations and 216 individuals from five hatcheries were analysed for six microsatellite loci (*Bgon22*, *Lr3*, *Lr12*, *Lr21*, MFW1 and *MFW17*) which were developed for other cyprinids. For comparison, 43 individuals from a hatchery in northern Vietnam, of Indian origin and introduced in 1984, also were analysed. Tests for all loci revealed H–W equilibrium in only two hatchery samples. Allele richness ranged from 2.3 to 8.5. Overall, observed heterozygosity was high in all Myanmar samples (ranging from 0.654 to 0.756) but relatively low in the Vietnam hatchery sample (0.303). Pairwise FST values among the Myanmar samples ranged from 0.000 to 0.096, and those between the Myanmar and the Vietnam samples from 0.353 to 0.506. Results of multidimensional scaling analysis (MDS) of pairwise FST and Bayesian method revealed that one wild and two hatchery samples from Myanmar were differentiated from others, which appeared highly admixed. The study has important implications for genetic management of mrigal stocks in Myanmar, and possibly elsewhere in the region. For baseline stock for selective breeding, it would be best to include representation of samples from all groups we have identified to ensure a broad genetic base for genetic improvement programs. As for stock enhancement, seed produced from several hatcheries examined here should not be used for restocking in certain locations to avoid genetic contamination.

Available online at: http://dx.doi.org/10.1016/j.aquaculture.2009.12.010

Responsible aquaculture and trophic level implications to global fish supply

Tacon, A.G.J., Metian, M., Turchini, G.M. and De Silva, S.S. (2010). Reviews in Fisheries Science 18(1): 94 - 105.

Hunger and malnutrition remain among the most devastating problems facing the world's poor and needy, and continue to dominate the health and well-being of the world's poorest nations. Moreover, there are growing doubts as to the long-term sustainability of many existing food production systems, including capture fisheries and aquaculture, to meet the future increasing global demands. Of the different agricultural food production systems, aquaculture (the farming of aquatic animals and plants) is widely viewed as an important weapon in the global fight against malnutrition and poverty, particularly within developing countries where over 93% of global production is currently produced, providing in most instances an affordable and a much needed source of high quality animal protein, lipids, and other essential nutrients. The current article compares for the first time the development and growth of the aquaculture sector and capture fisheries by analyzing production by mean trophic level. Whereas marine capture fisheries have been feeding the world on high trophic level carnivorous fish species since mankind has been fishing the oceans, aquaculture production within developing countries has focused, by and large, on the production of lower trophic level species. However, like capture fisheries, aquaculture focus within economically developed countries has been essentially on the culture of high value-, high trophic level-carnivorous species. The long term sustainability of these production systems is questionable unless the industry can reduce its dependence upon capture fisheries for sourcing raw materials for feed formulation and seed inputs. In line with above, the article calls for the urgent need for all countries to adopt and adhere to the principles and guidelines for responsible aquaculture of the FAO Code of Conduct for Responsible Fisheries.

http://dx.doi.org/10.1080/10641260903325680

Observations on metal concentrations in commercial landings of two species of tilapia (*Oreochromis mossambicus* and *Oreochromis niloticus*) from reservoirs in six river basins in Sri Lanka

Allinson, G., Salzman, S.A., Ruoczy, N., Nishikawa, M., Amarasinghe, U.S., Nirbadha, K.G.S. De Silva, S.S. (2010). Toxicological & Environmental Chemistry 92 (4): 749 - 763

Samples of the muscle of two species of tilapia (*Oreochromis mossambicus* and *O. niloticus*; 17-20 cm length) were obtained from at least one reservoir in each of the six river basins (Aruvi Aru, Kala Oya, Kirindi Oya, Ma Oya, Mahaweli, and Walawe Ganga catchments) in Sri Lanka. The metals Ca, Cu, Fe, K, Mg, Mn, Na, and Zn were consistently detected in the muscle tissue. Overall, there were few differences in the concentration of metals between the two species of fish, although there were also some statistically significant differences ($p < 0.05$) in the concentrations of some metals in fish obtained from some of the reservoirs. Aruvi Aru stands out as a river basin in which the two fish species have significantly lower concentration of metals when compared to other river basins. The concentration of the metals studied were below WHO and FSANZ guideline values for fish, suggesting that the consumption of the metals found in tilapia from these reservoirs poses little risk to human health.

Available online at: http://dx.doi.org/10.1080/02772240903049710

Meetings address climate change impacts on small scale milkfish farmers in the Philippines

Milkfish production is the second highest component of aquaculture production in the Philippines by volume (229,111 tonnes in 2007) and the highest of the animal aquaculture products, and also the second highest in terms of value (US$ 317 million in 2007) after giant tiger shrimp. Ilolio province of the Philippines is an area where a large amount of the milkfish production occurs. The province is vulnerable to climate change and thus was selected as a case study area for the impacts and adaptation of small scale aquaculture to climate change project.

Two focus group discussion meetings of milkfish farmers were held in Dumangas and Barotac Viejo towns in Iloilo City on 30 September 2009 close to the farms of participating milkfish farmers. The focus group discussion meetings mapped farmer perceptions of climate change including climate change issues, impacts on production, economic impacts, adaptation solutions, responsible agencies and matched impacts with seasonal and cropping calendars.

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A stakeholder workshop was held in Iloilo City on 1 October 2009 with a range of stakeholders including government representatives, scientists, milkfish farmers and milkfish farming support industry people. After hearing about the status of milkfish farming in Iloilo, climate changes that had occurred and the predicted future effects of climate change, stakeholders identified adaptation solutions in four areas: Operational measures (farmer measures),technical measures (science measures), institutional measures (local government units, provincial, regional and central measures), and financial measures (calamity insurance, etc).

The milkfish farmers identified a number of climate change impacts that they are currently experiencing and described their adaptive practices. Possible future measures to assist milkfish farmers to adapt to climate change were indentified at the research and institutional levels.

The project is now conducting a comprehensive survey of small scale milkfish farmers in Iloilo, the Philippines, which will be used with secondary information to assess their vulnerability and adaptive capacity to climate change.These activities are part of the climate change impacts and adaptation of milkfish farming in the Philippines case study; one of several case studies of the regional project *Strengthening adaptive capacities to the impacts of climate change in resource-poor small-scale aquaculture and aquatic resources-dependent sectors in the south and south east Asian region* funded by NORAD. The first annual report of the project is also now available for download from the project webpage. For information, please visit:

http://www.enaca.org/modules/inlandprojects/index.php?content_id=10

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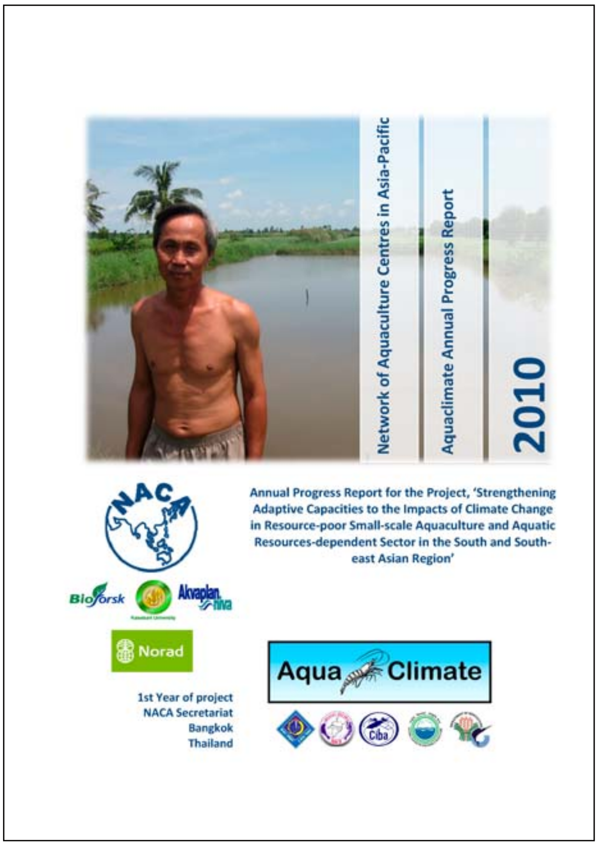

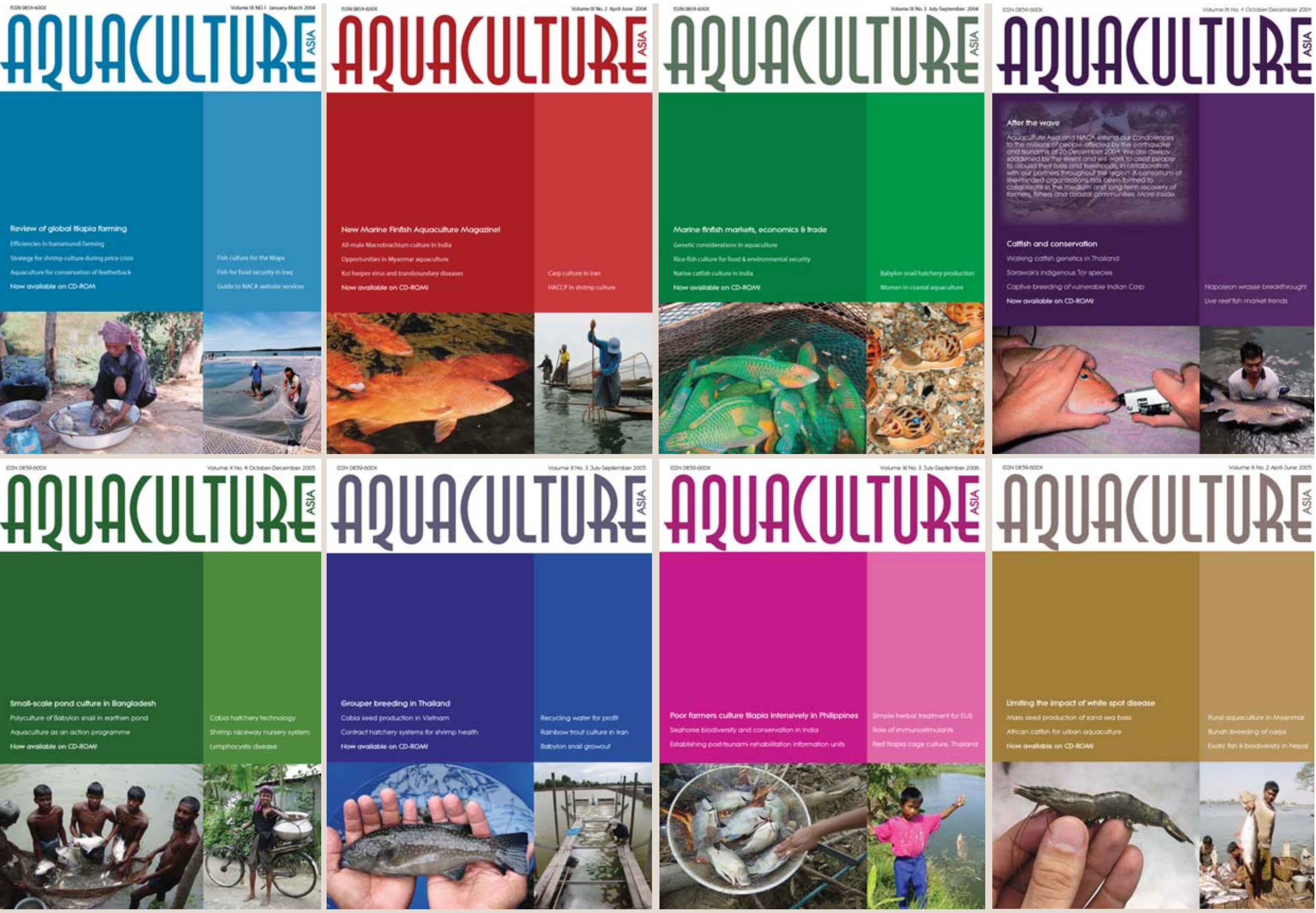
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Farming carps in leased ponds, Bangladesh

AQUACULTURE 2010 Global Conference

22-25 September 2010, Phuket, Thailand

Have your say on the future of aquaculture development

With aquaculture now providing nearly 50% of global food fish supplies, FAO in partnership with NACA and the Thai Department of Fisheries, are organising the *Global Conference on Aquaculture 2010*, to evaluate where the sector stands today and prepare for the challenges ahead. The objectives of the conference are to:

- Review the present status and trends in aquaculture development.
- Evaluate progress against the 2000 Bangkok Declaration & Strategy.
- Address emerging issues in aquaculture development.
- Assess opportunities and challenges for future aquaculture development.
- Build consensus on advancing aquaculture as a global, sustainable and competitive food production sector.

The conference will provide a global forum to build consensus to advance sustainable aquaculture development and contribute to the Millennium Development Goals.

Enquiries and further information

Please visit website for more information, or feel free to contact the conference secretariat:

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