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New model for rural development, Myanmar

Optimisation of Nile tilapia in Rwanda

Mud crabs, Scylla

EUS infection, India

Aquaculture Asia

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

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NACA

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

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Anti-microbials and alternatives

The use of anti-microbial substances (for practical purposes read “antibiotics”) in aquaculture is a persistent problem. For many years now food safety standards have been getting stricter. Some substances have been banned altogether due to potential impact on human health and the accepted maximum residue levels (MRLs) for those that are tolerated have been going down, basically tracking the limits of sensitivity for laboratory assays. In a previous job I once had to review EU MRLs, and at that time some of the limits they had set were an order of magnitude lower than what was actually detectable by the laboratory technology of the day! Some of the limits are now so low that we have begun to see cases where MRLs are being “exceeded” by the background activity of microbes naturally occurring in the environment (regulators seem to have forgotten that that’s where we actually get a lot of these things).

It is often argued – mainly by veterinarians – that safe use of antimicrobial substances in aquaculture and other livestock industries is possible. And in theory they are right. All you need is access to a veterinarian and possibly laboratory facilities to diagnose the problem and prescribe an appropriate treatment regimen, using an anti-microbial substance that has been studied and legally approved for use on the species you are farming.

In practice though, they’re wrong. Vets with aquatic animal health expertise are as rare as hens’ teeth and they certainly are not readily accessible in rural areas. The cost of a consultation may well be beyond the means of a small-scale farmer. The regulatory processes for registering a drug for use is generally species-specific and requires a huge amount of data to be gathered under permit, which a large species-specific industry such as poultry can do, but a relatively small aquaculture industry fragmented across hundreds of species cannot.

Progress towards overcoming these obstacles in aquaculture over the last 20 years has been essentially zero. In practical terms it is near-impossible for a small-scale farmer to use anti-microbial substances with legal sanction and professional oversight. As a result, they are using them without sanction or oversight, probably ineffectively, and there is clear evidence of anti-microbial resistant strains of bacteria on the rise in aquaculture farms.

NACA’s position on anti-microbial substances has been to focus on alternatives. Prevention is certainly better than cure and improving basic management practices on-farm goes a long way to reducing the incidence of health problems. Not just biosecurity aspects but also general husbandry – pond preparation, water quality, nutrition. Vaccines are another underutilised alternative to drugs in aquaculture, if one that requires significant research investment. And on the government side, it’s about time that regulators faced up to the fact that drug registration processes weren’t designed and are not suitable for the aquaculture industry, and some changes need to be made.

Simon Wilkinson

AQUACULTURE ASIA

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Successful demonstration of a new model for rural development in Myanmar

I was commissioned as an external consultant to review the project, the Development of Rural Aquaculture through Entrepreneurship in Women in Myanmar (short title: e-Women) last November. The aims of the project, to promote food security and increase incomes of families in rural Myanmar through improved agricultural and aquaculture production systems, have been achieved in such an impressive way that the novel model developed and implemented by the project should be replicated throughout Myanmar, one of the poorest countries in Asia.

The project located in Twantay Division, Yangon, was funded by the Italian Ministry of Foreign Affairs and was jointly executed by the University of Tuscia (UoT), Italy with two project partners: The Asian Institute of Technology (AIT), Bangkok, Thailand; and the Environmental Economics Research Institute (ERRi, Yangon, Myanmar. The Head of the Project was Dr Giuseppe Colla of UoT. The Project Coordinator for the first year of the project was Dr Eduoardo Pantanella of UoT. Dr. Ram Bhujel played a major role in project design and coordinated the AIT inputs. Dr Win Myint of the University of Yangon (UoY) coordinated ERRi inputs. The project started in December 2012 and initially was scheduled to end in December 2013 but was extended until the end of 2015 without extra funding.

Twantay District has a large and varied landscape. While some villages are located on good agricultural land with rice farming as the main occupation, others are on low-lying land mostly occupied by ponds. In fact Twantay District is one of the major fish farming areas in the country although mostly large-scale farms as I reported in earlier columns (Edwards, P. 2005. Rural aquaculture in Myanmar. Aquaculture Asia 10(2): 5-8; Edwards, P. 2009. Myanmar revisited. Aquaculture Asia 14 (1): 3-12. Thus, the topography of the land was one of the factors influencing the choice of selected technologies

A women's group with group bicycle.

A women's group with their nine individual record books.

by the women project participants. The farmers in one of the project villages reported that the low-lying village was mainly occupied by ponds as the land flooded, as well as rice farming providing low profit.

Project activities

The project partners carried out a participatory rural appraisal to define problems typical of villages in rural Myanmar in collaboration with Twantay local government officials. Partnerships had been established with the local Departments of Agriculture, Livestock and Fisheries, and with the University of Yangon (UoY), to develop a supporting team for village-level activities.

The women beneficiaries of the project were organized into a group in each village to ensure regular meetings to facilitate horizontal transmission of experience among farmers; to allow trainers and facilitators to bring in technological advances and market knowledge; and to develop a revolving fund for each group. Three main business options were chosen for project implementation by project staff based on their profitability determined through cost-benefit analysis: horticulture (vegetables and mushrooms), aquaculture and livestock. The 99 women members of the eleven village-level groups involved in the project, who mostly came from poor farming and landless households, were asked to select which technology they would like to receive project support for. Some women selected technologies that they were already involved in, others selected new ones.

The project team trained both trainers and women village-level beneficiaries in horticulture, livestock and aquaculture and distributed farming extension booklets produced by other organisations in the country in the Burmese language. Training of the trainers on aquaculture was held at AIT for both project staff from EERi, local government administrators and extensionists. Training comprised theoretical and practical lessons as well as visits to commercial farms and facilities. Prof Nicola Lacetera (UoT) gave lectures in Myanmar on ducks and pigs, Professor Bruno Ronchi (UoT) on goats and Professor Giuseppe Coll (UoT) on vegetables. Dr Pantanella also gave lectures on sustainable agriculture as well as on aquaponics.

A demonstration farm was set up at the Department of Fisheries, Twantay, to transfer know-how and to provide training on new technologies introduced through the project: aquaponics, mono-sex tilapia and mushroom cultivation. Ducklings, small goats and piglets, fish and prawn seed, and mushrooms and vegetable seed were distributed by the project team to villagers following training. Three shipments of juvenile mono-sex tilapia *(Oreochromis niloticus)* and river prawn *(Macrobrachium rosenbergii)* were made from Thailand with the aim of updating local traditional aquaculture systems to increase their productivity. Each women's group was provided with a bicycle to help them women to market their produce more easily.

As the villagers had previously lacked capital other than through loan sharks charging exorbitant interest rates of 15-20%/month, the project provided finance or seed money, Kyat 1 million (approximately US$833), to start each revolving fund which was deposited in a bank book of the Cooperative

Bank Ltd. through EERi. Contracts were made for each loan with the interest paid back after three months and the complete loan repaid after six months. The profit from each loan was returned to the villagers' revolving fund so that it increased in size over time to permit more borrowing. Thus, a major aspect of the project was confidence building of the women participants which distinguished the project from other projects. The women in each group met monthly to discuss livelihood issues and to exchange information on farming technology.

Regular monthly monitoring visits were carried out by project staff to each village to check the progress of each woman farmer as well as the village group. Although the project was only a one-year project for the year 2013, EERi had used unspent funds to continue to monitor the eleven women's groups on a three-monthly rather than a monthly cycle as during the first 1.5 years of the project for a further 1.5 years.

The project review

Summary of project women interviews

Dr Bhujel and I, guided by EERi staff, made field visits to all eleven project villages to evaluate the impact of the dozen or so improved and new farming practices introduced through the project. Individual farms were visited to observe examples of all technologies. The women farmers were interviewed about their respective technologies in the field, from one to four technologies per village depending on the number of representative technologies already observed as the field visits progressed. Focus group discussions were held with the nine members of each women's group in all eleven villages, a total of 99 women project participants, to elicit their views on the benefits and possible short comings of the project.

Although most of the farming technologies supported through the project were being carried out before project intervention, the training provided had led to new knowledge which had increased the productivity of farmed products and especially had reduced the incidence of livestock diseases which had been a major constraint even during the early phase of the project. The village women expressed confidence with new knowledge of farming their selected farmed products. For animals in particular there was still occasional mortality of fish and prawns, and ducks, goats and pigs, but it was relatively minor compared to previously when some farmed animals faced total mortality.

Some women had continued with a profitable farming option supported initially through the project e.g. goat and pig but many had changed their initial selected livelihood option for project support. Changes were made from their initial selection to most of the other farming technological options

Members of the project team, left to right. Dr. Win Myint and U Khin Maung Mya (foreground), Ms. Daw Nwe Nwe Tun and Ms. Ei May Khine (centre) and Dr. Ram Bhujel (background).

Ms. Daw Nwe Nwe Tun checking record book of a woman farmer.

available through the project but some others involved agricultural diversification, especially betel leaf which had not been supported by the project as it is a stimulant rather than a food, ornamental flowers such as jasmine, as well as a variety of vegetables. Seasonality also influenced the livelihood option as goats and pigs were reported to be most suitable to raise during the monsoon season when flooding occurred but that the animals were sold with the onset of the dry season as they wanted to raise vegetables, with livestock being raised the following rainy season.

Women who had been unsuccessful with their initial chosen technological option had been encouraged by project to change to other livelihood options which they had understood to be profitable if they wished to do so through having been being taught how to book keep to determine profit and loss. Many of the women farmers initially chose to continue with a livelihood that they were already involved in, especially landless households to raise goats and pigs which did not require the family to own land as did crops such as fish and vegetables. After project training had more or less solved the problem of animal mortality due to disease, some continued with livestock rearing, borrowing money from the revolving fund to replace animals that had died and/or to purchase additional animals to raise, while others changed to other livelihood options. Some women had borrowed from the revolving fund to start non-farming but profitable livelihood options e.g. opening a small-scale grocery store in the village, selling clothes, and making artificial fruit drinks kept cool in a refrigerator.

Financial aspects were especially appreciated by the women project participants. The provision of the Kyat 1 million starter fund for each group, the introduction of the revolving fund, and provision of initial inputs for farming. All women respondents without exception stated enthusiastically that they very much appreciated the revolving fund which had enabled them to make a profit unlike previously when they had to borrow at high interest from loan sharks. All women members of each village group were taking loans to support various livelihood activities, initially Kyat 60,000, then increasing to Kyat 80,000, through Kyat 90,000 and finally to Kyat 130,000. None of the women's groups reported a problem in returning loans, no doubt due in part to peer pressure. If a person would have a problem in paying back their loan, the groups said that they would help them temporarily but eventually the person would either have to pay back the loan or resign from the group and lose the privilege of further borrowing from the revolving fund.

The group members also were able to keep records of their activities and unlike previously were now able to estimate profit and loss. The project had a 100% success rate in teaching the women book keeping, a major achievement.

Technological overview

The status of project women's activities, originally selected and the latest, was outlined by project staff. A total of 41 farmers out of 99, or 41% had changed to other activities

Feeding rice bran to mono-sex tilapia.

Husband of prawn farmer with prawns and pond behind.

as the project encouraged change if there were no profit. Another factor influencing choice of technology as mentioned above was whether families owned land or were landless and landlessness was high in the project villages as is typical for Myanmar.

Only 4 out of 13 original fish farmers remained although only 4 of the original prawn farmers had changed. Only 9 of the original 44 pig farmers had changed as pig farming was profitable, especially once disease had been largely overcome from training and changing from an exotic to the more disease resistant local breed which also produced large numbers of piglets which found a ready market. Seven of the original 13 goat farmers had changed as disease was also a problem initially. Only 1 of the original 3 duck farmers remained as disease was a problem as was a shortage of water in the dry season. Only 3 of the original 13 vegetable farmers had continued growing them for diverse reasons.

Fish

Twantay District is the major fish farming area in the country although most of the ponds are large and owned by wealthy farmers. However, some villagers had started to raise fish before the project, stocking rohu in relatively small 0.5-2.0 acre ponds that they either owned or rented, and dug themselves using family and/or hired labour paid for with their own funds. They got the knowledge to raise rohu from being hired as workers on nearby large-scale farms.

The farmers raised rohu before the project as carp fingerlings were readily available in the villages through middlemen and aquaculture could be profitable if the villagers had enough money to buy rice bran and peanut cake as feed. However, some villagers reported that they had failed because of insufficient money to buy feed. It was recognised that it would be more profitable to nurse fry to fingerlings rather than grow-out of large fish as feed costs would be lower. Other constraints were the presence of wild predatory fish in the ponds such as snakehead and walking catfish which prey on small fingerlings. A village headman who was not part of the project gave another reason for poor results in fish culture: the ponds had never been properly prepared since commercial aquaculture had started in the area in 1980, without removal of sludge from the accumulation of waste from poor quality feed. There had been no fish mortality until about 5-7 years ago when water quality had started to deteriorate significantly. The area was also low-lying and subjected to flooding with loss of stocked fish.

Although the project had provided the women farmers with knowledge to grow fish, a major constraint was the high cost required for pond construction. Furthermore, government policy still prohibited the conversion of rice fields to fish ponds although fish could be stocked in the fields and wild fish caught. A rather unusual sight was the location of a betel leaf farming area in the middle of a fish pond owned by a project farmer who had changed from fish to betel leaf.

Mono-sex tilapia was a new technology that was introduced to some of the women participants. The project provided each participating woman farmer with 15,000 2-3 cm mono-sex tilapia fingerlings from Thailand and taught them how to nurse them to larger more predator resistant size in hapas installed in the ponds. Some of the women farmers reported that the fish stocked in the pond after nursing had disappeared. The fingerlings were nursed in hapas for 2 months but they may still have been too small to be released into the pond through improper feeding and/or clogging the net mesh which would have reduced water exchange. Thus the fingerlings stocked in the pond may not have been nursed properly to attain a large enough size to avoid being predated by wild fish in the ponds, most of which were reported to have only been partially prepared and thus infested with wild predaceous fish. Another possible reason was flooding of the low lying area which would also result in loss of fish.

One woman farmer visited during the review, however, had been successful with mono-sex tilapia as she had caught 70 large 500g fish and had not observed any small tilapia in the pond which would have indicated inefficient sex reversal of the original stock of mono-sex fish. She sold the fish for Kyat 1 million ($833) and many large tilapia were observed to still be in the pond.

Prawns

Nine prawn farmers remained out of a total of 13 prawn farmers who had received PLs from Thailand through the project, mostly in one village with an excellent water supply from and good communication through an adjacent large canal. All farmers in the village with the good water supply, about 100, were raising prawns. The project farmer interviewed reported that he had sold 160 kg prawns after stocking the 7,000 PLs provided by the project from Thailand in a 1 acre (0.4 ha) pond for Kyat 1,400,000 (US$1,167). The farmer had also borrowed money from the revolving fund to purchase pelleted feed. The farmer reported that he had been farming prawn for 3 years but that training received through the project had taught him how to raise them systematically and without mortality of PLs with double the production of other prawn farmers.

Farmers in other villages had successfully and profitably raise prawns, even feeding rice bran and peanut oil cake rather than pelleted feed, but had changed back mostly to rohu as fish seed was readily available because they were unable to buy prawn PLs locally. The cyclone Nargis had wiped out three local prawn hatcheries leading to a shortage of prawn seed.

Aquaponics

Aquaponics was a second new technology that was proposed for introduction to the villagers. An aquaponic unit had been set up at the local Twantay Department of Fisheries but unfortunately it had to be abandoned because of an unreliable electrical power supply. Although the Twantay set-up failed because of an unreliable electricity supply, it may be possible to run it in future on solar power.

Masters Degree level research on aquaponics was also carried out during the project at AIT to provide further insight into its feasibility. The study indicated potential for the landless to earn a living through such a system requiring only a few square meters of space, with advanced nursing fry to fingerlings rather than grow-out of table fish. It may be possible to stock 3,000-4,000 - 10,000-12,000 fry/tank and complete five to ten two-month nursing cycles which would be very profitable.

The aquaponics technology clearly requires more research before it could be trialled in villages. A further constraint is that villagers may not have sufficient expertise to maintain and repair the pumping system. Furthermore, such integrated systems may be too complex and risky for the village as the failure of one component would lead to failure of the others.

Soil-less hydroponics and simple drip irrigation may have more potential than aquaponics for rural Myanmar. There is increasing investment in other Asian countries in related greenhouse technology, the price of which is becoming increasingly competitive. Fine mesh netting to prevent entry of insects eliminates the need to use insecticides with the production of higher market value organic produce.

Chickens

Raising chickens was not initially selected by any of the women participants because intensification of production beyond widespread scavenging village chicken raising would require purchase of formulated feed. However, an impressive broiler chicken farm with 2,000 birds was being operated by a group of three women workers with the permission of the farm owner on the dike of a large-scale carp farm. One of the three women was a member of a project village group and had borrowed money from the revolving fund with the other two women using their own funds.

This was an especially impressive operation because it suggested a way to improve the welfare of thousands of poor carp farm workers who live in flimsy bamboo shacks on and near the pond dikes of large-scale carp farms. As the space on the large-scale carp pond dikes was mostly underutilised, the three enterprising women had demonstrated how their welfare could be considerably improved.

Former prawn pond converted to growing beetle leaf and catching wild fish.

Former prawn pond stocked with rohu.

Large-scale carp pond labourers' quarters (foreground) and broiler chicken coop (background) on dike of large-scale commercial carp pond.

Broiler chickens.

Ducks

Only three women had opted to initially raise ducks and two had changed to other businesses, one because the ducks had died of disease although some eggs had been already been sold for a profit, and the other because ducks had stopped laying eggs in the dry season due to a shortage of water. The remaining woman who had been provided initially with 37 ducks through the project was expanding the operation at the time of the interview, and she was also involved in the broiler chicken operation described above.

Goats

The project provided 7 goats to women selecting this option, 13 in total although 7 had changed to other livelihood options. Once the initial problem of disease had mostly been overcome through project training, goat rearing provided a stable profit through selling adult as well as young goats as they breed readily.

One woman reported that she had not raised goats before but only after she had obtained both knowledge and capital from the revolving fund. Goats were cost effective to raise in the village as they were fed with bananas and broken rice as well as being allowed to graze.

Pigs

The project initially provided each woman project participant who had selected pig, 44 in total, with three Charoen Pokphand (CP) improved breed, pink coloured, piglets but most of these had succumbed to disease as they were much less hardy than the local black coloured pig. The local pig could also be fed on locally available feed such as rice bran and broken rice as well as kitchen waste while the CP pig had to be fed with formulated feed which meant that even if they survived the profitability was low. Only one woman farmer was observed with large CP pigs still being raised. The other women who had chosen to continue raising pigs had used the revolving fund to buy local breed piglets. Although the local pig could be fed on locally available feed, some of the women were using the revolving fund to buy formulated pig feed to increase the profitability of raising even local pigs. Furthermore, the local breed produced large numbers of piglets which could also be sold. One woman reported that she had sold fifteen piglets for Kyat 600,000 (US$500), an impressive sum of money at the village level.

Ducks swimming on canal during day.

Goat raising.

As both pig and goat raising were profitable as well as suitable for the landless, only nine of the initial pig farmers had changed to other options, mostly the very profitable betel leaf.

Vegetables and other plant crops

There were thirteen initial vegetable farmers out of which ten had changed to leave only three for various reasons although others had since started to raise plant crops with capital from the revolving fund such as banana, bitter gourd, bottle gourd, cucumber, lady finger, papaya, pineapple and roselle.

Four women had been taught how to grow mushrooms profitably through the project. One woman was growing an ornamental flower, jasmine. Betel leaf grown for a stimulant was not supported initially by the project as it is not a food although it was reported by several women to be most profitable. Some landless women had borrowed money from the revolving fund to rent land to grow it although it was said to be risky because of pests and an unstable market because of overproduction on occasion leading to a reduction in price.

Conclusions and way forward

The project aimed to increased food security and income generation through improved livelihoods among women from the most vulnerable households by promoting aquaculture and agriculture, including livestock, and favouring access to markets. This has been achieved in a spectacular way through providing technical support and financial inputs to appropriate technologies selected by the women project participants themselves. The women have been organized into revolving fund credit groups to address the major rural issue of limited finance and have been taught how to keep financial records to determine the profitability of the activities in which they were involved. The most important aspect of the project was the successful empowerment of the women so that they had enough knowledge about various livelihood options and the ability to calculate profit and loss through having been taught book keeping. Thus the empowered women now had sufficient self confidence to be able to significantly improve their and their family's welfare.

A major aim of the project was to empower women who were considered to be disadvantaged. A gender expert made a visit to the project and recommended a special study by a local gender specialist to determine what were the specific gender issues that needed to be addressed and this study was carried out. However, women in the project area did not appear to be especially disadvantaged relative to their men folk and children, with all mostly suffering from poverty due mostly to the lack of finance to invest in productive activities because of the lack of access to credit at reasonable interest rates. Prior to the project the women project participants had only access to 'loan sharks' charging interest rates of 12-15%/month rather than that of 1.2%/month provided through the project.

One of the few surviving exotic pigs provided initially through the project.

Native pig with large litter.

Bottle gourd.

Watering betel leaf.

Women farmer with ice lolly from refrigerator bought through revolving fund.

An important point is that the project gave the women flexibility in being able to select the most appropriate and profitable livelihood option suited to local conditions and therefore more likely to be accepted by project beneficiaries as demonstrated. The project did not promote only a single technology such as aquaculture, the main specialities of two of the principle investigators mostly responsible for conceiving and implementing the project, as is the case for a majority of technologically-led development projects. Had this been the case in the project area in Twantay, the project would have had limited impact.

Projects are normally reviewed towards the end of the project period when financial benefits provided by the project still help to maintain farmers' interest and involvement in the project. However, this project was funded by the Italian Government for only one year, 2013, with unspent funds used by EERi staff to continue to monitor the project for another two years, 2014 and 2015. No further financial or material inputs were provided to the women during the two years following the end of the one year project although EERi staff made monitoring visits to each village every three months. This project is most unusual in that the external review has taken place essentially two years after project financial and material inputs ceased. Thus it has been unequivocally established that the project has not been a 'sunset project with the benefits disappearing with the project' but that the project is sustainable. Furthermore, benefits accruing to the women's groups have been increasing as each group's revolving fund has expanded in monetary terms, sustainably amplifying the initial benefits provided through the project.

The major project aims, national food security and rural development, are also included in the national political agenda. As these aims have been achieved in such an impressive way, the novel model developed and implemented by the project should be considered for replication throughout the country to help to develop rural Myanmar.

Chaw Khin Khin (Cindy), Chaiwoman of Myanmar Computer Company, the parent company of EERi making a presentation at Final Project Meeting.

Optimisation of Nile tilapia (*Oreochromis niloticus*) production in ponds based on improved farm management practices in Rwanda

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Fish farming was introduced in Rwanda by the Belgian colonial administration after the Second World War by creating two large southern state stations, Kigembe and Rwasave (SARNISSA 2.013). As elsewhere, also, fish declined after the independence of the country in 1962.

Since then several projects (EDF, CRSP, KUL, and University of Namur) have attempted to revive aquaculture activity within MINAGRI, National University of Rwanda (NUR) and NGOs such as HELPAGE. It seems that these efforts are beginning to pay off with integrated rural fish farming such as poultry cum fish culture and rabbit cum fish culture showing encouraging signs of development (MICHA 2013).

Surveys conducted in Rwanda revealed that many small-scale fish farmers consider fish to be a cash crop. Findings by Engle (1993.) indicated that fish farming provides cash to the family and supplements the diet of the Rwandan farmer. Molnar et al. (1991.) and Engle et al. (1993.) both found that fish production was the main cash crop for over 50% of cooperative members and private pond-holders.

Small-scale fish farming in Rwanda may also be viewed as a means to improve food security. Daily animal protein intake in Rwanda was estimated at 2.1 g per capita (Wikock 1986); however, the Ministry of Agriculture (MINAGRI 1987) reported that an adequate diet requires 5.9 g of animal protein daily.

With the projected 16 million people by 2020, the country will need 112,000 tons of fish annually if the population is to catch up with the average fish consumption in sub-Saharan Africa which is 6.7 kg (Rutaisire 2011).

Despite the enormous natural and socio-economic potential, historical and current public sector interventions coupled with current overwhelming national and individual farmer interest for development of aquaculture, the sector remains extremely underdeveloped with minimal contribution to the national fish harvest (Rutaisire 2011).

The current fish production has been estimated at 17,158 metric tonnes but these figures are from capture fisheries because the aquaculture sector has not yet developed and

Harvesting fish after the production cycle.

Measuring water parameters.

its statistics were not presented. The main species cultured in ponds and cages is tilapia, which is has a great market value and is preferred by consumers (RAB 2011).

From 2010-2012, the Government invested a lot of money in order to boost aquaculture through rehabilitating existing ponds, creating new ones and setting up demonstration tilapia production cages. The Government has constructed also a national hatchery with the capacity of providing five million quality tilapia fingerlings per year to satisfy the current need for seed for the whole country. At the same time, it has interested and sensitised the private sector to invest in aquaculture (intensive fish production, feeds and seed production) as well as banks and microfinance institutions to provide loans to aquaculture related activities and investments.

Considering the effort from the government side, many investors could have entered the industry because the market requirement is not met by local production, and today the country is importing more 10,000 metric tonnes of fish, which is nearly half of the current national production (RAB 2013).

Investors are still reluctant to get involved in aquaculture activities as many trials of fish production have been conducted with great sponsorship from the government; the present study intends to optimise Nile tilapia production in ponds based on improved farm management practices in Rwanda.

Approach

Experimental ponds

An experiment was carried out at the National Fish Centre of Kigembe located in the Southern Province; six ponds (surface area: 53 m^2, depth 0.60 m at inlet and 1.20 m at the outlet for each pond) were selected and prepared in the same condition including bush clearing, drying and application of lime with fertilisation by chicken manure to enhance natural feed production. Monofilament nets were used to fence all ponds in order to control predators such as frogs, snakes, birds, and crayfish.

Ponds were filled with water from the main canal and left to stand for one week to allow the decomposition of manure and the proliferation of plankton prior to stocking.

The study intended to improve and optimise the main farm management conditions including feeding, fertilisation, control of predators, and control of fish health through regular management of water quality parameters and good management practices. No other intensification technologies such as aerators were applied.

Experimental fish

All male Nile tilapia with an average weight of 10 g were graded, counted and held in hapas before transporting them to the prepared ponds. Before stocking, a seine net was used to remove possible predators and other aquatic animals that could compete for food. Seed were transported in buckets was done early morning to avoid stress and temperature shock; the stocking density for this research was 2; 4 and 6 fingerlings/m^2; for the treatment 1, 2 and 3 respectively.

Feed and feeding

Tilapia pond grower feeds with the following specifications were used: Crude protein: 25%; fat: 8.5% max and 7% min; crude fibre: 8.5% maximum; ash: 7% maximum; moisture: 11% maximum with the FCR estimated at 1.8.

The amount of feed to start with was determined based on the biomass of fish and the percentage was decreased every month from 10% in the first month, 8% the second month, 6% the third month and 4% for the last month.

Monitoring of water quality parameters

The major water quality parameters recorded and analysed during our experiment were temperature, dissolved oxygen, pH and transparency that were measured on a weekly basis (morning afternoon) in order to make sure that fish are kept under health conditions.

Sampling

Fish were fully harvested each month and kept in six holding tanks for few hours, each replicate within its own holding tank; this helped to calculate the survival rate each month, growth rate, fish biomass in order to adjust the required feeds, mean weight gained, FCR and SGR.

Fish health was regularly assessed by watching their behaviour especially during feeding, early morning and evening which is considered as the critical time for dissolved oxygen decreases and pH fluctuations.

The experiment was carried out over a four-month period and after this all fish were harvested by draining the ponds and the fish were quickly transferred to the holding tanks.

Results from this experiment were complemented by the data gathered through interview of former PAIGELAC Project Heads of 4 fish production Zones of the Country (Eastern, Western, Northern and Southern) in regards to farmers' production who practice the traditional pond management systems.

Results

Monitoring of water quality parameters

The major water quality parameters recorded and analysed during our experiment were temperature, dissolved oxygen, pH and transparency, which were measured on a weekly basis (morning and afternoon) in order to make sure that fish were kept under healthy conditions.

Table 1: Water quality parameters recorded during the experiment.

Parameter	Treatment 1	Treatment 2	Treatment 3
Temperature	24.8±0.03	24.8±0.00	24.6±0.04
Dissolved oxygen	4.7±0.03	4.9±0.09	4.7±0.00
pH	7.2±0.03	7.3±0.01	7.2±0.01
Transparency	27.5±0.06	27.9±0.25	28.1±0.02

The calculated means of these water quality parameters over the four months of the experiment are presented in table 1. There was no significant difference between treatments throughout the experiment ($p > 0.05$). This means that our experiment was carried out in a similar environment.

Fish survival, growth and feed utilisation efficiency output

At the end of the production cycle of four months, the survival rate (SR), weight gain (WG), specific growth rate (SGR) and feed conversion ratio (FCR) were analysed in order to evaluate the survival, growth and feed utilisation efficiency as presented in the table below.

Table 2: The mean value of SR, WG, SGR and FCR.

Parameter	Treatment 1	Treatment 2	Treatment 3
SR	83.0 ±1.00^{a}	81.5 ± 0.50^{a}	79.5 ± 1.50^{a}
WG	258.4 ± 5.10^{c}	163.05 ± 5.45^{b}	135.4 ± 2.75^{a}
SGR	2.6 ± 0.02^{b}	2.3 ± 0.03^{b}	2.1 ± 0.05^{a}
FCR	2.1 ± 0.00^{b}	2.6 ± 0.06^{a}	2.6 ±0.06^{a}

a, b,c in a row, means with a common superscript letter do not differ significantly ($P>0.05$) but means with a different superscript letter explains differ significantly ($P<0.05$).

The survival rate was calculated every month and at the end of experiment the final means were 83.0 ±1.00%, 81.5 ± 0.50% and 79.5 ± 1.5% for the Treatment 1, 2 and 3 respectively. The results of one-way ANOVA have revealed that there was no significant difference in survival rate between treatments ($p > 0.05$).

The mean weight gain was 258.4 ± 5.10 g, 163.05 ± 5.45 g and 135.4 ± 2.75 g for treatment 1, 2 and 3 respectively. A statistically significant difference was found between the fish of treatment 2 and 3 while for those of the treatment 1 did not.

The specific growth rate produced during the experimental period was 2.6± 0.02g/day, 2.3 ± 0.03g/day, and 2.1 ± 0.05g/day for treatments 1, 2 and 3 respectively. The statistical analysis showed a significant difference for the fish of treatment 2 and 3 while the treatment 1 did not show a significant difference.

The FCR obtained was 2.1 ± 0.00, 2.6 ± 0.06 and 2.6 ± 0.06 for the treatments 1, 2 and 3 respectively. They were statistically lower ($p < 0.05$) for the fish of treatment 2 and 3 whereas the difference was not statistical significant for the fish of treatment 1.

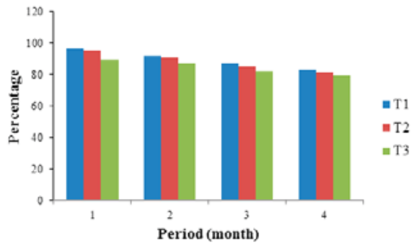

Figure 1: Survival rate trend recorded during the experiment.

Even if the survival rate calculated did not show a significant difference among treatments, the mortality recorded showed a decreasing trend with increasing of culture period.

Fish from the Treatment 1 grew faster than those in other treatments. As illustrated in the following figure, in the first month fish in all treatments grew slowly but a difference became clear from the second up to the fourth month.

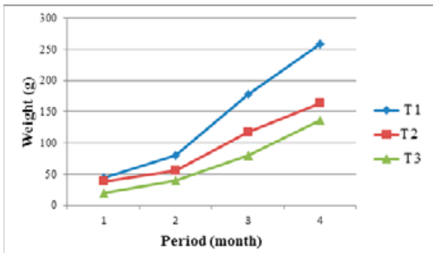

Figure 2: Mean weight gain trend recorded during the experiment.

Economic analysis of Nile tilapia fish production in pond

In order to compare the major production costs between the adoption of improved farm management practices and the farmers' normal practices, an economic analysis is detailed in Table 3.

Table 3: Comparison of economic analysis between improved farm management and farmers' management practices.

Item	Improved farm management practices cost (Rwf)	Farmers' practices cost (Rwf)
Estimated Investment		
Ponds construction value (1 ha)	1,000,000	1,000,000
Organic fertilisers cost (30 tons/ha/year)	300,000	300,000
Cost of fingerlings	1,400,000	1,400,000
Cost of feeds (1,000 Rwf/kg)	1,924,520	1,924,520
Manpower (60,000/month)	480,000	480,000
Total investment cost	5,104,520	5,104,520
Estimated Production		
Estimated production (kg/ha/year)	4,364	3,500
Estimated production value (2,000 Rwf/kg)	8,728,000	7,000,000
Benefit	3,623,480	1,895,480

1USD = 680 Rwf

The investment costs data were gathered from PAIGELAC Project Pamphlets on Fish Farming Techniques distributed in 2012 Agriculture Show (Trung D.V. 2009.) and (PAIGELAC 2012).

The above table compares the main production cost investment in Nile tilapia pond production in Rwanda for two management systems but did not take into consideration some of the other minor inputs such as seine nets, hapas, buckets, workers uniforms, laboratory tests and transport of fish to the markets. We were not exhaustive because these other costs are always similar for both the improved and standard practices.

Discussion

This research intended to optimise Nile tilapia production through improved farm management practices and among the practices taken into consideration were better feeding, better fertilisation, control of predators and control of water quality parameters.

We had the aim of increasing fish production compared to the production experienced by farmers following their normal farm management practices by improving practices of feeding, fertilisation, control of predators and fish health through control of water quality parameters.

After harvesting all fish and calculated the total production in different treatments, we found that the weight gain was 258.4 ± 5.10 g, 163.05 ± 5.45 g and 135.4 ± 2.75 g, while the specific growth rate was 2.6 ± 0.02g/day, 2.3 ± 0.03g/day, and 2.1 ± 0.05g/day for the treatments 1, 2 and 3 respectively. We realised that fish have grown fastest in the first treatment.

This may be because there was no much competition on feed and even on space. This was confirmed by Klanian and Adame (2013) in their study on Performance of Nile tilapia Oreochromis niloticus fingerlings in a hyper-intensive recirculating aquaculture system with low water exchange where they concluded that the growth and final weight were higher at the lower densities.

The feed utilisation was also effective because the FCR obtained at the end of the production cycle was 2.1 which is lower compared to 2.65 and 2.66 for the remaining treatments respectively. This may be because there was not much competition on both natural and commercial fish feed and even on space.

These results corroborate with those of El Naggar et al. (2008) in their study on influence of fertilisers' types and stocking density on water quality and growth performance of Nile tilapia and African catfish in a polyculture system. In their study they stocked three fish in two replicates one fertilised with organic and another with chemical fertilisers and another treatment with five fish with two replicates with the same types of fertilisers and they fed them with commercial pellets.

They found that Although 3 fish-chemical treatment had lower fish biomass than 5 fish-organic treatment, chlorophyll "a" concentration was higher in 3 fish-chemical treatment than 5 fish-organic treatment (however it was not significant) which mean that available natural food was higher in 3 fish-chemical treatment than that in 5 fish-organic treatment, which may account for the lower FCR in the 3 fish-chemical treatment as part of food consumed by the fish was natural food, thereby lowering the apparent FCR of the artificial feed.

After a four-month production cycle for this research we have obtained an average biomass weight of 23.64 kg of fish on a surface area of 53 m2 for the treatment 1; 29.94 kg/53 m^2 for the treatment 2 and 36.84 kg/53 m^2 for the treatment 3.

If we could extend the experiment for a period of 5-6 months, the average biomass weight would increase forward, and with these improved farm management practices it would be possible to grow two crops per year.

With the extrapolation of the production from pond surface area of 53 m^2 to 1 ha of ponds, it is possible to get 2,182 kg/ha/4 months crop (equivalent to 4,364 kg/ha/year) for the treatment 1; 2,780 kg/ha/4 months crop (equivalent to 5,560 kg/ha/year) for the treatment 2 and 3,497 kg /ha/4 months crop (equivalent to 6,994 kg/ha/year) for the treatment 3.

Similar results were found in Egypt by Green (2002) where they were evaluating five pond management strategies of tilapia in a study called evaluation of Nile tilapia pond management strategies in Egypt. After 145 days, they got a production of Nile tilapia ranging from 1,278-2,877 kg/ha.

General view of Kigembe Fish Centre.

For this research in the treatment 3, based on the results of 4 months, the possible production of one year would be 6,994kg/ha/year, but if this production cycle could be extended to at least 5 months, the total production would exceed 8 tonnes/ha/year.

Likewise, comparable results were obtained in Congo Brazzaville by de Graaf (2003), in a study of the Tilapia Farming Support Tool (TFST 1.0), the users manual for which says that they found that the use of proper feeding and stocking regimes led to productions of 6-8 tonnes/ha/year.

Based on the present research findings, after considering the possible production and the estimated production costs required in terms of feeds, manpower and organic fertilisers through comparing the WG, SGR, and even the FCR; we can confirm that if there is no other sophisticated inputs such as aerators and quality feeds are supplied, which are a requirements for intensive fish farming, farmers in Rwanda should keep a stocking density of 2 fingerlings/m^2 (20,000 fingerlings/ha) and embark on improved farm management practices.

Our results corroborate those of Suman (2010) in his study on the effect of Stocking Density on Monosex Nile Tilapia Growth during Pond Culture in India. In this study, male Nile tilapia were stocked separately in 0.01 ha earthen ponds at different densities (5,000, 10,000, 15,000, 20,000, 25,000 and 30,000 fingerlings/ha). The author found that the highest weight, length, daily weight gain, growth rate and protein content were observed for the 20,000 fish/ha density class. Thus, culture of monosex Nile tilapia at a density of 20,000 fish/ha can be considered ideal for augmented production of the fish.

Findings from our experiment were compared with results registered by farmers who were sensitised to adopt the same production system under the support provided by PAIGELAC Project/Ministry of Agriculture and Animal Resources during the years 2011 - 2012.

This support was provided in order to motivate farmers to use pellet balanced feeds and shift from subsistence to commercial fish farming system; the same project has procured the same feeds used in this study for use by selected farmers who had at least 0.5 ha of ponds and above. Supported farmers registered an annual production varying from 2,800-3,500 kg/ha/year.

They started harvesting after 6 months by selecting only market-sized fish, repeating the partial harvest every two months, again selecting table-sized fish and after one year they calculated the total production with the guidance of the project's Specialised Aquaculture Technicians deployed in different zones. Production was variable but ranged between 2,800-3,500 kg/ha/year with regional variations depending on environmental factors, mostly the temperature and management followed by farmers.

We have compared the results and found that with the improved farm management practices, based on the results obtained after four months production, we can expect to attain 4,364 kg/ha/year for the first treatment, while the high end of production obtained by farmers was around 3,500 kg/ha/year under similar conditions. This was due to careful feeding, the control of predators (birds, frogs, snakes and crayfish) through fencing of ponds with monofilament nets and netting all ponds every month during sampling of fish. This contributed to the enhanced survival rate and increased of production as well.

These practices are generally not applied by farmers because most of them do not have their own seine nets. According to the field technicians, farmers may have registered a low survival rate and reduction of production due to the effect of predators.

When we compared the production costs, mainly feeds, organic fertilisers and manpower, assuming that the improved farm management practices are applied and the routine farmers' practices, we realised that there was no difference in the production costs. This is justified as follows:

The manpower required for the management of 1 ha of ponds is the same; we need 1 person to take care of feeding and daily watch of the farm security and two persons for the farm security in the night and the monthly salary is almost the same in rural areas and it varies between 20,000-30,000 Rwf (around 50 USD)/Worker.

Feeds: We followed the same feeding protocols; the source of feed and even the price are the same. The difference might have occurred in the feeding and feed management whereby according to information from former project field technicians, the majority of these farmers did not comply with the feeding protocols provided at the same time of distributing feeds.

It was also reported by Engle and Neira (2005) in their training manual that the feed conversion ratio is the most important measure of input use efficiency, but similar measures can be calculated for labour, utility use, and other inputs.

Some of the farmers were caught throwing the amount of required feeds to be distributed two times a day once in the morning because they had to go somewhere for other business during the whole day.

Another point raised by specialised aquaculture technicians was that they decided to feed a little amount of feed and reserved the remaining for the next crop without considering the expiration date of the supplied feeds.

It is known that Nile tilapia is characterised by early and high reproduction, these farmers would have kept the same feeding regimes without considering the increase in biomass due to the reproduction while for our experiment, we have used sex reversed tilapia and kept netting fish every month in order to remove the unwanted fish and other competitor aquatic organisms.

Regarding the application of organic manure, farmers were sensitised to fertilise their ponds in order to boost the natural feed production and reduce the amount of artificial feed required but according the specialised aquaculture technicians, they preferred to use this organic manure on other agricultural crops such as vegetables and bananas instead of fertilising their ponds.

Acknowledgement

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EUS infection in fresh water fishes of Andhra Pradesh, India

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Fish is an important source of animal protein in developing countries such as India. Large-scale mortality often occurs among the fresh water fishes due to environmental stress followed by pathogenic attacks and parasitic afflictions, causing tremendous losses to the nation. In India, the state of Andhra Pradesh stands out in aquaculture practices; it ranks first in both coastal and inland aquaculture production in the country. The fish farmers of Andhra Pradesh adopt some unique practices in seed production, nursery rearing, grow-out culture, feeding practices and introduction of new species.

Epizootic ulcerative syndrome, popularly known as EUS, has caused severe damage to global aquaculture. EUS has been reported from more than 20 countries in four continents viz North America, Southern Africa, Asia and Australia. It appeared for the first time in India in 1988 and has now covered almost the entire length and breadth of the country and the disease has been reported from every state. One common feature of the disease is that it initially affects the bottom-dwelling species such as murrels (snakeheads), followed by catfishes and weed fishes. Subsequently, the Indian major carps also get affected. Unlike other diseases, this syndrome has been disturbingly found to affect a variety of fish species, both wild and cultivable, resulting in large scale mortalities.

EUS in initial stage in rohu.

EUS in advance stage in rohu.

EUS in advance stage in rohu.

EUS in advance stage in catla.

EUS in initial stage in common carp.

Species affected

EUS appeared for the first time in Andhra Pradesh in 1990 in coastal districts where carp culture was the dominant practice in fresh water bodies. Later it spread to the other area farming areas of Andhra Pradesh. The most severely affected species are *Channa sp., Puntius sp., Clarias batrachus, Heteropneustes fossilis* and *Mastacembelus sp.* Other cultured species that are affected are *Glossogobius sp., Trichogaster sp., Gadusia sp., Amphipnous cuchia, Wallago attu* and *Anabas*

EUS in initial stage in grass carp.

EUS infection advance stage in rohu.

EUS in initial stage in calabasu.

EUS infection in rohu.

EUS in advance stage in murrels.

EUS in initial stage at caudal region in grass carp.

testudineus. Among the carps, EUS has been recorded in catla, mrigal, rohu and kalbasu. Common carp and grass carp are also affected.

Murrels, also known as snakeheads, belong to the family Channidae (Ophiocephalidae), are a common group of air breathing freshwater fishes that are highly regarded as food fish in Andhra Pradesh. There are several species of murrels belonging to the genus *Channa*, but only four species are available in Andhra Pradesh, viz *Channa striatus, C. punctatus, C. marulius* and *C. gatchua.* Among these, one species, namely *Channa striatus*, also called the striped murrel, enjoys a good deal of popularity as food fish in many parts of Andhra Pradesh and other parts of India. Besides the high quality of their flesh in terms of taste and texture, they also have good market value due to low fat levels, fewer intramuscular spines, reputed medicinal qualities and because they are available for purchase live.

The most severely affected species are *C. striatus,* and *C. marulius,* rarely *C. punctatus* and *C. gatchua,* resulting in large scale mortalities. Murrels of all sizes are affected. However, the incidence of infection is greater in the younger

EUS infection advance stage in rohu.

EUS infection advance stage at caudal region in rohu.

EUS infection at dorsal region in rohu.

ones. Affected murrels with mild lesions may not show any clinical signs, whereas those with marked ulcerative lesions exhibit distinct abnormal swimming behaviour with frequent surfacing.

It is interesting to note that in all ponds under scientific and semi-scientific management where both desirable and undesirable varieties of fish occurred, murrels were typically affected at the first stage of the outbreak, followed by miscellaneous other species and finally by the carps. EUS occurs mostly at water temperatures of 18–22°C and after periods of heavy rainfall.

Table 1: Commercial fish species susceptible to EUS in Andhra Pradesh

Common name	Scientific name
Catla	*Catla catla*
Rohu	*Labeo rohita*
Mrigal	*Cirrhinus mrigala*
Grass carp	*Ctenopharyngodon idella*
Common carp	*Cyprinus carpio*
Striped snakehead	*Channa striatus*
Great snakehead	*Channa marulius*
Walking catfish	*Clarius batrachus*
Climbing perch	*Anabas testudineus*
Singhi	*Heteropneustes fossilis*

Clinical symptoms of EUS

EUS outbreaks have been associated with mass mortality of various species of freshwater fish in the wild (including tanks, lakes and rivers) and on farms during periods of low temperatures and after periods of heavy rainfall. Fish usually develop red spots or small to large ulcerative lesions on the body. The early signs of the disease include loss of appetite and fish become darker. Infected fish may float near the surface of the water, and become hyperactive with a very jerky pattern of movement.

There are three stages for identification of symptoms of EUS clinically. They are:

- Initial stage characterised by localised haemorrhages on scale pockets.
- Advanced stage showing sloughing off of scales with degeneration of epidermal tissue and the ulceration.
- Final stage characterised by deep and large ulcers on various parts of the body.

Fishes of all sizes are affected. However, the incidence of infection is more in the younger ones. Clinical signs and gross pathology in the affected fishes are similar in almost all the species with moderate to severe ulcerative skin lesions. The lesions start as small grain to pea-sized haemorrhagic spots over the body which ultimately turn into big ulcers of the size of a coin, with grayish, slimy central necrotic area surrounded by a zone of hyperemia. The disease affects the fish to such an extent that they start rotating while still alive, and eventually die. Affected fishes with mild lesion may not show any clinical sign, whereas those with marked ulcerative lesions exhibit distinct abnormal swimming behaviour with frequent surfacing.

Control measures of EUS

Several methods have been tries to control the disease. Many antibiotics and chemicals have been advocated as preventive and curative measures. Generalised treatments such as lime @ 44-220 kg/ha, $KMnO_4$ @ 4ppm in pond water were widely tried among the fish farmers of the country until the formulation of CIFAX, developed by the CIFA, Bhubaneswar. Marked improvement of the ulcerative condition is noticed within a week days of application of the medicine as the ulcers heal up slowly.

Impact of EUS infected fish on trade

The majority of the fish sales in urban, suburban and rural markets decreased due to this EUS disease outbreak. Consumers hesitate to purchase diseased fish in local markets. Consequently, pecuniary losses are suffered by farmers and fishers when EUS occurs.

Conclusions

In Andhra Pradesh, since fresh water aquaculture or inland capture and culture-based fishery activities are predominantly rurally based, the adverse effects of EUS disease outbreaks are felt mainly by the poor fishers. It is thus essential that adequate attention be given to the management of fish habitat and fish health in India. This would involve firstly, developing trained staff and infrastructure for fish health research, diagnosis and extension; and secondly, establishing a proper network for dissemination of information on fish disease and fish health management to interested parties during disease outbreaks.

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Development of pond reared broodstock / spawners of green mud crab *Scylla serrata*

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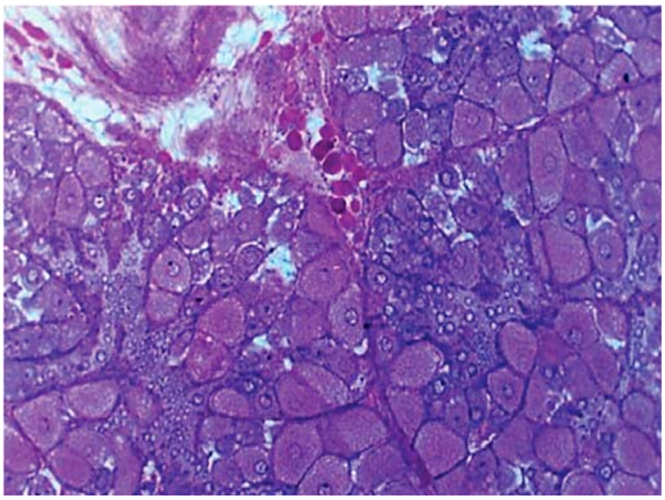
Mud crabs, species of genus *Scylla*, are one of the most traded live seafood commodities in India and southeast Asian countries. Although seed production techniques for mud crabs have been improved during the last one decade, the consistent availability of stockable 'crab seed' is a constraint for commercial mud crab culture. The main reason can be attributed to inconsistent availability of quality broodstock and unreliable hatchery seed production. Therefore, mud crab farming has largely remained as an extensive fishery based aquaculture. This necessitates to explore the possibility of development of pond reared broodstock for mud crab domestication. It has been reported that even though ovary maturation and spawning of mud crabs usually takes place in the sea, broodstock of matured crabs maintained in coastal ponds with salinity above 34 ppt have been found to be ovigerous1,2. Keeping this in view, we attempted to condition mud crab broodstock using on station and on farm experimental trials.

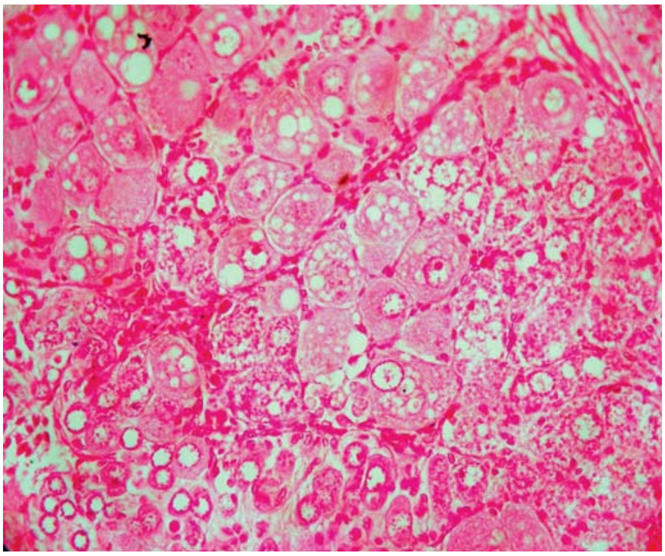
Overy fills carapace and body of the female crab.

In the on-station experiment, a 143 day culture experiment was carried out using hatchery reared seed in experimental ponds at Kakdwip Research Centre, Central Institute of Brackishwater Aquaculture (ICAR), Kakdwip, South 24 Parganas, West Bengal. Nursery-reared crab juveniles (mean: 60.87 ± 6.89 g ♂ and 54.57 ± 4.87 g ♀) were stocked at a density of 0.5 individuals / m2 in 100 m2 ponds. The crabs were reared as monosex (all female population) or as mixed sex ratio (1♂: 1♀). During the culture, with intervening rains the temperature and salinity of water varied from 27 to 10 °C and 13.3 to 8.1 ppt, respectively. After 143 days of grow out rearing, the crabs were harvested with a total survival rate of 57 and 50 % in monosex female and mixed sex culture respectively. Female crabs above 300 g had fully developed semicircular (half-moon shaped) abdomens. The percentage of females crabs that reached broodstock size (>300 g) was about 5.8% in monosex culture and 22 % in mixed sex culture (see adjacent histograms of percentage of female crabs with different size groups). A representative sample from the broodstock group (>300 g) were dissected and the ovarian stages were studied macroscopically and histologically. The gonado somatic indexes (GSI) of females were 10.55 ± 0.94 and 50% of crabs were in the ripe stage. However, none of the crabs were ovigerous. Histology results revealed that most animals were in early and advanced stage of vitel-logenesis. In the early stage of vitellogenesis yolk globules start to appear, whereas in late stages the yolk globules are abundant.

In the on farm experimental trial, ponds with high saline water (18-25 ppt) were selected. Nursery-reared mud crabs (39-43 g) were stocked at a stocking density of 0.7 individuals / m^2



Histology of ovary showing early vitellogenic oocytes.



Histology of ovary showing late vitellogenic oocytes.

Table 1. Water quality parameters of green mud crab in grow out pond.

Water Quality parameters	Range
ph	7.9-8.1
Salinity (ppt)	18.7-25
Alkalinity (mg $CaCO_3$/L)	140-164
Total ammonia nitrogen (µg/L)	105.36-132.65
Nitrite-N (µg/L)	29.37-35.72
Nitrate-N (µg/L)	123.49-153.41
Phosphate-P (µg/L)	22.46-43.23

Table 2. Growth characteristics of female black berried green crab Scylla serrata.

Growth characteristics	
Carapace length	110 mm
Carapace width	154 mm
Total weight	590 g
Weight of cheliped legs	90 g
Weight of ovary	57 g
Fecundity	1.21 million eggs

for grow out culture in farmers ponds (1000 m^2). The water quality parameters were within the optimum range for mud crab growth. The crabs were fed with 25% molluscan meat and 75% locally available trash fish feed at 5% body weight. The farmer used to provide continuous aeration for minimum 4 h during late night and early morning to reduce DO problem. Water exchange was also carried out at 15 day intervals. The crabs were harvested after 9-10 months. A total of 2% mud crabs were ovigerous in different phases of egg development and about 70% of females were at the advanced reproductive stage. The fecundity of crabs ranged between 1 to 1.42 million eggs. The colour of the berried crabs varied from yellow, orange to greyish black. Microscopic examination of berried eggs shows black eyespots as developing zoea.

In addition to the berried crabs, 81 juvenile mud crabs (below 5-20g) were also obtained from the crab ponds. The finding indicates that broodstock of green mud crabs can be developed in brackishwater ponds with juvenile mud crabs obtained within less than one year. These studies show that crab seed production can be conducted in backyard hatchery using pond reared broodstock.

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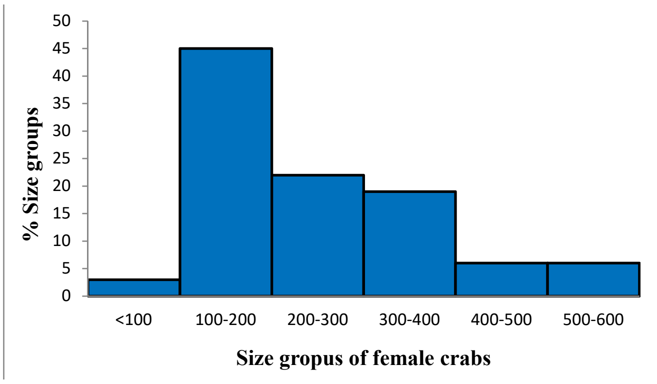


Fig 1. Percentage of different size groups of female crabs in mixed sex culture in on-station experimental ponds.

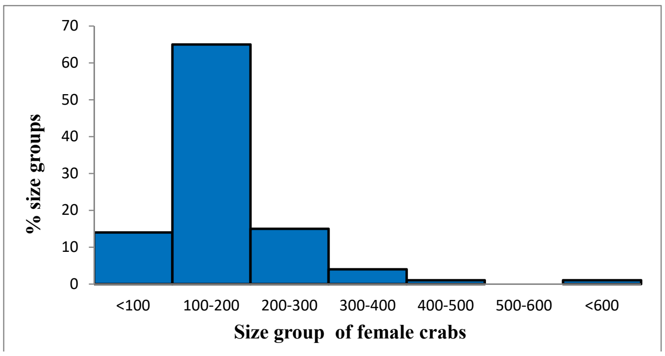
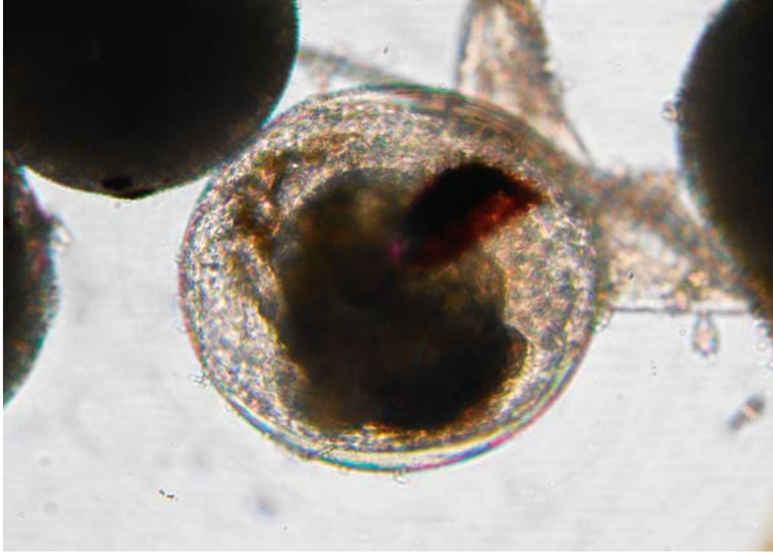


Fig 2. Percentage of different size groups of female crabs in monosex culture of mud crabs in on-station experimental ponds.

A fully gravid female mudcrab.



Microscopic view of bunches of eggs.

Fully matured berried green mud crab.

Green mud crab ponds at Uttarchandpiri, Namkhana.

Berried green crab with yellow coloured ovary

NACA Newsletter

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12th Technical Advisory Committee held in Cha-am, Thailand

Participants from TAC 12 visiting the Petchaburi Coastal Fisheries Research and Development Centre.

The twelfth meeting of NACA's Technical Advisory Committee (TAC) was held in the coastal town of Cha-am, Thailand from 9-12 March, approximately two hours' drive south of Bangkok. The meeting was attended by participants from sixteen NACA member states, the Regional Lead Centres for China, India, the Philippines and Thailand and the Food and Agriculture Organization of the United Nations.

The TAC meets every two years to review NACA's rolling work programme and propose amendments to realign it with the current needs of member governments and to account for new and emerging issues. In proposing changes, the TAC prioritises issues of common concern to multiple member governments where there are good prospects for regional collaboration. The NACA Secretariat uses the output to revise the work programme, which is submitted to the next meeting of the NACA Governing Council for consideration and adoption.

While there are many 'persistent' issues of ongoing interest to the region such as nutrition and environmental impact this years' meeting saw several shifts in regional priorities. Food safety and related certification and traceability issues are heating up with regards to international trade. Labour conditions, including for undocumented and migrant workers, are becoming a hot topic as major export markets are increasingly taking an interest in the conditions under which food is produced. Tough new legislation to address illegal, unreported and unregulated (IUU) fishing is likely to have traceability implications for the aquaculture industry, which will need to be able to demonstrate that its products have been farmed rather than fished, in order to avoid potential restrictions on trade.

Fish seed quality and availability was another standout issue. Given the near-absent genetic management of broodstock in hatcheries in the region it is not surprising that concerns about genetic degradation of broodstock, and as a consequence the quality of seed, are mounting. There is significant interest in selective breeding for the development of genetically improved varieties of important cultured species, but the general lack of capacity in broodstock management is a significant barrier to both developing and maintaining such lines.

Aquatic animal health remains a burning issue for the aquaculture industry with no letup in sight as far as the emergence of new pathogens is concerned. However, the TAC felt that it would be wise to invest more effort into the proactive management of health issues, such as through improving disease surveillance and early warning systems, biosecurity and quarantine, laboratory

Left to right: P. Jayashankar, Vice Chair; Brett Ingram, Chair; Cherdsak Virapat, Director General; and Hassanai Kongkeo, Technical Assistant to the DG.

capacity and investment in vaccines and better management practices as alternatives to the use of veterinary chemicals. It is well established that prevention or early containment of a disease outbreak is massively cheaper than responding after it has been given a chance to spread.

The environment, feeds and nutrition are core issues that are discussed at every TAC meeting, but the effect of environmental quality on aquaculture is gaining prominence. Pollution from external urban and agro-industrial sources and water quality degradation is increasingly causing problems for the aquaculture industry, notably in inland areas. For example cages installed in river systems suffering fish kills as a result of the release of industrial effluent upstream, which is driving a move into land-based pond systems in some countries. Assessments of carrying capacity and zoning of areas for aquaculture use are as-yet underutilised partial solutions worthy of wider investigation. Feed costs have risen heavily as the price of ingredients has escalated. Some countries such as Lao PDR and Sri Lanka are still heavily dependent on importation of commercial feeds as quality, locally made feeds are unavailable.

TAC working groups hard at it.

Other issues discussed included gender mainstreaming, a new area of work for NACA and a high priority for many member states, the potential impacts of climate change, integrated multi-trophic aquaculture and technology transfer between different administrative units of government (national, provincial) and at the regional level were also discussed.

As TAC members are usually also high-level officials from research centres participating in the network, the meeting also provides a good opportunity to discuss implementation of the work programme by the people at the coal face. The final half day of the meeting was spent drawing up a number of joint project concepts of broad regional interest on sustainable farming systems, aquatic animal health, genetics and biodiversity, climate change and south-south cooperation in aquaculture development.

The NACA work programme is currently undergoing revision and will be considered at the 26th Governing Council Meeting, which will be held in Bali, Indonesia, in May. The final document will be published on the NACA website shortly thereafter.

Audio recordings: WAS special session on regional cooperation for improved biosecurity

Audio recordings of the presentations from the ACIAR-funded Special Session on Regional Cooperation for Improved Biosecurity, held at the World Aquaculture Adelaide 2014 conference, are available for download. The session discussed i) regional cooperation in biosecurity, ii) dealing with emerging diseases, focussing on acute hepatopancreatic necrosis disease, and iii) domestication programmes and their implications for genetic diversity, disease susceptibility and resistance.

To listen or download the recordings please visit:

http://www.enaca.org/modules/podcast/programme.php?programme_id=14

AFSPAN Final Technical Report now available!

The final technical report of the AFSPAN Project is now available for download from www.afspan.eu.

Executive summary

The objectives of the Aquaculture for Food Security, Poverty Alleviation and Nutrition (AFSPAN) project were to strengthen the knowledge base and develop new and more rigorous methodologies of quantifying the contribution of aquaculture to combat hunger and poverty, thus providing the evidence upon which sound strategies, policies and research programs can be developed to support the sustainable expansion of aquaculture to maximise its impact on food and nutrition security and poverty alleviation.

The three-year project was implemented by eighteen partners in eleven Asian, African and South American developing and Low Income, Food Deficit Countries (LIFDCs), encompassing the spectrum of development conditions and role of aquaculture in national economies. The partnership also included EU partners and international organisations.

A theory of change was elaborated and range of analytical frameworks, economic models and indicators, complemented by surveys and case studies developed. The contribution of aquaculture to national GDP, excluding multiplier effects, was found to vary from negligible in countries with emergent aquaculture sectors up to 5% or more of national GDP in countries where the sector is very dynamic. Aquaculture was shown to have helped lower global fish prices, increasing economic access for all but the very poorest consumers. Although households engaging in aquaculture were found less likely to be poor than those that did not, poor households too benefitted from engaging in fish farming, irrespective of scale of operation. Fish consumption rates of households engaged in fish farming were typically higher than national averages.

Both immanent (e.g. economic growth) and interventionist (the implementation of policies promoting aquaculture development, improving governance and capacity) factors, as well as institutional arrangements, public-private partnerships and pioneering companies and individuals, were found to be capable of creating enabling conditions for aquaculture growth. Socio-cultural factors, especially gender and ethnicity, were also important: interventions tailored to match given specific socio-cultural contexts were most likely to lead to successful adoption and retention and delivery of equitable development outcomes, with lasting impact on livelihoods.

The volumes of seafood exported from developing to developed countries were found to approximate those of seafood imported by developing from developed countries. While expensive seafood may be being exchanged for cheaper but not necessarily less nutritious seafood, thereby minimising threats to food security, there remains a lack of supporting evidence that this is the case. With the exception of Bangladesh no policies or interventions linking fish, aquaculture and nutrition were found in study countries and little is included in nutrition education on aquatic animal foods.

Project outputs are being disseminated among the development community to help improve efficiency and coordination of development initiatives focused on aquaculture that promotes food and nutrition security and alleviates poverty and helps focus research on addressing researchable gaps. The development of science outputs has also begun.

Pillay Aquaculture Foundation Awards for Scientists in Least Developed Countries

The Pillay Aquaculture Foundation will confer awards that recognize and support scientists in least developed countries for outstanding contributions to national aquaculture research and development, education and extension.

The awards are available for the following fields:

- Aquaculture research and technology development.
- Aquaculture institution building and strengthening.
- Aquaculture education and extension.
- Promotion of aquaculture as a co-operative venture.
- Aquaculture product development and export promotion.

Eligibility

In 2015 the awardees will be selected from nationals of Nepal, Bangladesh, Bhutan and Myanmar who have contributed substantially to the cause of aquaculture development in the sectors as listed above. Their contribution should have qualitatively or quantitatively impacted aquaculture production and the quality of life of those involved in this venture.

Application for the awards needs to be routed through the head of the institution, along with:

- Three copies of his/her five best publications, if any, or proof of work done, in the related field.
- Three recommendation letters from persons occupying high positions in national aquaculture/fisheries institutions or government departments.

- A professional reference issued by his/her superior officer, preferably Head of Department.
- A brief resume, along with a summary of his/her work.

Nomination can also be made by any Board Members of the Pillay Aquaculture Foundation, either past or present (but not by office bearers).

Selection of awardees

Selection will be made by the Award Judging Committee of the Pillay Aquaculture Foundation.

Award

The award will consist of a citation and a gold plated silver medal.

The Pillay Aquaculture Foundation will provide an economy class air ticket and local hospitality to the awardees to attend the ceremony at the foundation's congress, 15-17 July 2015. Awardees are required to present their contribution before the congress.

The last date to receive applications for the award is **May 31, 2015** at the following Address:

Pillay Aquaculture Foundation
AFSIB Building
College of Fisheries Campus
Mangalore 575002
India.

Gender Seminar Conducted and ASEAN Gender Network Launched

The Gender and Aquaculture Seminar: Equity and Regional Empowerment in the Aquaculture Value Chain, a culminating activity for the NACA/USAID/MARKET Project's Thematic Studies of Gender in Aquaculture, was held on 24 to 25 February 2015 in Bangkok. The year-long project conducted research on womens' roles and influence on selected aquaculture value chains in Cambodia, Lao PDR, Thailand and Vietnam.

The goal of the research was to raise awareness and increase recognition of gender roles, policies and programs in the aquaculture industry in the selected countries to support more sustainable and responsible development. The outcomes and recommendations of the thematic studies were presented at the seminar, as part of the dissemination strategy for raising awareness, and to obtain feedback from other gender practitioners in the region. The seminar also provided a venue for public and private sector stakeholders to share their current activities supporting gender equity and empowerment in the aquaculture value chains. Discussions on creating opportunities to harness contributions of women provided insights on how an enabling environment especially in policy and engaging communities and the private sector could encourage equity and empowerment. In addition, a the panel discussion on gender education, training and capacity building revealed insufficiency in current capacities in the academic arena for gender inclusion, as well as the urgent need for equipping practitioners with tools in the field.

The lack of gender disaggregated data in aquaculture value chains has also been seen as a major issue, which will have an impact on formulating relevant policies on gender integration in aquaculture, business decisions and project interventions. The seminar was attended by project partners from Cambodia, Lao PDR, Thailand and Vietnam, and from relevant and interested stakeholders from universities, NGOs, and private sector in the ASEAN, including NACA and USAID/MARKET team.

Sharing experiences by those involved in varied networks for gender or other fields in various parts of the world provided a good lead on towards the introduction and launch of the ASEAN Gender in Aquaculture Practitioners' Network. As the aquaculture sector has become increasingly aware of the importance of gender sensitivity and integration in all its activities, there is a need for people working in this area to have a gender perspective. Currently there are a number of aquaculture practitioners and stakeholders advocating for gender integration and mainstreaming in aquaculture activities. In addition, there are already women involved in aquaculture and working alongside with the men. As they learn and gain experiences, there is a need to be able to share this knowledge so more people will become more aware and gain a gender perspective. This network therefore will be composed of people who are interested in advocacy for gender integration in aquaculture.

The objectives of the network are to promote gender integration in aquaculture and fisheries, advocate for and advance the status of women in aquaculture in ASEAN, assist practitioners in implementing projects which integrate gender at all levels, serve as a venue for information exchange and experiences sharing, conduct capacity building activities on gender development in aquaculture, and promote collaboration among organizations and development projects. The network will also be responsive to emerging issues at the regional level which have implications on gender issues in aquaculture.

During its launch, a set of activities for the first six months has been set-up by the members. This includes strategic planning, networks mapping, writing of concept notes/ proposals, setting up a website and fund sourcing. The Gender Programme at NACA in Bangkok will coordinate network activities.

For more information, email arlene@enaca.org.

A two-tube, nested PCR detection method for AHPND bacteria

A new method for the detection of AHPND-bacteria (AP4) has been published and is available for download at:

http://www.enaca.org/modules/library/publication.php?publication_id=1145

The advantage of the AP4 method over the previously published AP3 method is that the it has 100 times higher sensitivity. Because of its higher sensitivity, the bacterial culture enrichment step needed when using the AP3 with low levels of AHPND bacteria may be omitted. However, the AP4 method should not be considered as a replacement for the AP3 method but simply as an alternative choice for the users to choose should they need a more sensitive detection method.

The AP4 method has been tested with the same 104 bacterial isolates that were used for validating the AP3 detection method, and the results were identical, i.e., 100% specificity and sensitivity with the 104 isolates but at 100x lower template levels.

As with the previous announcements in this series, the AP4 method is provided for free use in the detection of AHPND bacteria. A positive control plasmid for the AP4 method will be sent out to those who are already on our mailing list as recipients of plasmids for our previous AP methods to detect AHPND bacteria. For those not already on our list, the plasmid will also be provided upon request to: Dr. Kallaya Sritunyalucksana (email kallaya@biotec.or.th). To join the mailing list, please visit the AHPND Detection Google Group, which you can join at:

https://groups.google.com/forum/#!forum/ahpnd

The AP4 PCR method was developed entirely by Thai scientists working in Thailand at Centex Shrimp,the Shrimp-virus interaction laboratory, BIOTEC and Aquatic Animal Health Research Center and Charoen Pokphand Co. Ltd. It was also supported entirely by research funding from Thailand. The authoris would like to acknowledge the support and encouragement for our research on AHPND from the Agriculture Research and Development Agency, the National Research Council of Thailand, the Thai Commission for Higher Education, Mahidol University, Faculty of Marine Technology at Burapha University, the National Science and Technology Development Agency, the Patani Shrimp Farmers Club, the Surathani Shrimp Farmers Club, the Thai Frozen Foods Association, Charoen Pokphand Company, SyAqua Co. Ltd. and Thai Union Co. Ltd.

9th Regional Grouper Hatchery Production Training Course – apply now!

NACA in collaboration with the Krabi Coastal Fisheries Research and Development Centre (Department of Fisheries, Thailand) will hold a training course on grouper hatchery production from 12 to 30 October 2015 at the Krabi centre.

The course is suitable for both commercial hatchery operators, technical staff and research biologists. Course contents:

- Biology of Grouper
- Site Selection, Hatchery Design, Equipment and Setup
- Broodstock Selection and Management
- Eggs Handling and Development Stages
- Culture Environment and Water Quality Management
- Larviculture and Nursery
- Live Food Production – Phytoplankton
- Live Food Production – Zooplankton
- Nutrition and Feed for Grouper Larvae (include artificial feed)
- Diseases and Fish Health Management in Hatchery
- Harvest, Packaging and Transportation

Participants are expected to gain the following skills:

- Assess a site for building a hatchery
- Select, maintain and handle broodstock
- Induce fish to spawn
- Incubate eggs
- Prepare live feed and develop feeding regimes for newly hatched larvae, and
- Nurse fry prior to seed harvesting, packaging and transportation.

The course will consist of approximately 30% classroom presentations on biological and hatchery management exercise, 50% hands on practical training and 20% field trips.

Applications and further information

The course fee covers costs for tuition, working lunches, coffee/tea breaks, airport pickup, local transportation and materials and supplies for training related activities. The fee does not cover the costs for international and domestic flights to and from the nearest airport, accommodation, breakfast and suppers, allowance and other personal expenses. To apply for the course please download the:

- Applications form: http://enaca.org/publications/announcements/2015/marine-fish-hatchery-training-application-form-2015.doc
- Course brochure: http://enaca.org/publications/announcements/2015/marine-fish-hatchery-training-brochure-2015.pdf

Developing an environmental monitoring system to strengthen fisheries and aquaculture in the Lower Mekong Basin

FAO and NACA convened a stakeholder consultation in Bangkok 25-257 March 2015 to discuss development of an environmental monitoring system for the lower Mekong Basin. The objective of the system is to strengthen the resilience of fisheries and aquaculture and to improve early warning for fishers and farmers.

The workshop was preceded by baseline assessments of existing environmental monitoring and early warning systems relevant to fisheries and aquaculture in the target area, which covers Vietnam, Cambodia and Thailand. The assessments also reached out to relevant agencies in the target countries to gather feedback on what environmental issues they considered important and what parameters should be monitored to meet these ends. While the main goal of the system is to serve the daily needs of farmers and fishers – providing information and warnings important to their livelihoods - a secondary objective is to facilitate long-term monitoring of the impacts of climate change over the long term.

The state of environmental monitoring was observed to vary between countries. Some such as Thailand, for example, have very good monitoring systems in place for meteorological and water management. Vietnam's meteorological bureau monitors also river levels and publishes flow and height forecasts. Cambodia has strong programmes to monitor water quality and biodiversity aspects, such as surveys of fish larvae and fish diversity and abundance in deep pools. However, these diverse systems are owned and operated by a raft of different agencies, as they have been developed to serve different purposes, and are not necessarily connected or sharing data. The workshop identified a need to try and integrate the available data produced by existing sources and to build on it, where required, to provide a unified environmental monitoring system capable of sharing data and reporting over different geographic scales, from the wider basin level (ie. between countries) to the local-level advisories of interest to farmers and fishers.

Another crucial issue is connecting the reports generated by the system to fishers and farmers using appropriate communication channels, to ensure that they actually receive the kind of information they need in a timely manner and can benefit from it. As accessibility to different forms of media, language and literacy skills are all substantial issues for often remote communities, communication channels must be chosen very carefully, and in line with the access, skills and convenience of fishers and farmers.

The consultation spent some time discussing recent technological developments. The dramatic increase in the penetration of mobile phones (especially smart phones) and coverage of mobile networks offers a way to directly deliver area-specific information services to farmers and fishers as well as the opportunity to involve them in data collection through custom applications. The 'internet of things' also offers new opportunities for low-cost data gathering. Cheap programmable micro-controllers - essentially the tiny computer you might find operating a hotel door lock - are now widely available even as hobbyist kits, excellent documentation and can be fitted with a surprisingly wide array of off the shelf environmental sensors to monitor anything from light, temperature and humidity to gas and radiation levels.

The findings of the consultation will be used to develop a pilot project, to be implemented on a long term or ongoing basis.

Participants in the workshop.

Regional Workshop on the Status of Aquatic Genetic Resources

FAO and NACA organised the Regional Workshop on the Status of Aquatic Genetic Resources in Asia-Pacific at Hotel Centara Grand Ladprao, Bangkok from 23-26 March 2015. This was the first workshop in the series of four to be conducted globally by FAO. The workshop was intended to enhance the capacity of national focal Points on Aquatic Genetic Resources within Asia-Pacific Region regarding the preparation of national reports on the current status of aquatic genetic resources for food and agriculture (use, conservation and management). These will be used as the major source of information for the first State of the World's Aquatic Genetic Resources for Food and Agriculture report, under the umbrella of the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA).

The national focal points from fifteen countries in Asia; Thailand, Cambodia, Lao PDR, Vietnam, Indonesia, Malaysia, Philippines, India, Pakistan, Nepal, Myanmar, Japan, South Korea and the Pacific participated in the workshop, along with Fiji and global experts. FAO staff including Dr Devin Bartley, Dr Halwart Matthias and NACA staff Dr Kuldeep K. Lal facilitated the process of workshop with expert input from Dr Graham Mair (Australia), Dr Tim Pickering (SPC), Dr Clemens Fieseler (Germany) and Dr Ruth Garcia Gomez (FAO consultant).

The workshop started with the welcome address from Dr Cherdsak Veerapat, Director General of NACA and opening remarks by Dr Devin Bartley. The workshop was opened by Dr Miao Weimen, FAORAP, Bangkok on behalf of Dr H. Konuma, ADG, FAO Office for Asia pacific, Bangkok. The participants were given an appraisal on the theme and concept of this workshop through four expert presentations on workshop content, process, expected outcomes and outputs and introduction to the CGRFA by Devin Bartley. The Aquatic Genetic Resources Component of CGRFA and the steps towards the State of the World's Aquatic Genetic Resources report were addressed by Matthias Halwart; the German National Technical Programme on the conservation and sustainable use of aquatic genetic resources by Clemens Fieseler and perspectives on aquatic genetic resources management and conservation in Asia-Pacific by Kuldeep K. Lal.

The national focal points and experts discussed each chapter of the report in the respective groups. The groups also prepared each chapter as an exercise with information from one member country as an example followed by a presentation on the chapter by respective group. This exercise was found useful by the national focal points as this not only provided them first hand feel of the whole questionnaire but also served as useful feedback for FAO colleagues to incorporate suggested modifications in the report format. Delegates found the training useful and that it will help them facilitate preparation of national reports.

A one day field visit was organised by NACA for the delegates to see the activities related to aquatic genetic resources in Thailand. The forenoon session was devoted to observing activities at the Thai Department of Fisheries Inland Fisheries Research Station at Bangsai. In addition to various aquaculture activities, an interesting feature was on farm conservation of the Mekong giant catfish *Pangasianodon gigas,* a near extinct species conserved through a dedicated breeding program. In the afternoon delegates visited National Centre for Genetic Engineering and Biotechnology (BIOTEC) at Thailand Science Park. Here delegates were exposed to the activities through presentations about BIOTEC and its shrimp biotechnology program by Dr Sirawut Klingbunga, Director of the Animal Biotechnology Research Unit. The delegates visited the laboratories and also the pilot testing plant.

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