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Murrel culture in backyard cement tanks

Meeting the future demand for fish

SE Sulawesi mariculture

Carp farming in India

Aquaculture Asia

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Editor

Simon Wilkinson
simon@enaca.org

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.

Contact

The Editor, Aquaculture Asia
PO Box 1040
Kasetsart Post Office
Bangkok 10903, Thailand
Tel +66-2 561 1728
Fax +66-2 561 1727
Website http://www.enaca.org

Submit articles to:
magazine@enaca.org

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Culture-based fisheries: An option for sustainable intensification of food production?

To make a long story short, our global population will probably hit around 9 billion by 2050 and we will need to produce about 60% more food to feed everyone by then. Our starting position is that globally around one billion people are suffering from hunger and poverty right now and more than half of them live in the Asian region. When you add in the likely increase in the cost of energy and constraints on natural resources in coming decades the prospect looks rather alarming. The term "sustainable intensification" has been coined in recognition of our need to produce this additional food without further degrading our natural resource base.

There's a couple of different ways you can go about sustainable intensification but basically they boil down to i) improving resource use efficiency (eg. better management practices) and ii) reducing wastage throughout the production-distribution-consumption chain (about 30% of the food we produce is lost or wasted).

Culture-based fisheries (CBF), the practice of stocking water bodies for harvest, is an option worth considering in our quest to sustainably intensify the global food supply. CBF activities, as distinct from stock enhancement, are usually carried out in smaller water bodies as the practice generally implies ownership, management and full harvest of the stock, which is generally not practical in larger ones. CBF can be carried out as a secondary or additional use of water bodies, for example in reservoirs used for other agricultural purposes. With a bit of planning it can often be carried out in ephemeral water bodies that dry up or are discharged for irrigation during the dry season and little capital investment is required. Perhaps most importantly, CBF is generally (with a few exceptions) unfed and based on natural productivity, resulting in a net removal of nutrients from the water body rather than adding to them, so there are no concerns about pollution.

CBF is well-suited to small reservoirs often managed by agricultural communities in rural Asia and lends itself to community-based approaches. With support from the Australian Centre for International Agricultural Research (ACIAR) NACA in partnership with Lao/Cambodian counterparts, Deakin University and Fisheries Victoria has successfully introduced CBF activities in Lao PDR and more recently to Cambodia. The project worked with national and local government counterparts to identify suitable water bodies and then with interested communities, mainly rice farmers, to develop a stocking and harvesting plan that fit in with their existing agricultural activities and pattern of water use. In Lao PDR communities are now sustaining CBF independently of project support and using the harvest in a variety of ways, some selling it for income while others allow community members to fish for their daily household needs, improving nutrition and allowing them to spend more time on their core farming activities.

The outcomes of the project will be wrapped up at a regional meeting on culture based fisheries to be held in Siem Reap, Cambodia 21-23 October 2014. The lessons learned from the project will be published as a Better Management Practices guide in the near future, which will be published on the NACA website in due course.

Simon Wilkinson

AQUACULTURE ASIA

Peter Edwards writes on

Rural Aquaculture

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

Towards meeting future demand for fish: Aquaculture in inland or marine land or water-based systems?

Overview

The production of food fish (finfish, crustaceans and molluscs) by aquaculture has to increase by about 50% from current levels to meet the projected demand of a fast-growing and more affluent global population in 2030, in just less than a quarter of a century. It is generally accepted that most of the future supply of fish has to be provided by aquaculture as production from capture fisheries has levelled off. The world's population is predicted to reach 8.3 billion by 2030 (FAO, 2011). Aquaculture needs to produce 79.1 million tonnes by 2030 to maintain the current (2008) per caput fish consumption of 17.1 kg, another 26.6 million tonnes of fish in addition to the 52.5 million tonnes of fish produced by aquaculture and consumed in 2008.

What is less clear and indeed is a highly controversial is issue is where this projected future supply of fish will be farmed? There are finite limits on land and water resources so where will most of the future production of fish occur; in which ecosystems or agro-ecosystems in inland land or water-based systems, or in coastal land or water- based or off-shore water-based systems?

Two mantras in both popular and scientific literature, statements that are being made so frequently that they run the risk of being accepted as indisputable or the truth, are challenged in this column. The first mantra is that because there are increasing pressures being placed on both the amount and sustainable use of land and freshwater, aquaculture cannot compete with agriculture for these resources. The second mantra follows on from the first, namely that the future of aquaculture is in the oceans rather than in inland land or water-based systems.

Conversion of rice fields to fish pond in Bangladesh.

Land use for agriculture or aquaculture?

The idea that aquaculture should not compete with agriculture goes back more than half a century. The British Government constructed the Tropical Fish Culture Research Institute near Malacca in the late 1950s in present day Malaysia to serve as the aquaculture research station for the tropical Commonwealth Territories of the UK. The site was selected for the construction of the ponds because it was regarded as totally useless for agriculture because of the high aluminium and iron contents of the soil, even though fertilisers and feeds for traditional inland pond aquaculture are provided by integration with agriculture derived from adjacent crop and livestock farm subsystems. More recent quotations indicating the continuing perception of a land use clash between agriculture and aquaculture are 'competitive uses of land preclude large-scale expansion of pond area'; and 'a slowing down of aquaculture growth is anticipated due to constraints in available land and water'.

Coversion of rice fields to fish ponds in Indonesia.

Conversion of rice fields to fish ponds in Nepal.

Most global fish production today is from ponds and they are likely to remain the major grow-out system for freshwater fish production in the future. There is huge potential to increase fish production from expansion of aquaculture through newly-built fish ponds from conversion of agricultural land as well as the ongoing intensification of pond culture. Most inland fish ponds in Asia have been converted from rice fields and most countries continue to convert land to fish ponds although the practice has now been banned in China where most fish ponds were converted from rice fields during the 1970s and 1980s. A ceiling has recently been established in Vietnam on national rice field conversion to maintain at least 4 million ha of rice fields due to concerns about national food security. However, Vietnam previously encouraged the conversion of previously low-yielding rice fields to more profitable pond-based integrated agriculture-aquaculture systems (IAAS) with raised broad dikes for vegetables, fruit and livestock less susceptible to monsoonal flooding than

Raised pond dike producing fruit and vegetables in rice field converted to fish pond in Vietnam.

Raised dike with ducks integrated with fish culture on a pond built from a converted rice field in Vietnam.

the previously low-lying rice fields to improve farmer earnings. Thousands of hectares subject to flooding and able to produce only one rice crop annually in the Red River Delta, Vietnam, have been converted to fish ponds with elevated dikes in concentrated areas of 20-100 ha with 50-150 households. The minimum return is 3-5 times higher than rice with a reduced risk of flooding. The recent acceleration of development of aquaculture in Nepal has taken place mainly in ponds converted from rice fields (Edwards, 2013).

The conversion of rice fields to fish ponds is a most contentious issue because governments are faced with a difficult choice: continued national food security through farming of staples such as rice for human populations that continue to grow in absolute number; and agricultural diversification for farmers, many of whom are poor, out of primary staples to more profitable crops such as vegetables, fruit, livestock and of course fish. Rice production

Raised pond dike producing bonzai tree in rice field converted to fish pond in Vietnam.

does need to be increased for at least the next two decades because the demand for rice from human population growth is expected to be greater than the decline in per caput rice consumption from the universal trend in diversification of diets associated with economic growth and urbanisation. However, diversification of rice cultivation has been identified as the most important way to reduce the poverty of small farmers as rice earns a relatively low income for farming households. There is still considerable potential to increase rice yields in many countries so that some farm land could be taken out of rice production and converted into more profitable crops such as fish.

Two cases indicate that the conversion of rice fields to fish ponds may have relatively limited impact on national rice production. One million tonnes of striped catfish (*Pangasianodon hypophthalmus*) have been produced from 6,000 ha of ponds in Vietnam and 300,000 tonnes of striped catfish have been produced from 7,400 ha of ponds in Bangladesh, one of the most densely populated countries in the world, both from converting less than 0.1% of the total area of rice fields in both countries to ponds. An extreme example of the more efficient use of both land and water is the conversion in China of rice fields producing a relatively low-value rice crop below a reservoir, with an abundant year round supply of available water, to an intensive fish farm raising high-value paddy field eel (*Monopterus albus*) (Edwards, 2013).

Alternative use of water

There is likely to be increasing scarcity and quality of water in the near future, with less water available for agriculture, including aquaculture. More efficient use of water could be attained by integration of aquaculture with natural and constructed water bodies. Large fish ponds, 100s to 1,000s of ha in area, built centuries ago, are an integral part of the Czech landscape where they function for irrigation, water management, recreation and nature reserves as well as for fish culture.

The productivity of water may be increased through integrated irrigated aquaculture (IIA), the integration of aquaculture in irrigation systems, with aquaculture essentially a non-consumptive activity with fish farmed in the water on its way to or from agriculture (FAO, 2006). Community or culture-based fisheries (CBF), usually extensive aquaculture in small water bodies, leads to the production of more fish from existing waters with minimal external feed inputs. It has been estimated that there are 67 million ha of small water bodies in Asia, constructed mainly for irrigation, that could be used for CBF although there are usually complex technical, social and institutional issues to be addressed regarding biodiversity, access to water bodies, social equity arrangements, and competition for use of water.

The rice field eel farm built on converted rice fields below a reservoir in China.

The rice field eel farm (left) and rice fields planned for eel farm expansion (right) below a reservoir in China.

There is also considerable potential to expand cage culture in under-utilised reservoirs and irrigation canal, lakes and rivers although it requires coordination between the water authorities that manage the water bodies and fish farmers. Agricultural water storage reservoirs are dual purpose water bodies in Egypt and Israel as they are also stocked with fish.

Although there is major concern about the limits of water to sustain future increases in agriculture and aquaculture, renewable freshwater does appear to be adequate for considerable expansion of aquaculture, especially outside Asia (Boyd et al., 2012).

Open ocean aquaculture

The mantra that the future of aquaculture is in the oceans because of perceived constraints of land and freshwater dates back at least half a century: 'It seems not outrageous to suggest that the oceans may someday produce a greater proportion of the food consumed by humans than is grown on the land' (Brittain, 1952). Other more recent quotations include: 'the era of mariculture' and 'the oceans…will constitute the next food revolution in human history'.

The open ocean covering about 70% of the worlds surface does seem to offer tremendous potential to increase global aquaculture production with almost unlimited space for cages and water volume for diffusion of wastes. Significant expansion of coastal aquaculture is constrained in many countries as favourable sites are often being used already for aquaculture, there may be competition for space from multiple users, and coastal areas are often polluted by domestic and industrial effluents. The composition of fish production would also have to change for open ocean aquaculture to contribute significantly to global food supplies as mariculture is currently dominated by seaweeds (46%) and bivalve molluscs (43%) at 89% of total production, which do not provide major sources of human food; crustaceans (2%) and finfish (9%) provide only a total of 11% of total mariculture production (FAO, 2013). Furthermore, there are technological, operational, economic and political challenges, including the

The reservoir dam (foreground) and the rice field eel farm built on converted rice fields (background, left) in China.

lack of institutional or regulatory frameworks, that need to be met before open ocean aquaculture could make a significant contribution to global fish production.

The way forward

Inland aquaculture is likely to continue to be the major source of fish rather than mariculture, including open ocean aquaculture. While there is considerable on-going R&D towards expansion of aquaculture into open marine waters, numerous challenges remain to be resolved before the oceans become a major supplier of farmed fish; according to FAO (200), the 'growth of such developments is unlikely to be high'. Inland ponds are likely to continue to dominate global aquatic food production. The fastest growth of the global food fish supply to 2030 is likely to come from freshwater carps, striped catfish and tilapia (World Bank, 2013), most of which are raised in ponds.

A major challenge to increase the production of fish required to meet projected future demand is to resolve potential conflicts and competition for increasingly scarce land and water for which there are multiple demands from agriculture (to farm crops and livestock), increasing urbanisation and industrialisation, and nature conservation and tourism, as well as from farming fish. Clearly, there is a need to make the most efficient use of finite land and water. As agriculture is by far the largest user of both land and water as well as having potential to sustainably increase its production on less land in many countries, conversion of at least a relatively small amount of agricultural land to fish ponds offers the greatest potential contribution towards meeting the future demand for fish.

The practice of the conversion of rice fields to fish ponds is likely to continue. This is especially so in countries with relatively recent introduction of aquaculture rather than those with well developed aquaculture sectors where there is concern to maintain a minimum area of rice land for national food security. However, even in countries with a well developed aquaculture sector such as China and Vietnam, there is a need to assess the relative merits of using land and water for aquaculture rather than rice cultivation in specific areas, especially those in which rice production is sub-optimal because of poor soils or frequent drought or flooding often leading to a reduced harvest. Research is required on the merits of conversion of at least marginal, low-yielding rice fields to fish ponds. The conversion of rice fields to fish ponds should hardly be an issue in terms of reduction of national rice production because of potentially huge fish production from relatively small areas of converted rice fields as the cases presented illustrate.

Note

This column is based on a keynote presentation, 'Aquaculture environment interactions: past, present and likely future trends' at the Elsevier conference 'Aquaculture 2013, Celebrating 40 Years of Aquaculture', held in Las Palmas, Gran Canaria, Spain in November last year.

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Status of carp farming in India

B. Laxmappa

Department of Fisheries, Mahabubnagar – 509 001, Andhra Pradesh, India. Email: laxmappaboini@gmail.com

Good sized rohu fingerling used in carp culture in Andhra Pradesh.

The carps (Cyprinidae) are a very large family of freshwater fish native to both Asia and Europe. A wide variety of carp species are used as foodfish and provide a cheap source of protein for subsistence aquaculture in warm temperate to tropical countries.

Carp production is increasing tremendously throughout the India and caters to the tastes of all classes of people ranging from aristocratic urban consumers to the rural poor. India is the third largest producer of fish and second largest producer of inland fish in the world.

Carps are the mainstay of Indian fish farming contributing over 85% of the total aquaculture production. The three Indian major carps, viz. catla, rohu and mrigal represent the bulk of the production in the country, whereas commonly cultivated exotic carps such as as silver carp, grass carp and common carp form the second important group (Table 1).

Chinese hatchery technology introduced to India in the 1980s led to the large scale production of carp seed in the country and the spread of carp culture technology. Carp culture has been popularised throughout the country and the average productivity levels are reported to be around 2,500 kg/ha/year using the polyculture systems of carps.

Farmers of Andhra Pradesh, particularly in the Krishna, East Godavari and West Godavari Districts have innovated several new techniques in carp culture and those have contributed to increase the carp culture productivity in the country substantially. Farmers in this state are now able to get an average production of 8,000 kg/ha/year with rohu as the most dominant species in the culture system. This impressive production has been made possible by adapting various techniques in the culture system (Table 2).

Similar spectacular developments in carp culture have taken place in the state of Punjab where farmers have modified the technology to suit their areas and obtain an average production of more than 5,000 kg/ha/year. Farmers resort to multiple stocking and multiple harvesting and use of all species of carps in the culture unlike in Andhra Pradesh wherein the system revolves around rohu and catla.

Besides the above two states, West Bengal on the Eastern side of India not only produces significant amount of carps, but also most of the production from the states like Andhra Pradesh have been reaching fish markets in West Bengal and other Eastern States.

Sound technological inputs, entrepreneurial initiatives and financial investments in carp farming have significantly increased the pond productivity from about 600 kg/ha/year in 1970s to present level of 2,500 kg/ha/year and some farmers are even demonstrating higher production levels of 8 to 12 tonnes/ha/year.

Seed rearing and grow-out culture are the two main components of carp culture technology, which have undergone modifications and refinements over the years to evolve to the present todays package of farming practices. Culture systems, from extensive to intensive have been developed depending on the inputs and resources available to farmers.

Carp culture is undertaken mostly in earthen ponds of varying dimension in the country. Over the years, several culture practices were also developed for different water resources utilising feed resources as main inputs. The standardised practices for carp polyculture include pond preparations, liming, fertilisation and stocking management.

Constraints

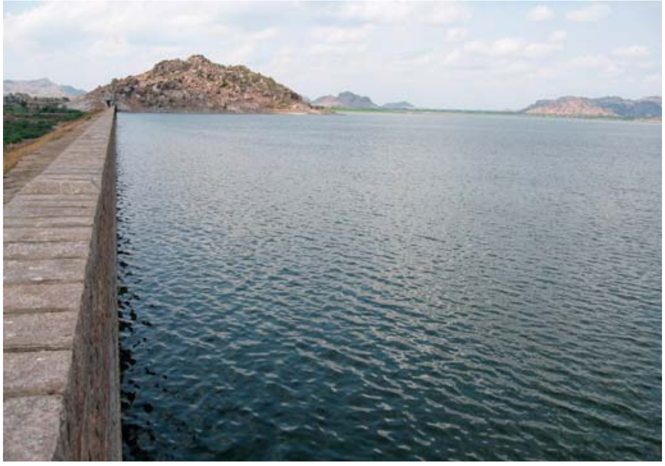
Although India is producing significant levels of carp there is still scope to enhance production further. For this to happen there are some constrains in carp farming that must be overcome. The main constraints in carp farming are:

- Since the tank/pond resources of the country are mostly rain fed, an erratic rainfall or reduction in rain increases the risk of drying up or water depth reduction to critical level, rendering them unsuitable for providing optimal growing condition of carps.
- The country is self sufficient for fry production at present but non-availability of quality fingerlings of desired species and size has been a major constraint over the years.

Carp seed collection from rearing pond.

Carp seed stocking in reservoir.

Carps culture in irrigational tank.



Carp culture in reservoir.

Supplamentary feeding in carp culture pond.

Trial netting in carp pond.

Carp harvesting from culture pond.

Collection of harvested carp from net.

Harvested carp.

- In carp farming, fingerling rearing processes are often ignored due to shortage of rearing space. Higher cost involvement and cumbersome process of long distance transportation of fingerlings also forces the farmers to resort to stocking their tanks/ponds with fry directly, and often with an inappropriate quantity, which lead to poor survival and low production.
- While ideal culture practices recommend different ratios of the carp species depending on their combination and situation farmers often do not have any choice but to use whatever seed and species are available at stocking time from seed farm / vendors. Such situation often leads to suboptimal stocking and this failing to achieve the best potential harvest.

Well grown healthy carp.

Collection of carp for weighing & packing.

Table.1: Commercially cultured carp species in India.

Category	Common Name	Scientific Name
I. Indian major carps	Catla	*Catla catla*
	Rohu	*Labeo rohita*
	Mrigal	*Cirrhinus cirrhosus*
II. Exotic carps	Silver carp	*Hypophthalmichthys molitrix*
	Grass carp	*Ctenopharyngodon idella*
	Common carp	*Cyprinus carpio*

Table 2: Factors attributed for higher carp production in Andhra Pradesh

Activity	Management Practices
Seed stocking	Stunted fingerlings of larger initial weight.
Feeding	Regular feeding with farm made feed consisting largely of rice bran mixed with different types of oil cakes.
Manures & fertilisation	Heavy fertilisation with both organic manures and inorganic fertilisers.

- Productivity levels have declined in many tanks/ponds in the country as many farmers resort to stocking large number of fish seed without providing any other inputs in significant quantities.
- Many irrigational tanks exist in India that are suitable for carp's culture, but these tanks are frequently infested with aquatic weeds and production is significantly hampered.
- Small and medium reservoirs are a huge untapped resource for fish production, but utilisation of these water bodies from the fisheries point of view has been poor to date.

Keeping in view of these constraints, there is a large yield gap between potential production and actual production obtained. For example, researchers and farmers in Andhra Pradesh have demonstrated the potential for obtaining over 15 tonnes/ha/year production in carp culture and Andhra Pradesh farmers are actually harvesting 8-10 tonnes/ha, while the national average is presently is around 2.5 tonnes/ha and in some states it is much lower. Hence it is necessary to reassess the methods being followed for transfer of research outputs to the farming community.

Role of the National Fisheries Development Board

The National Fisheries Development Board (NFDB) was set up in 2006, with its headquarters at Hyderabad in India to realise the gaps, resources, potentials and constraints in adoption of various activities. The following approaches are proposed for enhancement of fish production in the country:

- Intensification of aquaculture in ponds and tanks by extending technical and financial support.
- Setting up new fish seed hatcheries and rearing centers in diverse resources utilising different technologies to meet the increased demand for carp fish seed in the country.
- Setting up of feed mills of various capacities suitable for big entrepreneurs, farmers and government departments is being supported by the NFDB.

- In order to augment the reservoir fish production, the NFDB is supporting financial assistance and training to fisher folk of reservoirs with regards to stocking adequate and appropriate quantities of carp fingerlings of the right size and quality at the right time.

Conclusion

Carp being the main component species of Indian aquaculture they are expected to continue to contribute the major share of the fresh water aquaculture produce in the coming days. The technology of cage and pen culture for utilising deep water bodies such as reservoirs and lakes and running water system has to be refined to make it economically viable. With only 40% of utilisation of the 2.36 million ha available ponds and tanks in the country for fish culture at present and excavation of new pond area and small and medium reservoirs the sector provides enormous scope for horizontal expansion.

However, earthen ponds and tanks are often infested with marginal, floating, submerged and emergent aquatic weeds. The presence of these weeds cause many problems and also hampers the productivity. Therefore, these aquatic weeds are controlled by employment manual, mechanical, chemical and biological methods, or by improvements such as deepening to render them more suitable for fish culture.

Periodic fertilisation and liming of tanks are essential for augment the plankton growth which is the natural food of fish. Rearing of carp fry (25 mm) into fingerlings (80-100 mm) in 45 - 60 days for stocking in tanks and reservoirs is necessary for better survival and higher fish production.

Further, there is a necessity to improve the unit area productivity through intensification of the carps farming systems with due emphasis on environmental health and sustainability.

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Fisherman with well grown catla from the tank.

Fisherman with well grown grass carp fish from resevoir.

Fisherman with well grown common carp fish from tank.

Recent trends in mariculture in S.E. Sulawesi, Indonesia: General considerations

Wa Iba Sahrir[1], La Ode M. Aslan[1,6], La Ode Ridwan Bolu[2], Geoff J. Gooley[3], Brett A. Ingram[4], Sena S. De Silva[5]

1. Faculty of Fisheries and Marine Science, Halu Oleo University, Kendari, SE Sulawesi, Indonesia; 2. Marine and Fisheries Agency of SE-Sulawesi (Dinas Kelautan dan Perikanan/DKP), Kendari, SE Sulawesi, Indonesia; 3. CSIRO Marine & Atmospheric Research, Private Bag1, Aspendale, Vic. 3195, Australia; 4. Fisheries Victoria, Department of Environment and Primary Industries, Private Bag 20, Alexandra, Vic. 3714, Australia; 5. School of Life & Environmental Sciences, Deakin University, Warrnambool, VIC 3280, Australia; 6. Research Institute, Halu Oleo University, Kendari, SE Sulawesi, Indonesia.

The island of Sulawesi (38,139 km^2), with a coastal area of 114,879 km^2 and a coastline of 1740 km, is recognised by the Government of Indonesia as a major area for development of mariculture. Within Sulawesi, one of the least developed areas is the SE Sulawesi Province. SE Sulawesi is strategically placed, being located in the center of the "Coral Triangle" (Figure 1). SE Sulawesi, with a population of 3.4 million, covers an area of 37,128 km^2 of which the surrounding sea areas account for 72% and is considered to be a region with extensive mariculture potential. Equally, being at the centre of the coral triangle it also imposes numerous challenges with regard to ensuring the region's biodiversity when embarking on mariculture development. Economically, SE Sulawesi is a comparatively impoverished province of Indonesia, with a per capita GDP of just US $1,200 and ranked 24th among the 34 Provinces in Indonesia, with a national GDP of US $4,700 (2011 est., http://www.gbgindonesia.com/).

The southeast province (120° 45' and 124° 06' E: 3° and 6° S) consists of the southern and southeast part of Sulawesi Island and some small islands surrounding. Total peninsula area and the province island are about 38,140 km^2, and the sea is about 110,000 km^2, with border area. SE Sulawesi consists of 12 districts, comprising ten regencies and two major urban centres, including Kendari which is the major population and commercial centre, and Bau Bau on Buton islands (Figure 2).

Indonesia is a major aquaculture producing nation globally, with a recorded production of 7,937,072 metric tonnes in 2011, valued at US $ 7.485 billion, which is approximately 9.5% and 10.4% of global and Asian production respectively and in value of 5.5% and 7.0%. Fishery related activities are of importance to SE Sulawesi and are currently estimated to be about 12% of annual GDP. Mariculture as a commercial enterprise is well established and contributes approximately

Figure 1. The coral triangle area (dotted line) where SE Sulawesi province (red box).

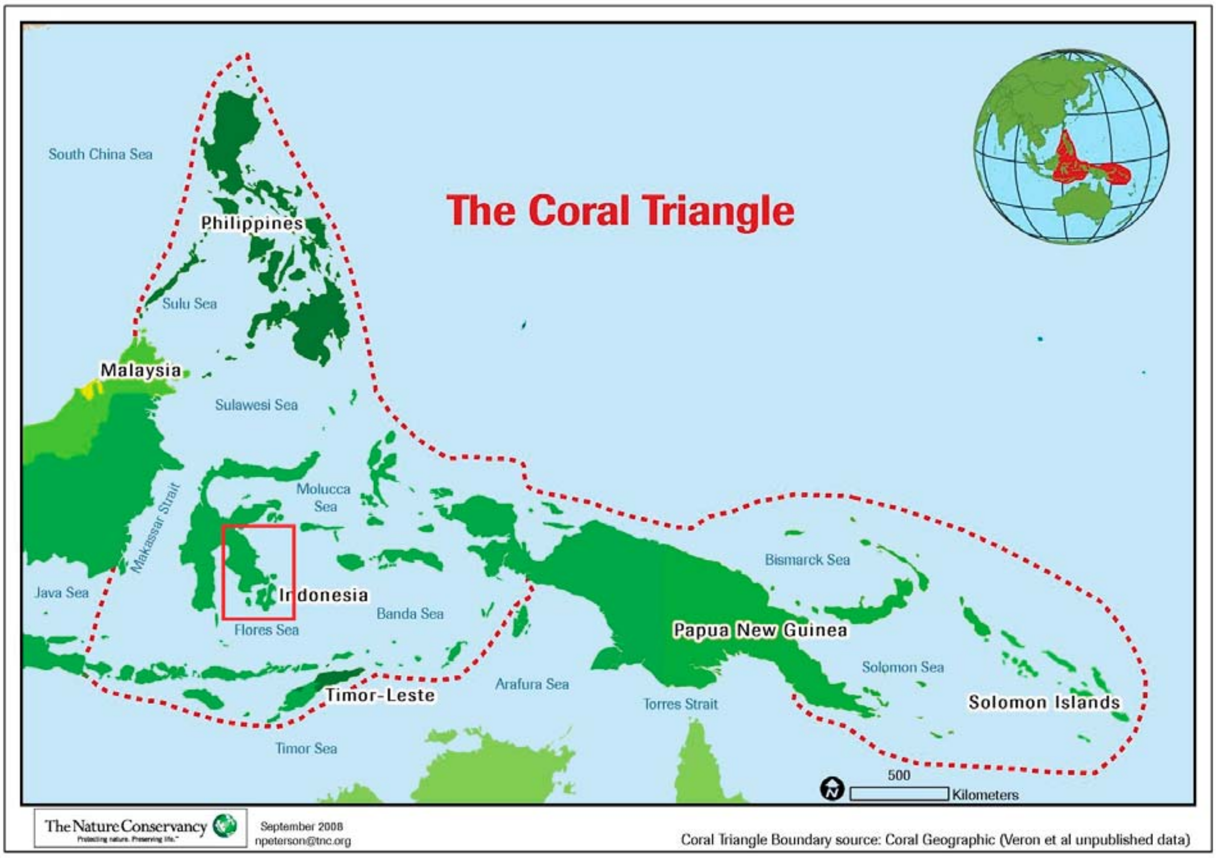
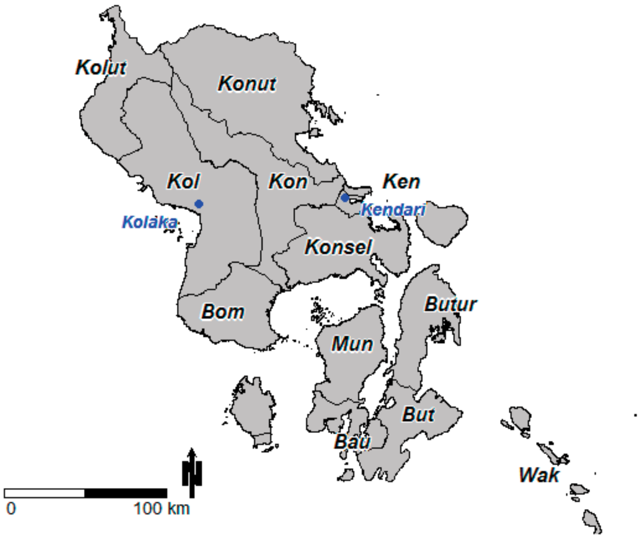
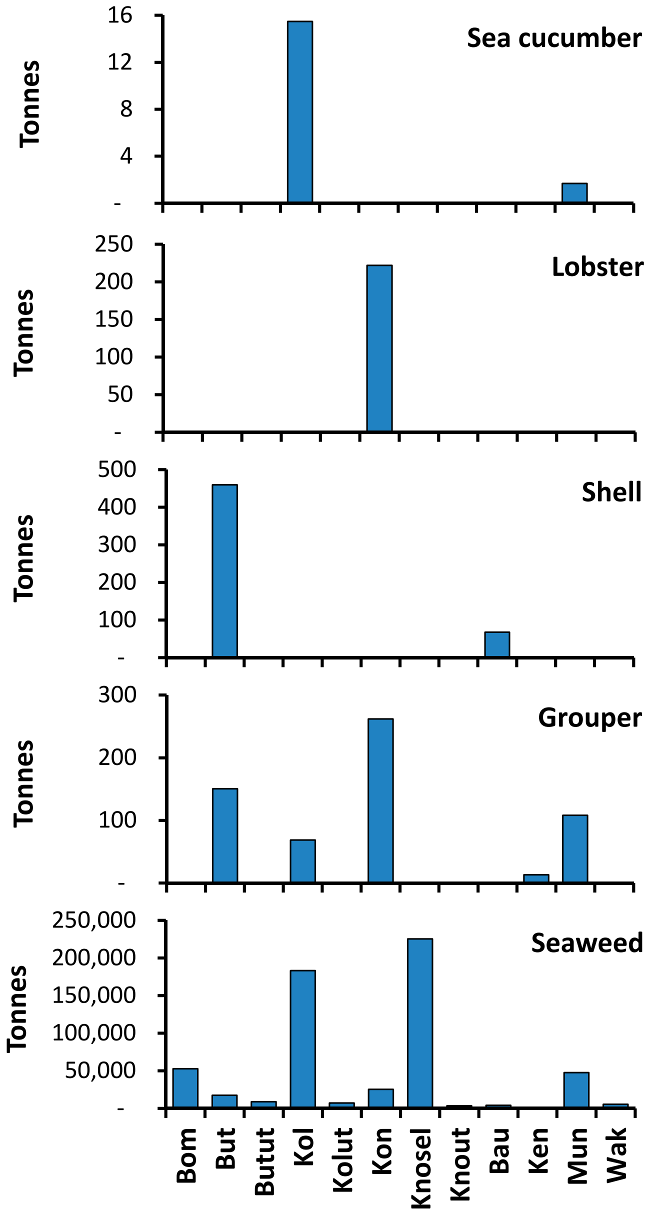


Figure 2. Aquaculture production areas of SE Sulawesi and annual production (mean values for 2010-12) of main mariculture species.





Bombana (Bom), Buton (But), Buton Utara (Butut), Kolaka (Kol), Kolaka Utara (Kolut), Konawe (Kon), Konawe Selatan (Kon sel),Konawe Utara (Konut), Kota Bau-Bau (Bau), Kota Kendari (Ken), Muna (Mun), Wakatobi (Wak).

3-4% of the GDP estimate for fisheries, with most activity centred around the islands of Buton and Muna, and in the outer Kendari Bay area near Kendari city. In 2007, aquaculture production in the Province, including mariculture, reached 153,160 tonnes, valued at approximately IDR 1000 billion (IDR 10,000= 1 US$), with an estimated >115,000 households and >160,140 persons involved. Major production to date (> 85%) has been primarily centred on farming of red seaweed (*Kappaphycus alvarezii* and *Eucheuma denticulatum*), largely in response to increasing global market demand for raw materials, However, a variety of other high value products are presently being farmed for local and export seafood markets in Sulawesi, Indonesia and the broader Asian region.

In this article the overall trends in mariculture in SE Sulawesi are considered. This will be followed later on with an article on the details of the practices of the major commodities and the values chains thereof.

Development initiatives

Although the legislative and regulatory framework designed in part to facilitate development of mariculture in Indonesia has been in place since the mid 1980s-early 1990s (ICMFSER 2009), it is apparent that most developments have taken place within the last 5-7 years (Dinas Perikanan dan Kelautan Prov. Sulawesi Tenggara 2009). As evident from Figure 3 aquaculture in SE Sulawesi was primarily based around brackish water fish culture, mainly the culture of milkfish (*Chanos chanos*) in shallow ponds in mangrove areas, referred to as tambaks as in most coastal states in Indonesia. This form of extensive aquaculture, in accordance with increasing the need to improve culture practices and obtain economically high yields etc., and the growing pressures for coastal/mangrove land reclamation, was gradually replaced by mariculture, commencing since about 2002-2003. The conditions in coastal, inshore sheltered waters in SE Sulawesi were very conducive for the culture of commodities such as seaweeds, and involved relatively low capital investment. As such in the decade that followed mariculture in SE Sulawesi grew rapidly whilst brackish water and freshwater aquaculture remained almost static.

In order to encourage mariculture, for export as well as for increasing domestic consumption of seafood, the ‘Aquaculture and Fisheries Vitalisation Initiative for East Indonesia’ of the Government of Indonesia (GOI) is being implemented at the provincial level through the Dinas. Under this initiative, aquaculture products including shrimp, lobster, groupers, seaweed and sea cucumber have been targeted. The initiative, which aims to bring about institutional (farmer groups) empowerment, essentially consists of providing soft loans to small-scale farmers formed into groups of 5-10 individuals

Figure 3. Aquaculture production in SE Sulawesi between 2001 and 2012.

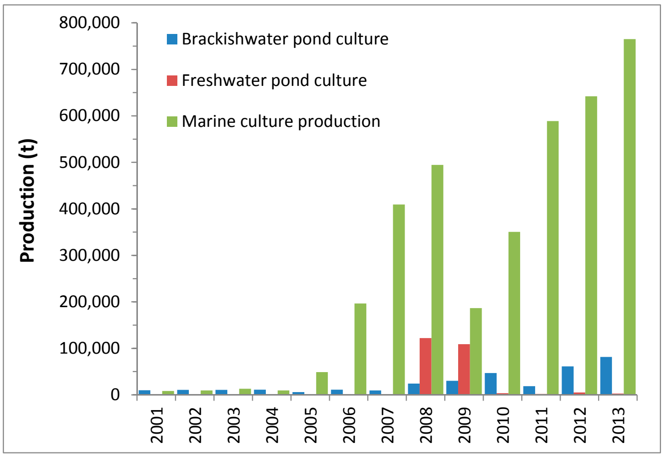


Figure 4. Total aquaculture production and mariculture production between 2001 and 2010.

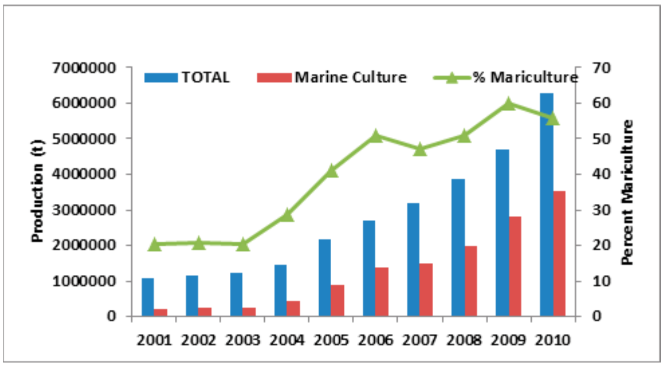
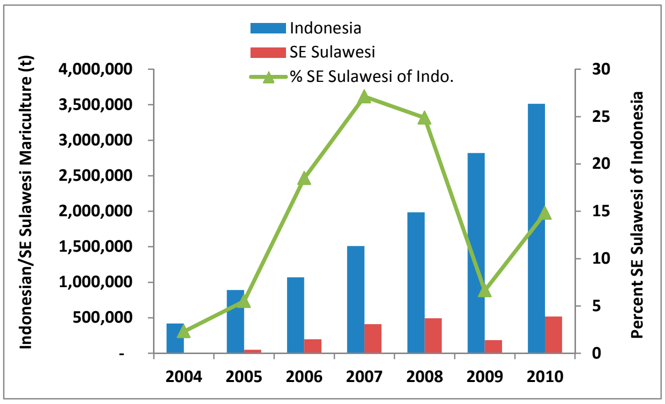


Figure 5. Mariculture production in Indonesia and SE Sulawesi between 2004 and 2010.



and provision of training. The average loan provided is in the order of IDR 5-6 million, and the farmers are expected to invest these funds in seed, netting and feed procurement, and improving cage infrastructure. For SE Sulawesi, IDR 1 billion has been made available by the GOI in 2008 for investment in 12 districts/towns throughout the province.

Apart from the GOI initiative, for the most part development to date appears to have been mostly opportunistic, somewhat ad hoc and fragmented, with little strategic industry or market focus. The consequence is that much latent potential remains untapped, with limited opportunity being realised for expansion, diversification and increased profitability; this at a time when the mariculture sector throughout the region faces major challenges from among other things, climate change, market globalisation, the global economic crisis and rapidly changing consumer preferences for higher value, quality assured seafood products for human consumption.

Mariculture production trends in SE Sulawesi

In order to stress on the importance of SE Sulawesi in the context of mariculture development it is relevant to consider the growing emphasis of mariculture development in the whole country, which is depicted in Fig. 4. It is evident from the latter mariculture production has continued to grow over the last decade and currently accounts for nearly 50% of the overall production.

Mariculture production in SE Sulawesi, has in most ways reflected the national trend (Fig. 5). Production in SE Sulawesi reached almost 25 % of the national production, and then declined dramatically between 2008 and 2009 and now it is showing signs of recovery. This decline was due to a significant reduction in seaweed production (see Table 2), which is thought to have been caused by unusual and adverse seasonal weather patterns.

Commodities cultured/farmed

The commodities cultured/farmed in SE Sulawesi (Table 1) in all probability have had a bearing on types of naturally available seed in the region as well as on the pristine water quality and relatively calm weather the sheltered coast offered. It is not surprising, therefore, that the commodities cultured range from seaweed to finfish, such as grouper, and fattening of lobster and sea cucumber. The latter three commodities being cultured/ farmed in sea cages of varying design and located at varying depths, and in most instances with facilities for the operator to “live in”. In recent years the dependence on naturally available seed for the culture of grouper species has declined, almost completely, as farmers become more dependent on the import of artificially produced seed from Bali and other West Java hatcheries. It is also important to note that the diversification of the high valued commodities (except grouper; such as lobster, sea cucumber and pearl oyster) have occurred in the latter part of the last decade only.

The available data (Table 2) shows that SE Sulawesi mariculture is dominated by the culture of seaweed, which accounts for over 95% of the region’s total production and clearly provides a large number of employment opportunities to the relevant communities. On the other hand, the economic gains from grouper culture per unit of production far outweigh that from seaweed. For example, the average farm gate price of live grouper ranges from US$ 16 to 38 (for mouse grouper, Cromileptes altivelis, weighing 1.5 to 2.0 kg) as opposed to US $ 1.2 to 1.5 / kg for dried seaweed. These

Table 1. The main commodities cultured/ farmed in SE Sulawesi, with relevant information on each.

Group/ species	Main culture areas	Observations/ notes
Seaweeds		
"Cottonii" (*Kappaphycus alvarezii*) "Spinosum" (*Eucheuma denticulatum*)	All provinces, mainly Konawe Selatan, Kolaka, Bombana and Muna	Seaweed seedlings are from earlier crops, or bought from other farmers from outside of SE Sulawesi Province. Reared used traditional methods, dried then exported for processing.
Grouper		
Mainly tiger grouper (*Epinephelus fuscoguttatus*) and mouse grouper (*Cromileptes altivelis*)	Mainly Konawe, Buton and Muna	Wild-caught seedstock reared in cages, but increasingly hatchery-bred seedstock are being used. Sold live at 0.5-5 kg to traders .
Lobster		
Mainly ornate lobster (*Panularis ornatus*) also bamboo lobster (*P. versicolor*) and pasir lobster (*P. homarus*)	Mainly Konawe	Wild-caught seedstock reared in cages. Harvested lobsters (>500g) are sold live to traders.
Sea cucumber		
Several species including sandfish (*Holothuria scabra*)	Kolaka and Muna	Wild-caught seedstock reared in cages.
Pearl oyster		
Winged pearl oyster (*Pteria penguin*)	Baubau, Kolaka, Konawe and Muna	Raft culture. Used to produce half pearls.

Table 2. Production (t) of the major mariculture commodities in SE Sulawesi.

Year	Total	Grouper	Seaweed	Others*
2001	8,465			
2002	9,400			
2003	13,039			
2004	9,659	118	8,930	610
2005	49,088	123	48,774	191
2006	196,739	1,169	195,042	528
2007	409,230	458	408,267	505
2008	495,296	247	492,843	2,207
2009	186,626	631	185,239	756
2010	520,620	623	518,641	1,356
2011	589,010	647	586,965	1,398
2012	641974	543	639,192	2,239

** Including other finfish species, lobsters, crabs, sea cucumbers and shellfish.*

aspects will be dealt with in detail in a follow up article. As such, there has been a growing trend in SE Sulawesi to continue diversification with many households embarking on the culture/ farming of high valued commodities, such as grouper and lobster. This trend is clearly evident from Table 2 which indicates that the production of these commodities (apart from groupers) has increased from 610 tonnes in 2004 to 2,240 tonnes in 2012, an approximately fourfold increase in six years. In fact an increase of this magnitude was reached by 2008, but was followed by a marked decline, in the subsequent year. This decline is thought to have been caused by unusual and adverse weather conditions, such as excessive high rainfall affecting salinity in coastal areas. Since then production of high valued commodities has increased at a reasonable rate, which may be due, in part, to the GOI initiative

Challenges confronting mariculture development in SE Sulawesi

Like most aquaculture developments the rapid developments in SE Sulawesi mariculture are also confronted by many challenges. Some of these challenges are unique to the region awhile others are global, and are market associated and driven.

Of primary concern among those challenges unique to the region is the heavy dependence of seed stocks of grouper, seaweed and lobster the great bulk of which being sourced from distant areas. For example the bulk of grouper seed stock is imported from the Island of Bali, adding heavily to the cost of the operations and, in a manner, also imposing a degree of unreliability of the supplies. Because lobster seed is wild caught, mainly from neighbouring areas, there is a high degree of unreliability of seed stock supply. Seaweed seed stock is also mostly sourced from neighbouring islands and the previously mentioned issues apply here too. As such for SE Sulawesi mariculture to major increases in production it will be necessary to improve seed stock availability and reliability of supplies, and also improve access of these to farmers. In general, there is very limited extension material and or services available to farmers in SE Sulawesi. They have learnt on their own and kept on improving the practices through personal experiences; often a costly and time-consuming process. This needs to be rectified if mariculture developments in SE Sulawesi are to progress as desired.

Although farmers are able to recognise when a disease occurs, such as milk disease in lobster, they are unaware of the available treatments, and actions that are required to prevent the spread of a disease. Perhaps, formation cluster groups and regular meetings thereof

Typical lobster farming operations in SE Sulawesi.

need to be geared for extending technical knowhow among farmers, and also as stages for demonstration of relevant treatments when diseases occur.

There is also a dearth of suitable technical material that could be disseminated among the farming communities. Equally, simple, easily comprehensible manuals on each of the cultured commodities need to be available for use by the extension personnel, and useable by farmers. In SE Sulawesi there are seven primary languages - dialects, each very different from one another. Accordingly, to be maximally effective, all dissemination materials need to be made available in each of these indigenous dialects.

In SE Sulawesi although grouper culture has been going on for a decade or more, and lobster farming for a relatively lesser period, together with farming of wild caught trevally (Family Carangidae), all carnivorous species, compounded feeds are rarely used. The dependence on wild caught, low valued fish, often termed "trash fish" is considered to be undesirable from a number of viewpoints. The most important of these is the unreliability in supplies and the ever increasing price. These, together with the perceived notion that trash fish brings about a higher degree of negative impacts on water quality and the possibilities of transmitting diseases and parasites, make this practice increasingly less and less tenable in the long term. This is especially so if the aquaculture of these commodities is to grow at a significant rate in the ensuing years in SE Sulawesi.

The market channels and the supply chain as a whole remain conservative and unchanged for a decade or more. The system as it exists does not encourage competition among wholesalers, each commodity being dominated by a few,

Typical grouper cage culture farm.

resulting in the farm gate prices for each commodity being always relatively lower than "world prices". For example the farm gate price for dried seaweed has remained around US$ 1.0 to 1.5 per kg for the last decade. A revamping of the marketing channels, possibly through the establishment of farmer cooperatives, may prove to be useful for bring about more realistic farm gate prices. Such increases will likely have a secondary impact on the farming practices reflected by higher production and improved product quality.

Finally, if mariculture developments in SE Sulawesi are to leap frog from the current levels, apart from meeting the above mentioned challenges, there is a need to put in place a major planning and a monitoring activities. Further developments are likely to entail increase in intensity of ongoing practices, a greater degree of diversification and an increase in the number of practices. All of the above will impact on water quality and introduce a degree of competition for space, resources and markets. As such a master plan needs to be developed, taking into consideration the salinity and temperature contours and the seasonal variations thereof in the major areas suitable for culture, demarcating areas for each if the major commodities; the practice of ad hoc commencement of culture of a commodities need to be curtailed and more defined system, perhaps based on the issue of permits need to initiated. For example, past experiences has shown that seaweed culture in certain areas of the sheltered bays tend to be grossly impacted by floods that lowers the salinity considerably. In these areas, seaweed culture should be seasonal (outside the monsoon season), and/ or alternately a monitoring and a warning system needs to be put in place when such major losses can be minimised, or not used for seaweed culture.

Harvested seaweed being dried.

A grouper collecting facility with a Chinese ship equipped to carry live grouper.

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Murrel culture in backyard cement tanks: A breakthrough and a success story

M. A. Haniffa and S. Jafar Sathik

Centre for Aquaculture Research and Extension (CARE), St.Xavier's College (Autonomous), Palayamkottai, Tamil Nadu 627002, India, email haniffacare@gmail.com, www.caresxc.org.

Regarding freshwater edible fish culture, carps and tilapia have been given importance for decades by fish farmers. Air-breathing fishes, especially murrels (snakeheads) and native catfishes such as *Heteropneustes fossilis* and *Mystus* species, have been neglected due to various reasons including lack of seed supply, unavailability of readymade feed and disease management issues. Moreover, at present fish farmers are attracted by culture of African catfish (*Clarias gariepinus*) and Thai catfish (*Pangasius sutchi*) due to short term benefit, ever availability of seeds and wider feeding spectrum, even though they pose a great danger to biodiversity of native fishes[1] and are banned locally.

Edible murrels and difficulties in their culture

Among air breathing fishes, murrels commonly called snakeheads, are widely preferred by consumers all over Southeast Asia, due to their taste, few intramuscular spines and medicinal value[2]. Since murrels are air breathing and survive in oxygen depleted water bodies, they are suitable for profitable culture in tropical shallow systems[3]. The giant murrel *Channa marulius*, the striped murrel *C. striatus*, the spotted murrel *C. punctatus* and the red line murrel *C. micropeltes* are widely preferred in India as well as Southeast Asia because of their large size as food fishes[4]. However, fish farmers interested in murrel farming are afraid, since murrels are carnivorous, piscivorous and cannibalistic. Moreover unlike carps, there are no seed supply centers and no readymade feed is available for murrels in markets. To overcome these difficulties, the research team of the Centre for Aquaculture Research and Extension of St. Xavier's College, Palayamkottai, Tamilnadu is giving regular training to women and Self Help Groups (SHG's) under a major project funded by Department of Biotechnology New Delhi (BT/PR15422/SPD/24/548/2011) to produce murrel seeds and to culture murrels in their backyard utilising bio-wastes such as chicken intestine.

C.striatus cultured at CARE Aquafarm

Construction of cement tanks for culture of striped murrel

Among the housewives who attended training, Mrs Poornima Ravindran from Maharajanagar, Tirunelveli district of Tamilnadu, constructed a rectangular cement tank of 25m^2 in her house, and covered the surface of the tank with fishing net. Water was supplied from nearby bore well to maintain 1 meter depth. Water quality parameters (pH: 7.0-7.2; temperature: 27-29°C: dissolved oxygen: 6.5-7.1 ppm and salinity: 1.77±0.006 ppt) were recorded throughout the culture period. Five hundred fingerlings (2.5 cm length and 5g weight) of striped murrel *Channa striatus* were introduced into the tank in the month of December 2012. Chicken intestine and liver collected from nearby broiler shops were cleaned, washed, chopped and supplied to the fingerlings at a rate of 4% body weight (100g initially). After three months, water was completely drained from the tank, and murrels were captured and measured for length and weight. Two hundred murrels of equal size were selected from the stock and again introduced into the tank and supply of feed was increased based on total weight of the fish at the rate of 4%. In our previous attempts[3,5], we succeeded in culture of murrels in earthen ponds of different dimensions according to availability of land and water and the bottom was filled with clay to prevent seepage. But in the present study, the bottom of the tank was pasted with cement in contrast to our previous murrel culture practices. Murrel culture in cement tanks did not require more water. Moreover seepage was prevented. Cannibalism was avoided since equal size of murrels was introduced into the tank and the feed was supplied ad libitium. Hence, the stakeholders need not have any fear of cannibalism of murrels. After one year, Mrs Poornima harvested the murrels and when they were counted, they were 150 in number and the weight ranged from 600-900g and the total weight was about 100kg.

C. marulius cultured at CARE Aquafarm.

C. diplogramma cultured at CARE Aquafarm.

C. punctatus cultured at CARE Aquafarm

Rectangular cement tank for C. striatus culture.

Uniqueness of murrel culture using cement tank

The present growout culture of striped murrel is unique and the first of its kind in the murrel culture scenario. In all our previous murrel culture practices, we insisted on a sand bottom with clay filling in artificial earthen ponds and a stocking density of 1 fingerling/m^2 according to availability of land and water resources. However, in the present growout culture, 150 murrels were harvested in a rectangular tank of 25m^2 i.e. one murrel for every 0.17m^2 area and no doubt the present attempt is a breakthrough in murrel culture history. In our previous culture practices5, 60 kg of striped murrels were harvested in a rectangular pond of 225m^2. Similarly in our attempt on giant murrel C.marulius culture, in an area of 75 m^2 50 kg of giant murrels were harvested in a culture period of 6 months[3] . No doubt the present murrel culture practice showed about 6 times yield when compared to previous reports.

Marketing of murrels as live or fillet

At present, consumer's demand for murrels is increasing everywhere but, supply is in decline. Since capture fisheries are affected due to monsoon failure, the availability of murrels in markets is not consistent throughout the year but only during the summer season April – June; when the ponds and lakes dry, fishermen capture and bring them to the markets. Hence, to satisfy the consumer's demand culture fisheries is the only way and stakeholders especially women have to be encouraged to practice murrel culture in their backyard to meet the present demand. In the Indian scenario, the striped murrel *C.striatus*, the giant murrel *C.marulius* and spotted murrel *C. punctatus* are widely preferred by consumers all over India. Marketing may not be a problem, since murrels are most tasty. More over they have fewer intramuscular spines and the fillet quality is very soft when compared to that of marine fish especially shearfish and pomfret which are very expensive. In India, live striped murrel is sold at Rs 350-600/ kg in different states. In north India, especially in Delhi fillets are made from live and frozen murrels and supplied to star hotels and restaurants. However, such filleting technology has not yet spread to southern states other than Andhra Pradesh.

C. striatus fingerlings.

Portion of harvested murrels.

Chopping cleaned chicken intestine.

Table 1. Economics of production of table size murrels.

Item	Rupees
Expenses	
A. Capital cost:	
1. Pond construction (25'x 10 x 3'= 875CFT. Rs 55/CFT)	48,125
2. Motor pipelines	15,000
3. Fencing & net	3,400
B. Operational cost:	
1. Cost of fingerlings 500 x Rs 4/individual	7,500
2. Feed cost (300 days x Rs 25/day)	1,000
3. Electricity	2,000
4, Maintenance cost	3,200
Total expenses of A&B	80,225
Income	
Fish sales of 100kg at the rate of Rs 500/kg	50,000
Total expenses other than capital cost	13,700
Net profit per year	**36,300**

Murrel fillets.

Once the fillet is prepared from live or frozen murrel it can be stored for more than 30 days when refrigerated and frozen and no doubt there is wider scope to sell murrels as live or frozen and the profit is assured. Since murrels have medicinal value especially for wound healing and treatment of arthritis and convalescence, stakeholders prefer culture of murrels rather than carps or tilapia.

Economics of production of table size murrels

Construction cost of 25 m² pond with a depth of 1m was Rs. 48,125/-. Expenditure on motor pipeline and fishing net was Rs. 17,400/- and the total capital cost was Rs. 66,525/-. The total operational cost was Rs. 13,700/- and the total expenses of both account Rs. 80,000/-. The harvested murrels 100kg were sold at a rate of Rs. 500/kg and the net profit was Rs. 36,000/- for an investment of Rs 80,000/- (Table 1). As per availability of area in the backyard, one can either increase the area of the culture tank (250 m² – 100m²) or the number of culture tanks (1-4). For instance if 100m² area is available, at the backyard, housewife can earn about Rs 150,000/year by selling 400 murrels.

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Mobile telephony – ICT enabled fisheries extension service for sustainable shrimp farming

D. Deboral Vimala*, K. Ramkumar, M. Kumaran, T. Ravisankar, P. Mahalakshmi, P. Ravichandran and A.G. Ponniah

*Central Institute of Brackishwater Aquaculture (ICAR), 75, Santhome High Road, R.A.Puram,Chennai – 600 028, Tamil Nadu, India, *email drdebvim@ciba.res.in*

Information and Communication Technologies (ICTs) are being used across the fisheries sector in resource assessment, capture and culture fisheries, processing and commercialisation of fishery products. Some of the special technical applications of ICT include the use of Global Positioning System (GPS) and sonar for navigation and locating fish shoals in marine waters. A more simpler and common form of ICT is the use of mobile telephony for trading, information exchange and emergencies, web-based information and networking resources. By this method a wide range of technologies can be introduced to non reachable remote communities and once appropriated by users, these technologies can have a positive impact on their lives.

Emerging research in ICT shows that by way of mobile telephony there is also veritable reduction in communication costs which has tangible economic benefits, improving agricultural labor market efficiency and producer/ consumer welfare in specific circumstances and countries (Jensen, 2007; Aker,2008; Aker, 2010; Klonner and Nolen, 2008). As telecommunication markets mature, mobile phones are evolving from simple communication tools into service delivery platforms. This has shifted the development paradigm surrounding mobile phones from one that simply reduces communication and coordination costs to one that could transform lives through innovative applications and services.

India is expected to outsmart China by 2013 in mobile telephone ownership in numbers and teledensity, 1.159 billion i.e., 97% of population will have access to mobiles by 2013. The total number of cell phones is 929.37 million with a monthly cell phone addition of 8.35 million and a teledensity of 79.28% (May 2012) was reported by Telecom Regulatory Authority of India (TRAI, GoI,2012).

Currently mobile telephony is an innovative and prime mode of communication in the field of fisheries. The purpose of this innovation is to bridge the gap between the farmer and the researchers. It can also help farmers get personalised advice and latest information/technology to help increase yield, reduce cost, fetch better prices and improve farming efficiency. Mobile telephony in fisheries/aquaculture addresses issues such as, quality of seed, stocking size and density, soil, water, disease symptoms and diagnosis, Coastal Aquaculture Authority rules, local market price, details of probiotics, their availability and application, diversification of species, better management practices, weather advisories, technologies, extension services in brackishwater, wave length, wave height, wind direction in marine fisheries and carp culture details in freshwater.

The analysis of various ICT applications for information communication in fisheries and aquaculture showed that these initiatives have had positive results (Vimala et al 2007, Vimala et al 2008, Vimala 2011, Vimala & Ravisankar 2012). This paper presents the snap shot of mobile telephony initiatives rooted in India in the fisheries sector. All the six models varied with significance of services provided, extension advice, development programmes, and information from government/private sources.

1.Tele Aqua

The objective of the case study was to understand the existing models available in mobile telephony. Tele Aqua is the modified version of e-Sagu Aqua of IIIT,Hyderabad and V-Aqua of Byrraju Foundation in operation in West Godavari district of Andhra Pradesh. The primary center of Tele Aqua was housed at Akkivedu, Bhimavaram (West Godavari) and manned by a fishery expert. It contained four components viz. farmers, coordinator, fishery expert and a data base. The data base contains information (in Telugu) of farm parameters, shrimp, soil & water details, farmers profile, fact sheets, disease history and a photo gallery.

A field co-coordinator selected by the farmers was allotted a fixed number of farms to visit in a single day. He collected the details of the farms with photographic evidence. Followed by this the fishery expert, prepared the farm specific advice at the lab with the help of the knowledge of database. The same was transmitted to the concerned farmer either via field coordinator or directly through mobile.

2. Fisher Friend Mobile Application (FFMA)

Since 2007 the M.S. Swaminathan Research Foundation has been providing knowledge connectivity to the rural communities in the form of mobile applications called Fisher Friend Mobile Application (partnering with QUALCOMM). This model provides the fisherfolk with information in Tamil about weather, wave height, forecast information, potential fishing zones as influenced by seasons / shoaling patterns, GPS based navigation solutions and information to alert fishermen during rough weather, Government schemes relevant to the fisherfolk, Government subsidies, schemes for social development and other general announcements by Government, market information, information on landing centers and clips of the day (Vimala 2011c & Vimala and Ravisankar 2012).

3. MobiAqua

MobiAqua of A.A Biotech Pvt Ltd of India has now launched a new application that can be used by the brackish water aquaculture sector in an inexpensive way and over a vast geographical area. The language used is English. It is structured into three categories:

- Registered clients: are those buyers, sellers or traders who register themselves for any of the keywords. Registered clients would then receive a mail and SMS from customers who intend to buy, sell or trade their products according to their keyword.
- Customers: A person who is interested to inquire about purchase or sale of the products. The customer is the one who would sends his message to the particular keyword.
- Keywords: are those letters used for connecting customers to the registered clients. The seven key words available are the Shrimp, Fish, Products, Seed, Equipment, Feed and Aquarium.

If a customer, is interested for eg. to sell shrimp to any buyer, all he needs is to type the key word (shrimp) and then ‘sell’ and send the text from a mobile as “Shrimp <space>sell” followed by the text “have shrimp for sale” to 96770 96770. This message would be delivered to the registered buyers. (Uadya (2010) and as cited by (Vimala, 2011c).

4. IFFCO Kisan Sanchar Limited

The IFFCO Kisan Sanchar Limited (IKSL) model was found to be a tri-lateral joint venture between the Indian Farmers Fertiliser Cooperative Ltd (IFFCO), Airtel and Star Global Resources Limited. The service provides five free voice messages everyday in ten Indian languages across eighteen states in India. Each voice message is of one minute duration and covers different subjects such as crop management, dairy, animal husbandry, market rates, weather forecast, human health, employment opportunities and Government schemes. Importance was given to address focused communities like fishermen in the fisheries sector. IKSL distributes Airtel SIM cards branded ‘Green SIM’ to the farmers. The Green SIM functions as a normal SIM as well as providing the agricultural value added services (Agri VAS). Helpline support has also been provided to the subscribers. Information as disseminated by FFMA is also provided by this model.

5. SMS services of Krishi Vigyan Kendra, Kattupakkam

Krishi Vigyan Kendra (KVK), Kattupakkam, an ICAR funded organisation under the administrative control of TANUVAS has launched an innovative information system for the farming community which involves dissemination of innovations and other information in the form of short messages in English. There are about 1,000 registered KVK farmers who are availing of this short messaging service. The service was initiated by KVK, Kattupakkam, in the year 2010. The information is sent to the registered farmers from KVK through Way2SMS software to their individual mobile phone.. The maximum characters of the SMS currently sent are 160. Frequency of sending the message is thrice a week in the morning around 9am. Daily SMS alerts are issued on agriculture, horticulture, dairy, poultry and fishery technologies and developments and call for events. The service is also being used to send information on important trainings and other programmes like field days, seminars, workshops, frontline demonstrations, exposure visits etc., to the members of the farmers Clubs, commodity groups, individual farmers and Self Help Group networks under the KVK.

6. CIBA's mobile telephony project

Based on the understanding gained from the models studied, CIBA proposed a project, pertaining to TOT through mobile telephony to disseminate information related to coastal aquaculture through voice mail service to aqua/fish farmers. The information disseminated to the farmers is sourced from CIBA publications and the institute's website. Technologies, news, training programmes, market information and weather advisories were provided through this platform. The focus area identified is Tamil Nadu State, wherein about 300 farmers were covered under this service. This service can be availed free of cost (Vimala 2011a,b & c).

The study revealed that use of mobile telephony for information exchange in fisheries sector facilitate need based information exchange and found to be appreciated. It is cost-effective and timely. This medium offer great potential to help and support fish/aqua farmer and fisher folk to improve their livelihood standards and protecting them from occupational hazards. The study inferred that all the models must focus on useful and relevant content generation to be successful in using ICT for rural development including fisheries extension. Extension researchers, officials, workers should also be well trained in other ways of using digital ICTs to increase their visibility and effectiveness. This potential on mobile telephony has to be fully exploited to benefit the small farmers/fisherfolk and to exploit this opportunity, governments at national and state level should reorient agricultural policies and create a strategy harnessing ICTs' specially mobile telephony to or supporting agricultural/fisheries development.

Acknowledgement

The authors are grateful to NABARD for providing assistance under Rural Innovation Fund (RIF) to carry out this work. The authors are also grateful to Dr.Kumaravelu Shri.A.Ali, Dr.Velvizhi, Shri.UdayaRamJothy and Dr.Prabakaran for according permission to conduct the studies.

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International Symposium on Small-scale Freshwater Aquaculture Extension, 2-5 December, Bangkok

The Japan International Cooperation Agency (JICA), NACA and the Thai Department of Fisheries convened an International Symposium on Small-scale Freshwater Aquaculture Extension in Bangkok, from 2-5 December 2013 at the Centara Grand Hotel Ladprao.

The objective of the symposium was to bring together stakeholders from JICA-assisted projects to share experiences and lessons learned, and particularly to evaluate the effectiveness of "farmer-to-farmer" extension approaches in rural aquaculture. The symposium brought together 81 stakeholders from 12 countries working on development projects in Cambodia, Lao PDR, Myanmar, Benin and Madagascar as well as key development partners including the FAO Regional Office for Asia and the Pacific, SEAFDEC, the Asian Institute of Technology and the Thailand International Development Cooperation Agency.

Small-scale freshwater aquaculture has a long history in the region and has provided diverse benefits to rural farmers including income generation and nutritional improvement, while integrated farming systems have also offered improved sustainability. However, improvements to practices and technology are still required and in many cases have not yet reached or been disseminated to many small-scale farmers. The lack of access by many small-scale farmers to simple, existing technologies on seed production and grow out practices has hindered aquaculture development and the benefits therefrom.

The symposium found that JICA's "farmer-to-farmer" approach to extension has been an effective way to transfer technologies and improved management practices to small-scale farmers. The advantage of this approach is the exposure and training is conducted by experienced "core" farmers, who have practical knowledge in the application of these technologies, which they have tested themselves. The technology extension, moreover, is conducted in the farmers own dialect and based totally on local resources which can be easily accessed by the farmers.

The farmer-to-farmer approach can be initiated by proper training of selected core farmers, who apply the technology to increase their own aquaculture production and augment family income. This system not only provides economic benefit to the core farmers but also enhances their social role as local leaders and extension workers, although it should be noted that careful selection of core farmers is critical to success. Once the core farmers are trained and established, they share their experience with other selected farmers who are willing to try it for themselves. This process will continue

Participants in the symposium.

from one farmer to another, thus benefiting many rural farmers and helping them to at least improve their production or profitability from their small-scale holdings.

Farmers that had voluntarily participated in or experienced the JICA projects from the above-mentioned countries shared their experiences at the symposium. From initially having a few tanks or ponds for their culture operations, most had managed to gradually expand their facilities and production, often going on to supply fingerlings to other local farmers (usually to the ones they trained through farmer-to-farmer approach) and sell part of their harvest for additional income. Their willingness to train other farmers in their community and to share their experiences with others was also a contributing factor in the overall improvement of the local fish production within the local area or even at neighbouring villages or communes.

In some cases, local farmers that were trained by core farmers became core farmers themselves, going on to train and extend assistance to others. Despite some problems that have been encountered in the implementation of this approach (e.g. criteria for initial selection of core farmers; willingness of voluntary farmers to join the program), results obtained from the implemented JICA projects in some countries in the region indicate the effectiveness of the approach in ensuring continuity of technology extension from one farmer to another.

By and large, results of the farmer-to-farmer approaches of technology extension in small-scale freshwater aquaculture can be potentially be applied to other small-scale aquaculture systems (e.g. brackishwater and marine). The symposium recommended that a Guidebook on Farmer-to Farmer Extension Approaches on basic aquaculture technologies be developed, based on the outcomes of the JICA projects. This guidebook will then be used to develop a Regional Training Course module, to train prospective core farmers involved in small-scale aquaculture (freshwater or marine) who are willing to extend assistance to other local farmers using this approach.

Audio and video recordings of the technical presentations from the workshop, including discussion group conclusions, plus the workshop programme are available for download or online viewing from the NACA website at the link below. The report of the workshop will also be made available for download shortly:

http://www.enaca.org/modules/podcast/programme.php?programme_id=13

12th Meeting of the Asia Regional Advisory Group on Aquatic Animal Health

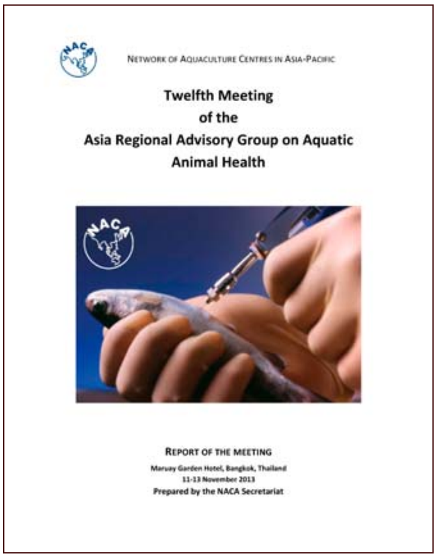
The 12th meeting of the Asia Regional Advisory Group on Aquatic Animal Health was held at the Maruay Garden Hotel, Bangkok, Thailand from 11-13 November 2013.

The Advisory Group was established by the Governing Council of the Network of Aquaculture Centres in Asia-Pacific (NACA) to provide advice to NACA members in the Asia-Pacific region on aquatic animal health management, through the following activities: (a) evaluate disease trends and emerging threats in the region; (b) identify developments with global aquatic animal disease issues and standards of importance to the region; (c) review and evaluate the Quarterly Aquatic Animal Disease reporting programme and assess the list of diseases of regional concern; (d) provide guidance and leadership on regional strategies to improving management of aquatic animal health including those under the framework of the Asia Regional Technical Guidelines; (e) monitor and evaluate progress on Technical Guidelines implementation; (f) facilitate coordination and communication of progress on regional aquatic animal health programmes; (g) advise in identification and designation of regional aquatic animal health resources, as Regional Resource Experts (RRE), Regional Resource Centres (RRC) and Regional Reference Laboratories (RRL); and (h) identify issues of relevance to the region that require depth review and propose appropriate actions needed. Members of the Advisory Group include invited aquatic animal disease experts, World Animal Health Organization (OIE), Food and Agricultural Organization of the United Nations (FAO) and collaborating regional organisations.

The report of the meeting includes details of discussions concerning OIE standards and global issues; a review of the regional disease status, reports on aquatic animal health programmes from partner agencies; discussion of disease reporting; and implementation of the FAO/NACA Technical Guidelines on Responsible Movement of Live Aquatic Animals.

The report is available for download from the NACA website at the link below.

http://www.enaca.org/modules/library/publication.php?publication_id=1132



National Workshop on EMS/AHPND of Cultured Shrimp held in India

A national workshop on acute hepatopancreatic necrosis disease (AHPND) of shrimp, also commonly referred to as EMS, was convened in Chennai, India from 20-21 January 2014. The meeting was opened with messages from Dr Yadava (Bay of Bengal Programme IGO), Dr Raja Sekhar Vundru (Joint Secretary of Fisheries), Dr P. Ravichandran and Dr Eduardo Leano (NACA Aquatic Animal Health Programme Coordinator).

The workshop commenced with an overiew of AHPND, followed by a presentation on the status of this disease in Thailand. Dr Siripong Thitamadee presented the progress of AHPND research in Mahidol University with emphasis on the PCR kit that they have developed in collaboration with researchers from Taiwan Province of China. Dr Loc Tran presented on diagnostics and status in Vietnam.

Dr Oliver Decamp of Inve gave a keynote presentation on Prevention and Management of EMS/AHPND from Other Asian Countries, and Dr Indrani Karunasagar of the Magalore College of Fisheries gave a keynote presentation on *Vibrio parahaemolyticus* and *harveyi* clade – so common, so complex. A discussion group session was held with the theme "contingency planning for emerging diseases".

The workshop was attended by around 70 people representing key government organisations and research institutions in India and the private sector including the Society of Aquaculture Professionals, Marine Technologies, All India Shrimp Hatchery Association, Waterbase Ltd., Growel Feeds Ltd. And the Prawn Farmers Federation of India. The proceedings of the workshop will be released in due course.

Participants in the national EMS/AHPND workshop.

Report on early mortality syndrome / acute hepatopancreatic necrosis syndrome of shrimp

A new FAO Fisheries and Aquaculture Report, Early Mortality Syndrome (EMS) or Acute Hepatopancreatic Necrosis Syndrome (AHPNS) of Cultured Shrimp, focuses on this emerging disease that has devastated the shrimp industry of China, Malaysia, Thailand and Viet Nam over the last three years.

FAO project TCP/VIE/3304 "Emergency assistance to control the spread of an unknown disease affecting shrimps in Viet Nam", implemented by Viet Nam's Ministry of Agriculture and Rural Development, organised an FAO/MARD Technical Workshop on EMS/AHPNS last June.

Sixty-three participating international experts and local stakeholders from the shrimp farming sector discussed the outcomes of the work carried out under the TCP project and the current state of knowledge on EMS/AHPNS in the affected countries. The Workshop agreed on a list of specific and generic actions and measures that may help reduce and manage the risks of EMS/AHPNS, directed to various shrimp stakeholders (public and private sectors).

The report is available for free download from FAO website at:

http://www.fao.org/docrep/018/i3422e/i3422e.pdf

Sustaining Ethical Aquaculture Trade Newsletter

The November Newsletter of the Sustaining Ethical Aquaculture Trade Project (SEAT) is available! This issue covers the debate over aquaculture certification, how non-filltet fish products are used and valued in Europe and Asia, the benefits of transdisciplinary research and how management measures have reduced parasite risks in Thailand and China. To access the newsletter, please visit:

http://seatglobal.eu/news-november2013/

India and the AFSPAN Project

Vishnu Baht, Department of Animal Husbandry, Dairying and Fisheries

To provide food to a world population expected to surpass 9 billion in 2050, it has been estimated that agricultural output, originating primarily from crops, livestock and fisheries, including aquaculture, must increase by 70%. Meeting this target is a formidable challenge for the international community considering that an alarming number of people, currently around one billion, or one-seventh of humanity, presently suffer from hunger and poverty. Finding opportunities to alleviate poverty and increase food security through agriculture is vital and timely.

The contribution of aquaculture to food security, nutrition, employment creation, income generation and women's empowerment is significant, globally, and must be enhanced. However, it is recognised that the current knowledge and understanding of aquaculture's contribution to human development is inadequate and that better tools, and more systematic and quantitative assessments are needed to improve the current knowledge and information base. Better understanding of this contribution is expected to assist low-income food-deficit countries and development partners to develop and implement sustainable policies, strategies and plans for improving the livelihoods of millions of poor people.

The AFSPAN Project is an initiative to better understand the current status of the contribution of aquaculture to food and nutrition security and poverty alleviation. In particular, the project will:

- Review the current knowledge on the contribution of aquaculture to food and nutrition security and poverty alleviation.
- Develop methodologies for better assessment of this contribution.
- Disseminate widely among countries, governments and civil society, the knowledge gained.
- Elaborate strategies for improving the contribution of aquaculture to food security, nutrition and poverty alleviation.

India is the second largest global fish producer after China in terms of aquaculture production. The present annual production from freshwater and brackish water aquaculture in India is estimated to be around 4.18 million tonnes and 0.25 million tonnes, respectively. Indian aquaculture has come a long way from being a traditional subsistence-level activity to a predominantly commercial enterprise in recent years, and plays a significant role as a source of food and nutritional security, poverty alleviation and overall rural development.

With diverse resources ranging from deep seas to lakes in the mountains and more than 10% of the global biodiversity in terms of fish and shellfish species, India has shown continuous and sustained increments in aquaculture production in recent years. The present scenario is that freshwater aquaculture, notably carp culture, is witnessing considerable growth with minor contributions from catfish and freshwater prawns. Similarly, the export-oriented shrimp aquaculture in coastal areas has also been growing in a rapid way.

Freshwater aquaculture, which represents about 84% of India's total production by volume, is the mainstay of Indian fisheries and aquaculture. Much of this contribution is from Indian major carps farmed through pond culture or raised in freshwater tanks and other water bodies. In fact, in India, the aquaculture sector started as a subsistence fishery amongst small and marginal farmers, subsequently, owing to export demand and other commercial gains, coastal aquaculture developed on a commercial scale with the involvement of enterprising entrepreneurs. Nevertheless, the aquaculture sector is dominated by small and marginal farmers who represent more than 90% of the industry, considering the farm holding and the number of farmers involved. Most of them are resource poor in terms of skills, financial capacity and other technical aspects.

About 40% of the available pond and tank resource of 2.36 million hectares is underutilised and the mean national pond productivity has remained at about 2.9 tonnes per hectare per year, despite production levels of 6-8 tonnes being realised by farmers in some parts of the country. This indicates vast scope for enhancement both by horizontal and vertical expansion of freshwater aquaculture. Shrimp aquaculture in coastal areas witnessed substantial growth during the early nineties with production levels reaching 140,000 metric tonnes during the beginning of this decade. However, on account of disease, the production level during 2008-09 declined to about 88,000 tonnes. Coastal brackishwater aquaculture is now on path to revival with the introduction of exotic SPF shrimp L. vannamei.

In India, fish is a very rich and cheap protein source that can be afforded by the common people. Domestic demand for fish in India is growing rapidly due to increased availability of fish, economic growth, rising population, shift in dietary patterns, tastes and preferences for high protein and nutritional content foods. The increase in supply will make fish more readily available to consumers at a cheaper price, which will in turn likely increase fish consumption. In fact, as per an estimate the domestic demand for fish is likely to grow at an annual rate of 2.5% between 2000 and 2020. The domestic demand for fish is likely to grow to around 8.46 million tonnes in 2020. The annual per capita fish consumption at national level is projected to grow from 5.6 kg in 2011 to 6.3 kg. in 2020. Thus, for meeting the future additional fish demand the aquaculture sector is key, given the stagnation of capture fishery resources. Aquaculture output is likely to grow at about 6-7% per annum and the higher share of aquaculture in total output of fish has been projected to rise from 52% in the year 2000 to 61% in the year 2020. Among aquaculture species, the Indian major carps and shrimp will emerge as great opportunities for the future fish supply scenario in India. The government has also given much emphasis on the creation of an additional supply of protein through the National Mission on Protein Supplements, in which aquaculture has found a prime place.

Aquaculture has long been seen as an important source of food fish for the masses. It has also been contributing substantially to economic growth as well as human welfare, considering its support to livelihood activities for a large section of the underprivileged population of India. Therefore, in the present context, and with the emphasis on sustainability, the objectives put forth in the AFSPAN serve as an impetus to ameliorate the socio-economic status of the small and marginal aqua farmers. The project thereby assists the country in identifying thrust areas for meeting the requirements of small and marginal aqua farmers and for taking forward the overall aquaculture sector.

The AFSPAN Project is considered in the positive thinking of the Government to be giving an edge to country's vision of fisheries development and management programmes, which aim to improve the sustainable production of food fish, contributing to food security and amelioration of the socio-economic conditions of the population.

For more information about AFSPAN visit www.afspan.eu.

Report on AFSPAN Chilean survey

The AFSPAN survey in Chile was conducted by a team of five young research assistants between 11 April to 6 May. They were able to interview 126 aquaculture centre managers and 122 households in three coastal regions (Coquimbo Region, The Lakes Region and Atacama Region) covering 34 localities and approximately 3,500 km of territory by land, plus inter-regional travel by air. Before starting their actual work the survey team underwent a two week training period including trial interviews in the Valparaiso Region, home of the Pontificia Universidad Católica de Valparaíso.

Coquimbo Region

The team began their survey in Tongoy, a typical coastal village in Coquimbo Region, located 375 km north of Valparaiso. Tongoy has a semi-arid climate, with a current population of around 9,000 people, approximately 60% of whom are engaged either in fisheries or aquaculture activities.

Aquaculture in Tongoy is mainly scallop farming (Argopecten purpuratus), raised from seed to market size individuals. Seed collection is a critical activity. Sixteen interviews were conducted in Tongoy covering small, medium and large producers. In addition, sixteen interviews were conducted with households involved inscallop aquaculture. Surveys were conducted in this locality over two and a half days, before returning to Valparaíso by land.

Port of Caldera.

Small-scale scallop producer in Caldera-Bahia Inglesa.

The Lakes Region

On 14 April the team flew down-south to Puerto Montt city in the Lakes Region around 1,100 km south of Valparaiso, in order to survey the most important aquaculture area of Chile, covering territory from south of Puerto Montt city, the capital of the region, to the southern tip of Chiloe Island. Target aquaculture activities for this part of the survey were salmonid aquaculture, including Atlantic salmon (*Salmo salar)*, Rainbow trout (*Oncorhynchus mykiss)* and Pacific salmon (*Oncorhynchus kisutch*); Chilean mussel (*Mytilus chilensis*) and pelillo algae (*Gracilaria chilensis*).

The team deployed first in Chiloe, an island some 180 km long and 50 km wide, which is part of the last portion of the coastal cordillera running north-south almost all along the country, divided into ten municipalities. The island and the entire archipelago are characterised by its maritime and agricultural tradition and it is home to a rich culture combining catholic religion and local knowledge, beliefs andmythology.

The team conducted surveys in the following municipalities and localities: Ancud (Quetalmahue, Puente Quilo, Mar Brava, Caulín, Chacao, Manao, Linao, Doca, Hueldén, Pido and Hueihue), Quemchi (Quelquel, Quiquel, Calen and Rilan), Castro-Chonchi (Nercón, Curahue Puqueldón, Aldachildo), Dalcahue-Quinchao (Dalcahue, Curaco de Velez, Chuyic, Achao, Castro Tutil, La Estancia) and Quellón (Huildad, Yaldad, Punta Lapa, Candelaria).

After 18 days of work the team was able to complete 31 salmon farm surveys, 30 salmon-related household surveys, 33 surveys for Chilean mussel farms and 31 related households, and 31 farms and 30 housholds involved with pelillo algae.

Atacama Region

On 2 May the team flew directly from Puerto Montt, Lakes Region, to Caldera in Atacama Region, some 850 km north from Valparaíso, the last of the areas to be surveyed. The coastal city of Caldera was founded in 1852 as a maritime hub for the mining activity based from Copiapo city some 100 km inland from the Port of Caldera. Today in addition to the port to export minerals and northern Chilean grapes, Caldera is an important vacation resort and the main centre for the fisheries and aquaculture activities conducted in the region. Caldera is home to northern scallop aquaculture (*Argopecten purpuratus*) as well as to some pelillo algae farming. After nearly four days the team had obtained 15 surveys from scallop farmers and another 15 from households engaged in this activity from Caldera and its surroundings (Calderilla and Bahía Inglesa).

Comments from the respondents

Most of the respondents for both surveys requested to be informed of the results of the survey data analysis and the conclusions reached by the project. The main reason for this was an interest in the solutions or actions that would be proposed which might help to improve their quality of life. The input provided by respondents was generally good, although many farm respondents indicated that information about labour, income and cost information was potentially sensitive.

The team

The survey team was led by Alondra Vega in close collaboration with Allan Gomez, both permanent assistants to this project and also comprised by Andrea Mendez, Carlos Molteni and Nelson Tapia. Felipe Hurtado and Ricardo Norambuena collaborated with contacts and itinerary planning.

Finally, we would like to congratulate and thank our survey team for a work well done!

Network of Aquaculture Centres in Asia-Pacific

Mailing address:
P.O. Box 1040,
Kasetsart University
Post Office,
Ladyao, Jatujak,
Bangkok 10903,
Thailand

Phone +66 (2) 561 1728
Fax +66 (2) 561 1727
Email: info@enaca.org
Website: www.enaca.org

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

Feeding and feed management of Indian major carps in Andhra Pradesh

This study reviews the aquaculture of Indian major carps, rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus cirrhosus*) with special reference to current feeding and feed management practices in Andhra Pradesh, India. The study is based on a survey of 106 farmers from four regions in Andhra Pradesh (Kolleru, Krishna, West Godavari, and Nellore). Kolleru and the surrounding districts of Krishna and West Godavari are the primary culture areas. In Nellore district, Indian major carp culture is practiced at a lower intensity to that practiced in Kolleru. In East Godavari district, Indian major carps are primarily cultured in polyculture systems with either black tiger shrimp (*Penaeus monodon*) or giant river prawns (*Macrobrachium rosenbergii*). While the study primarily focused on the feed management practices associated with Indian major carp production, management practices that are used under polyculture conditions with other species-groups were also assessed.

The study revealed that mash feed was the most popular and widely used feed type. De-oiled rice bran was used as the principal feed ingredient, followed by groundnut cake and cottonseed cake. All the farmers reported using de-oiled rice bran, while 56 percent used groundnut cake, 40 percent used cottonseed cake, and 30 percent used raw rice bran and other mash feed ingredients. The poor quality of the mash feed ingredients, especially the de-oiled rice bran, groundnut cake, and cottonseed cake was an important issue of concern to the farmers. Commercially manufactured pelleted feeds were used by 33 percent of the farmers to complement their mash feeds, with the majority choosing to use sinking pellets. Since 2007, there has been a marked increase in the use of commercially manufactured aquafeeds, most notably for the large-scale production of the striped catfish (*Pangasianodon hypophthalmus*).

In the nursery and rearing ponds, the commonly used feed ingredients included groundnut cake, de-oiled rice bran and raw rice bran. The most common feeding practice was broadcast feeding. Rohu broodstock that were collected during the breeding season were fed in a similar manner to the fish in the grow-out production systems. Catla broodstock were segregated from the other culture species, and fed a diet comprising soybean cake, dried fish, and a mineral mixture. Constraints to Indian major carp production were identified, and research and development needs characterised. This publication may be downloaded for free from the FAO website at:

http://www.fao.org/docrep/019/i3146e/i3146e.pdf