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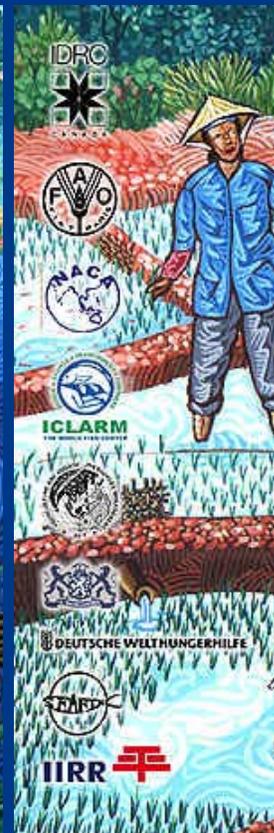
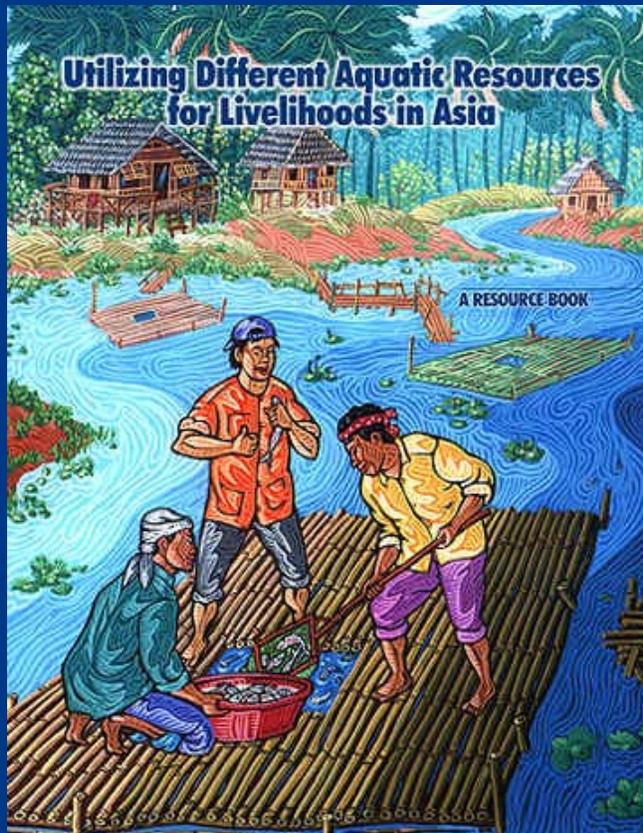
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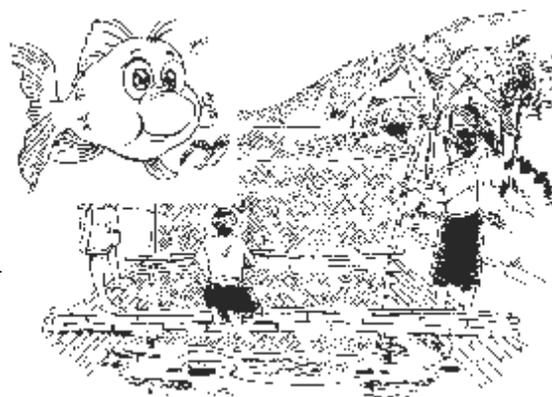
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## Introduction

The search for sustainable, livelihood approaches to reduce poverty continues to pose a challenge to rural development planners and practitioners. Often this is because of the very nature of poverty itself, which remains complex: the very poor are vulnerable to an interplay of a rather wide range of forces and factors. However, natural resources, especially water resources, continue to be available to poor families in many parts of the world and poor families have demonstrated that they can utilize these resources in a sustainable manner. Farmers, the landless and fishers all over the world, continue to face (and often overcome) the challenges of poverty by developing their water-based, natural-capital stocks. They often do it using human capacity and the social capital available locally. Development agencies too have attempted to add value to these efforts by undertaking research and development efforts that build on these initiatives. Success stories are abundant especially in Asia. But mistakes have also been made, resulting in the destruction of these very assets that could help alleviate poverty. New programs can benefit from these experiences as lessons are now readily available for wider sharing.

### How this resource book was produced

This resource book consists of a compilation of proven experiences (from Asia) that are totally field-derived. This book is the result of the participatory workshop process conducted on September 18-28, 2000 at the International Institute of Rural Reconstruction (IIRR), Y. C. James Yen Center, Silang, Cavite, Philippines. Thirty-seven participants from 12 countries worked closely with a production team of editors, artists and desktop publishing staff.



Prior to the workshop, an initial list of topics was developed by the steering committee. A set of guidelines for developing the first draft papers was drafted and sent to the participants.

During the workshop, each participant presented his or her first draft, using overhead transparencies of each page. Copies of the draft papers were also provided to all other participants who critiqued the draft and suggested revisions.

After the first presentation, an editor-artist team helped the author revise and edit the draft and draw illustrations to accompany the text. The edited draft and artwork were then desktop published to produce a second draft.

Each participant then presented his or her revised draft to the group for the second time, also using transparencies. Again, the audience critiqued it and suggested revisions. After the presentation, the editors, artists and desktop publishing staff again helped the author revise the material and develop the third draft. At the end of the workshop, the drafts were put on display for review and sign off by the authors.

Throughout the workshop, the participants worked together in informal groups to discuss and improve the manuscripts. Although the principal authors are listed on each paper in this resource book, all the papers benefitted from a critical review by workshop participants.

After the workshop, a semi-final draft was reviewed by the advisory committee members (Dr. Harvey Demaine, Dr. Julian F. Gonsalves, Dr. Matthias Halwart, Dr. Dilip

Kumar, Dr. S. S. Tabrez Nasar, Dr. Gary F. Newkirk, Dr. Rolando Platon and Dr. Mark Prein). The publication was managed and coordinated by an IIRR team: Dr. Tabrez Nasar, Ms. Joy Caminade, Ms. Jel Montoya and Dr. Julian Gonsalves. Jel Montoya and Mr. Jeffrey Oliver coordinated the final publishing of the manuscript.



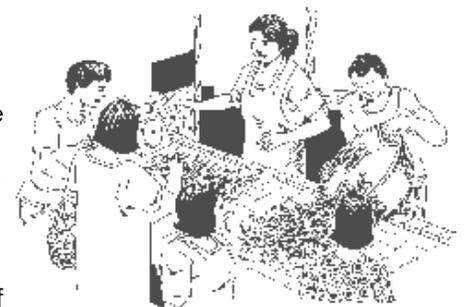
The workshop design and subsequent reviews benefited greatly from inputs from members of the advisory committee. However special mention must be made of a few individuals who provided strategic inputs during the entire process. Without their inputs this publication would not have been realized: Dr. Gary Newkirk of Dalhousie University/International Development Research Centre (IDRC), Dr. Mark Prein of International Center for Living Aquatic Resources Management (ICLARM), Dr. Matthias Halwart of Food

-- and Agriculture Organization of the United Nations (FAO), Dr. Dilip Kumar formerly of Network of Aquaculture Centers in Asia-Pacific (NACA), (now with FAO-RAPA) and Dr. Pedro Bueno (NACA).

Very special acknowledgments are due to Dr. Gary Newkirk of IDRC/Dalhousie University, Dr. John Graham, Dr. Brian Davy and Dr. Stephen Tyler of IDRC and Ms. Eva Marischen and Mr. Stephan Jansen of German Agro Action (GAA) who saw value in this effort, right at the outset. They encouraged the original proponents from IIRR, Dr. Julian Gonsalves and Dr. Tabrez Nasar through the difficult two years, when it appeared as though additional funding might not be available from other donors. Fortunately FAO, NACA and the Netherlands Embassy came in at the critical stage with the absolutely essential, supplementary- funding inputs. Special mention must be made of Ms. Elsa da Costa and Mr. Maurits ter Kuile of the Dutch Embassy who responded positively to a request for supplementary funding, made only a few weeks prior to the initiation of the workshop. With partners like Southeast Asian Fisheries Development Center (SEAFDEC), the Asian Institute of Technology (AIT) Aquaculture Outreach Program, ICLARM, FAO and NACA, we are sure that these materials will get disseminated and used with relevant audiences.

This resource book is complementary to the publication produced in 1992 (*IIRR and ICLARM. 1992. Farmer-Proven Integrated Agriculture-Aquaculture: A Technology Information Kit*) which focused mainly on lowland freshwater systems and has been published in revised form by FAO in 2001 (FAO/ICLARM/IIRR 2001. *Integrated Aquaculture: A Primer*. FAO Fisheries Technical Paper No. 407. Rome, FAO. 149p).

Comments were made during the workshops that many aquaculture conferences and meetings do not provide enough of an opportunity for healthy and constructive critique of ideas. This publication intentionally presents a diversity of perspectives and positions. The views presented remain those of the authors (whose names appear at the end of each article). The fact that the reader is presented with a diversity of viewpoints and perspectives make portions of this resource book of relevance to a wider range of development practitioners, local government officials and academic institutions. Addresses are provided for readers to contact the authors directly. Special consideration is given to the need for an integrated conservation-development perspective. This resource book presents, in a single compilation, information on how a wide range of aquatic ecosystems are utilized. Poor people's livelihoods, based on aquaculture are characterized by diversity and it is important therefore, to understand landscapes and sub-ecosystem linkages. The role that fresh, brackish and coastal water systems (and various other systems in between) can play in people's livelihoods in Asia is discussed (as it relates to aquaculture). Household food security, nutrition, income generation, the need for conserving the resource base and gender considerations were constantly considered during the workshop, as materials were recast and repackaged.



Conflicts in resource use by various stakeholders, often engaged in different forms of water-based livelihoods are discussed by many individual authors. These are lessons from the field and are shared so future action is influenced. These perspectives show up in most articles.

The partners in this documentation effort encourage wide use of these materials. There is no copyright. Feel free to use the materials in advocacy, training, planning and field-support work. Consider using in newsletters and newspapers (including presenting the materials in serialized forms) after acknowledging the original authors and the co-publishers of the resource book. We all realize the value and need for upscaling our efforts in small scale aquaculture: this publication could potentially feature prominently in any effort to broaden the opportunities for improved livelihoods for the poor, based on the careful use of aquatic resources.

## General Issues and Principles

[The Role of Small-Scale Aquaculture in Rural Development](#)

[Aquatic Resources Management for Sustainable Livelihoods of Poor People](#)

[Social and Cultural Considerations in Small-Scale Aquaculture](#)

[Socio-Economic Impact of Rural Pond Fish Culture](#)

[Involvement of Women in Small-Scale Aquaculture](#)

[Impact of Aquaculture on the Environment](#)

[Conservation of Aquatic Genetic Diversity](#)

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[Introducing Aquaculture into Farming Systems: What to Look Out For](#)

[Importance of Fish in Household Nutrition](#)

[Managing the Introduction of Exotic Species](#)

[Primary Health Care in Aquaculture](#)

[Fish as Biocontrol Agents of Vectors and Pests of Medical and Agricultural Importance](#)

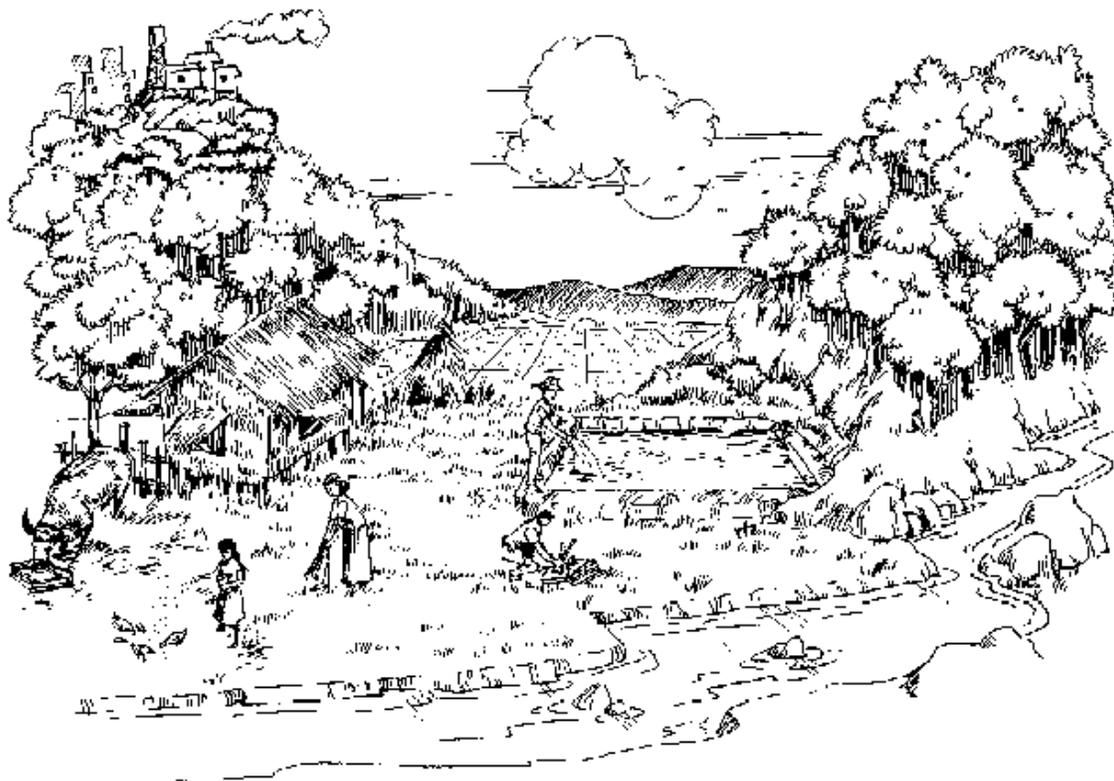
[Possible Public Health Hazards Associated with Farmed Fish and Shellfish](#)

[Improved Handling and Quality Assurance of Fish and Fishery Products](#)

## General Issues and Principles



# The Role of Small-Scale Aquaculture in Rural Development



Poverty alleviation is central to the concept of rural development. However, the prevailing development strategy in the 1960s and 1970s of structural change based on urban-industrial growth did not lead to the trickle-down of benefits to poor people in rural areas. "Rural development" approaches, thus, emerged to address more directly the problem of rural poverty.

## Different approaches to rural development

- Basic minimum needs provision, implying a continuation of paternalistic attitudes by government
- Integrated rural development, emphasizing the need to address both the economic and social issues
- Employment creation, emphasizing the economic sector

## Key principles emerging

- Peoples' participation
- Bottom-up planning



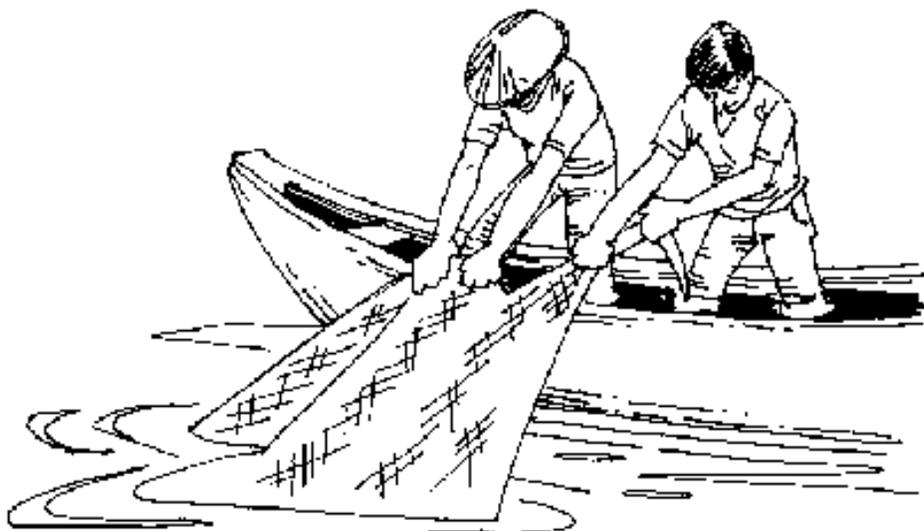
This has been just as true of aquaculture as with other sectors. After concentrating on intensive systems based on high-external input

technologies in the last decade, significant attention has begun to be paid to rural aquaculture, a portfolio of technologies which are specifically oriented to address the needs of the poor people.

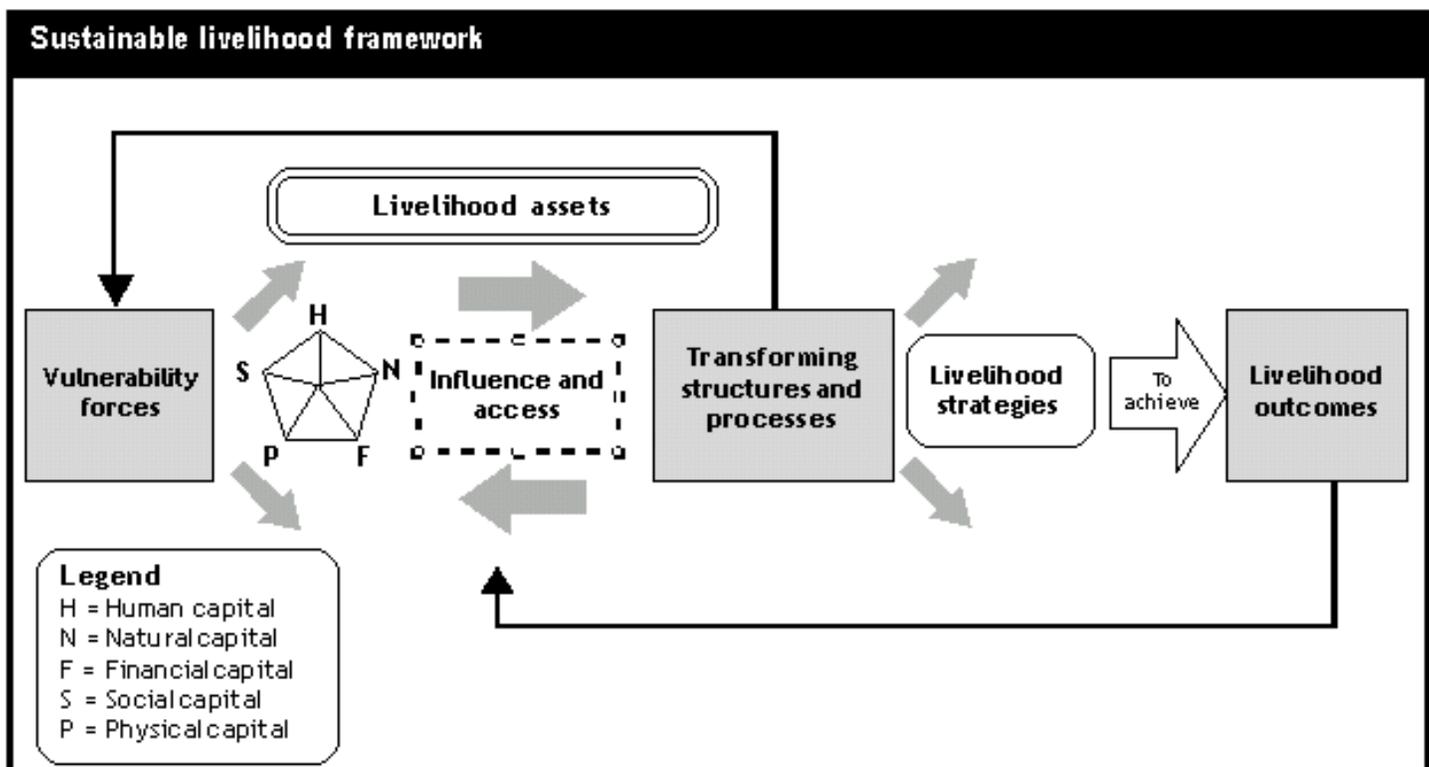
Poverty, however, is complex and poor rural people do not rely for their livelihood on the agricultural sector alone. This perception has led in recent years to the emergence of “sustainable rural livelihoods” as an approach for the analysis of poverty and possible intervention for its alleviation. This approach examines the position of rural households in relation to the availability of various capital assets.

### Assets

- **Natural capital:** access to land, water, forests and other resources
- **Physical capital:** presence of roads, irrigation systems, schools and other important economic and social infrastructure
- **Human capital:** available labor and skills, experience and education of the rural household
- **Financial capital:** investment resources available to the household, whether from their own savings or the presence of credit systems



- **Social capital:** namely the networks which may be tapped to support the individual household. Support may come from informal associations within the village community or from formal institutions at local, sub-regional and even national level.



## Factors affecting the basic assets

### Vulnerability forces

These forces may include sudden shocks in the physical environment such as drought, flood or typhoons, or longer term trends in the economic environment and resource stocks. Both of these can reduce the assets normally available to the household.

### Transforming structures and processes

Transforming structure and processes refers to the nature and operation of the institutional environment, encompassing public and private institutions, laws, policies which can work positively or negatively to affect access to capital and maintenance of it (Carney, 1999). It is in response to their asset situation, in the context of the various vulnerability factors and the prevailing structure and processes, that the rural poor develop their livelihood strategies.

The challenge for aquaculture is whether it can help strengthen the assets available to rural households so that they are better able to

withstand shocks, become less vulnerable and are better able to influence the policy/institutional environment in their favor. We now examine whether aquaculture is able to do this.

### **Potential roles and impacts of aquaculture on poverty and rural livelihoods**

Aquaculture may assist poor rural households by enhancing their natural capital stocks. In relation to natural capital, rural people may be poor because:

I they lack such capital assets (for example land, in the case of the landless);

I the scale and quality of their natural capital (the context of small-scale farmers in resource-poor environments) are limited; and

I the natural capital on which they depend has been degraded (for example in the case of fishers previously dependent on catches from either the freshwater or the marine environment).



By creating, adding value to or restoring natural capital, aquaculture may contribute to the livelihoods of poor households directly involved in the enterprise. The underlying benefits of direct involvement would be improved food security, creation of employment opportunities and income generation. In addition, aquaculture may improve the sustainability of other farm enterprises.

For those with land, where pond aquaculture is practiced  
The pond offers an extra source of water to help offset the effects of drought on staple crops and provide water for vegetables and fruit. This is particularly the case in areas of resource-poor agriculture, which is dependent on erratic rainfall.

Where aquaculture is practiced in paddy fields  
The incorporation of fish in the system can both improve rice yields and reduce costs of production.

### **For the landless**

Common property resources may provide an opportunity for aquaculture provided that villagers have the social capital to secure

access to the resources and eventually enhance them. In these cases, aquaculture becomes an entry point for building up other assets.

### **For fishers**

Aquaculture may help to replace the livelihood lost through overfishing or environmental destruction. In order to ensure a sustainable operation, the need for major investment in physical capital is recognized.

### **Indirect benefits from aquaculture**

- Reducing the cost of fish to rural consumers
- Creating wage employment on larger farms or in fish products processing
- Cheap fish for urban consumers

### **Barriers to entry of aquaculture**

The high investment required in the creation of physical capital for aquaculture such as pond, trench or cage, the excavation, etc., might not seem affordable. Additionally, the costs of fish seed, feed and/or fertilizers and harvesting equipment have to be considered.

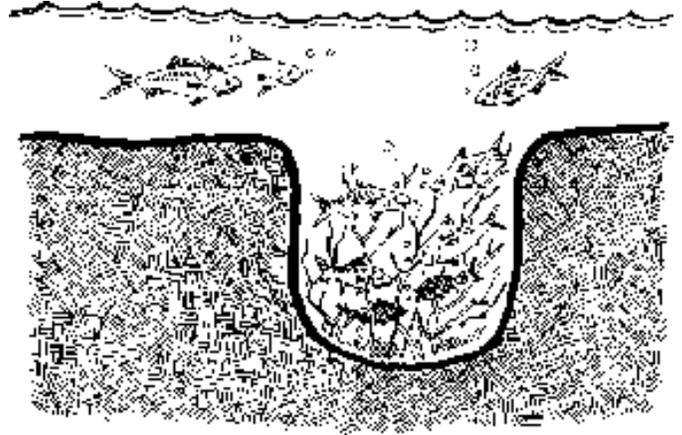


In fact, the investment costs are rarely as high as might be assumed, especially in traditional rice-fish societies, so that access to aquaculture is well within the existing financial and social capital stocks of the farmer.

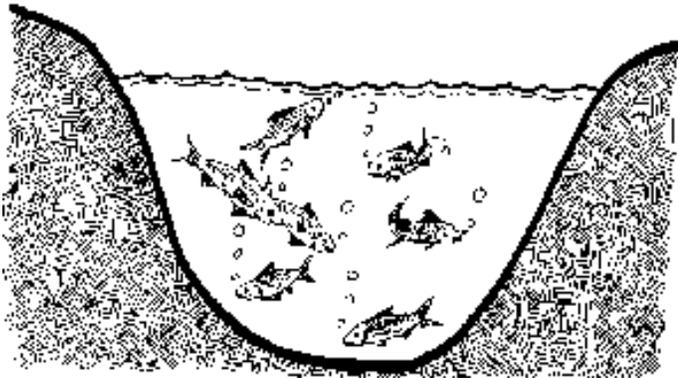
In order to provide human settlement in low-lying lands in flood plains,

ponds are excavated in order to use the soil as a platform for the homestead to raise it above the flood.

This automatically gives the household at least a small pond close to the house. Aquaculture frequently develops as the pressure on the existing rice-field fishery increases. To attract wild fish to their particular part of the paddy, farmers dig small pits or ponds which act as sumps as the water recedes trapping the fish. These "trap ponds" may be widened and deepened as the farmer becomes more oriented to aquaculture.



While these traditional practices form a low-cost basis for the development of aquaculture, so do development projects.



Construction activities usually require excavation of soil for landfill elsewhere and farmers may find themselves being given an opportunity for free pond excavation as a result. Evidence from Bangladesh demonstrates that even burrow pits and on-farm ditches can be a resource for the landless, especially with the introduction of tilapia culture which offers the opportunity of sale of swim-up fry after just a few months.



In traditional rice-fish culture in upland areas in the Lao PDR and Vietnam, these ponds may be used to stock broodfish throughout the winter season, allowing farmers to produce their own seed locally and to reduce dependence on more expensive, imported supplies.

At present, development projects recognize that the farm pond is a key element in the creation of physical/natural capital for poor households, thus, offering free or subsidized services for pond construction. Whether this is seen as a fish pond or not, fish culture usually adds value to the resource unless it is also to be used for drinking water supply (as was the constraint in the Family Food Production Project, an early attempt to promote aquaculture in Cambodia).

These issues only relate to land-based systems. For the rural poor, often landless, open access or common property aquatic resources may offer access to aquaculture:



### **Freshwater context**

Resources may include backswamps and oxbows in flood plain environments or small reservoirs, including watershed catchments in small tributary valleys.

### **Coastal areas**

Where many coastal fishers have been suffering from reduced catches in recent years, sheltered estuaries and bays constitute potential resources. The big issue in these cases is whether the rural poor can secure permanent access to the use of the water bodies concerned, i.e., whether existing power structures and processes in the community facilitate this access.

Another constraint to coastal aquaculture is the openness of the area. With open access to coastal areas, individuals have difficulty obtaining tenure and even communities may not have jurisdiction. Even when they do have jurisdiction, their ability to enforce control is constrained by the physical openness of the sea.

### **Technical options for small-scale aquaculture**

Many opportunities await the rural poor people when they take part in this enterprise without major capital investment. The issue centers on availability of suitable technology for fish culture and if this technology is accessible to poor people. Aquaculture technology is perceived to be either physically inaccessible or too risky for many rural poor people. However, these were based on conventional approaches that are now being superseded.

## **Two main stages in aquaculture production**

### **1. Seed production**

Supply of quality seed is fundamental to developing the enterprise. Apparently, many areas are characterized by inadequate seed supply despite the widespread development of large-scale hatcheries, often with donor funding. However, hatchery facilities have been decentralized and small farmers in rural areas can even produce their own seed without conventional hatcheries.

For many estuarine and marine species, natural sources of seed with acceptable reliability are abundant. Wild seed is currently the only acceptable economic option for oysters, mussels and clams. For other marine species, there is sufficient wild seed for small-scale production, although this begins to be an issue as the area of culture expands.

Farmers in the highland valleys of Vietnam and the Lao PDR have traditionally spawned fish (e.g., common carp in paddy fields). Such systems remain common in more developed areas in Indonesia and China. Small carps and tilapias can be bred locally in pond culture, which not only reduces costs and improves quality – since long-distance transportation is no longer needed – but also provides employment and income for small-scale farmers. Those with slightly better water resources are able to breed fish, while others can nurse fish in cheap nylon cages for onward sale. Such systems have been developed in Bangladesh, Cambodia and the Lao PDR where they have had a powerful multiplier effect (Edwards, 2000 and RDC, 2000).

### **2. Grow-out stage**

Aquaculture may be practiced in a wide variety of options. The

technologies, which offer valuable livelihood options to the rural poor, are available. These center around herbivorous and omnivorous species, which can thrive on various on-farm fertilizers and feeds and inputs that can be gathered from the wider resource system. Several systems of fish culture are based gathered grasses and other vegetation.

Other systems depend on fertilization strategies using animal manures. Some cultural constraints exist in the use of manures as well as limitations in the nature of the agricultural system, particularly where livestock are not penned. However, the culture of some improved species of Nile tilapia by the rural poor, with only limited applications of inorganic fertilizer, also has been successful.



In northern Vietnam, aquaculture systems have centered on grass carp for the last 40 years since its introduction from China. This species is reared in both ponds and cages, fed with grasses, maize residues and cassava leaves. In the south of Vietnam, an equivalent "poor person's system" based on giant gourami, which also feeds on vegetable matter (although growth rate is a constraint), exists.

In southern Vietnam, the culture of pangasius catfish (*Pangasius hypophthalmus*), reared in overhung latrine ponds, is a second low-cost system. These grow quickly without purchased inputs and can be the basis of a more diversified system.

## Coastal aquaculture

More work has been done in freshwater aquaculture than in coastal aquaculture in developing production systems suitable for poor people. The culture of mollusks and seaweeds appears to have high potential, while requiring only minimal investment. These water-based systems do require some investment in order to develop aquaculture but, at least initially, cages and poles for shellfish culture can be made from relatively cheap and locally available materials like bamboo.

Most coastal aquaculture technology, however, has been aimed at moderately high to high-value species. These species are too expensive for household consumption of the poor people and low-cost culture systems for these species are rare. The culture of high-value species

entails more investment for crop security, either for physical confinement or protection from theft. Aside from the financial constraint, it is questionable whether poor people would undertake such risk-prone activities.

## Conclusion

Aquaculture is more accessible to poor rural people than has been generally realized and a range of technological options now exists. However, much remains to be done.

- It is important that efforts in research and development continue to be focused upon the sorts of technical options that were described, particularly in coastal areas.
- National governments must be committed to providing an environment which allows poor people access to productive assets and resources, possibly through specifically targeted support packages.
- Strategies will often require major changes in policy and in attitude among government departments and individuals.
- Finally, bearing in mind the sustainable rural livelihood approach, the participation of the rural poor in aquaculture will depend on a whole range of social and economic factors at the farm, community and regional/national levels. In a more general context, these factors may include the key economic issue of relative “catch per unit effort” to be obtained. In the narrow sense, this involves assessment of the merits of aquaculture compared to capture fisheries and assessment of other alternative livelihood opportunities, both on and off farm.



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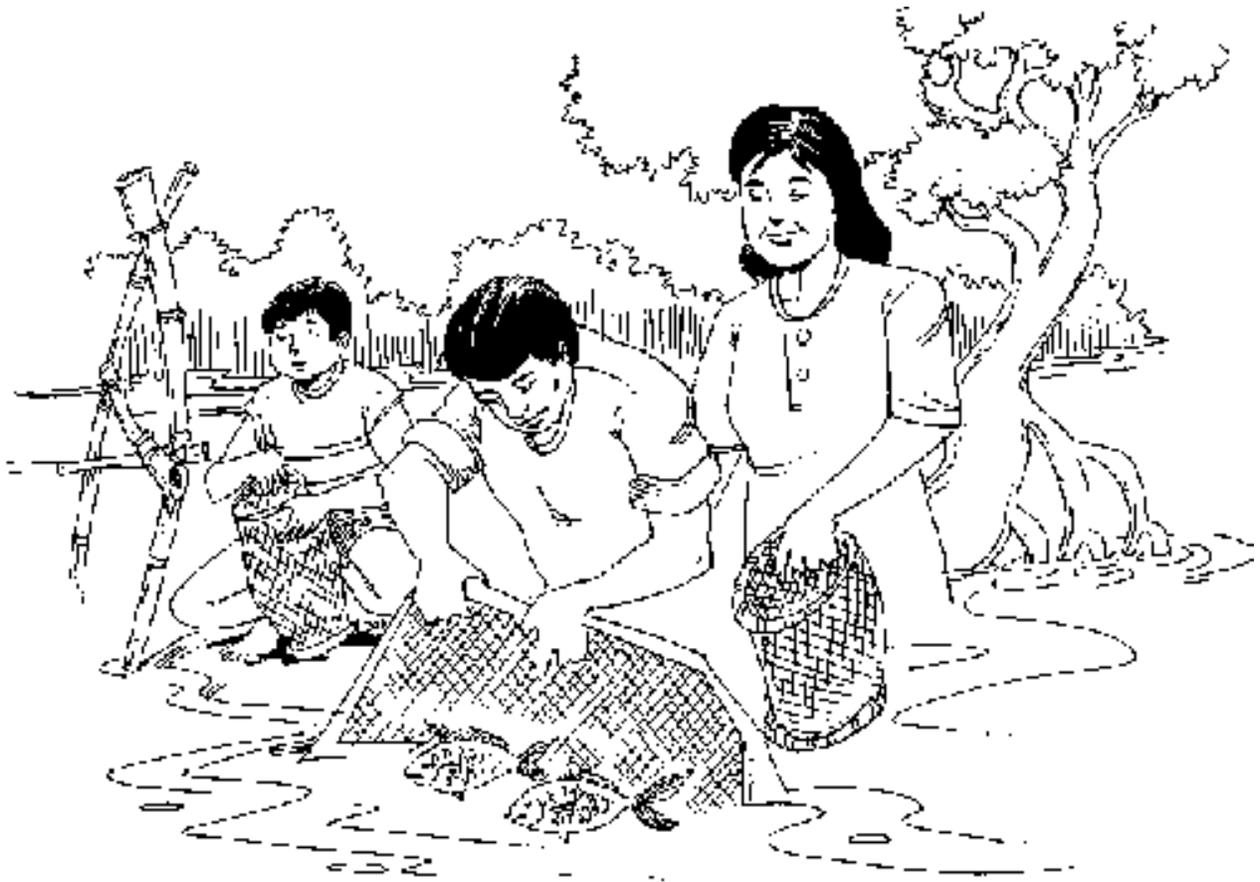
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# Aquatic Resources Management for Sustainable Livelihoods of Poor People



The role of aquatic resources in poor peoples' livelihoods is complex and context specific. Aquatic resources management in the context of poverty is not limited to technology or forms of aquaculture but could include improved access to natural stocks of fish and other aquatic organisms. Policies, institutions and processes that support livelihood strategies involving aquatic resources are also important. In the past, there has been a failure to recognize the contribution of aquatic resources management to food security for the rural poor. The livelihoods of the poor, in fact, can be adversely affected by policies and practices in other sectors (especially agriculture and water management) that undervalue aquatic resources. For example, some forms of irrigated agriculture (weir and dam schemes) have had negative impacts.

Aquatic resource diversity	
<b>Temperate/Tropical</b>	
<i>Inland</i>	<i>Coastal</i>

<i>Riverine</i> Rivers Floodplains Irrigation channels  <i>Lacustrine</i> Lakes Reservoirs Ponds  <i>Palustrine</i> Swamps Rice fields	<i>Estuaries</i> Lagoons Coral reefs Mangroves Mudflats Ponds  
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Livelihoods based on aquatic resources are characterized by diversity of resources, environments, resource users and the ways people exploit resources and incorporate them into their livelihoods.

It is difficult to assess aquatic resource use by poor people. The complexity of seasonally and spatially variable environments and stakeholder activities often results in incorrect resource use estimates. Good case-study evidence may provide more valuable information. The social context is especially important, particularly access arrangements and the assessment of benefits to livelihoods.

Technical issues and lack of new knowledge are not major constraints to aquaculture development. There is a wealth of knowledge, including local knowledge, that only needs effective widespread dissemination to enhance human capital. People, not ponds or technology, are the entry point for aquaculture development. There has been a positive shift from technology-led production-oriented project interventions to a people-first sustainable livelihood approach. Poverty and environment degradation can be eliminated through holistic development interventions that facilitate diversified sustainable livelihoods.

Available statistics on aquatic resource use do not reflect reality well: they commonly under or over estimate the resource. Little information is given on seasonality and markets.

Well collected and presented information on the value of aquatic resources to poor people empowers users and their advocates. Such information is less easily ignored by competing sectors.

## **Evidence of the role of aquatic resources in poor peoples' livelihoods**

In some parts of Southeast Asia, aquatic resources constitute a large share of the animal protein intake of poor households. Households catch and consume significant quantities of fish and other aquatic products. But there is increasing evidence that wild aquatic resources are declining.

What general evidence is available on the role of aquatic resources in the livelihoods of poorer groups? For those working in the field, the role of aquatic resources in poor peoples' livelihoods is self-evident. However, policy makers need hard evidence for formulating more pro-poor policies or to make resource allocation decisions. Evidence can play a role in supporting planning and legislation and improving the institutional context of decision-making. Greater emphasis on advocacy (outside the sub-sector) is required to raise awareness of the role for aquatic resources management in rural development and to bring about desirable institutional changes.

<b>The role of aquatic resources in food security of poor households in Southeast Asia</b>				
	<b>NE Thailand</b>	<b>Cambodia</b>	<b>Lao PDR</b>	<b>Vietnam</b>
<b>The role of aquatic resources in the diet</b>	72-82% of animal protein consumed in the wet season in Yasothon Province comprises wild aquatic resources, derived from rice fields.	Fish and fish products account for 70-75% of the dietary protein intake of the population of Cambodia.	Fish had traditionally contributed 85% of animal protein intake. A recent survey in Luang Prabang Province found fish to represent 50-55% of animal protein intake. Fish still represents the largest component of animal protein in the diet.	Fish in An Giang Province contributes nearly 76% of the average person's supply of animal protein. The role of aquatic resource in the diet of northern provinces is much less.
<b>Fish production/ consumption estimates</b>	Average consumption for northeast Thailand 30-34 kg/cap/y according to three independent studies. Fish availability in the hungry season is highly valued.	Average consumption 28-41 kg/cap/y. However, eight provinces around the great lake and the Mekong (population 4.1 million out of a national population of 10.5 million) household sample surveys suggest the	Average consumption 11-22 kg/cap/y in poor villages in Savannakhet Province. In some parts of Luang Prabang Province in the north, per capita consumption is 22 kg/y.  Some small water	Production and consumption is greater in the south than in the north. In the northern mountains, several kg/cap/y is common. In the south, e.g., Long An Province, farmers catch 531 kg/hh/y; and average fish consumption is 60

		consumption of fish and processed fish to be at least 67 kg/cap/y. Some rice fields outside of the above provinces provide families with 62 kg/ha.	bodies contribute 66 kg/hh/y to production in Savannakhet. Average household catches in parts of Lao PDR can range from 40-108 kg (US\$80-215). The average value of a rainfed rice crop is US\$100.	kg/per/y. In An Giang Province, average wet rice fish catch is 835 kg/hh/y and consumption is 78 kg/capita/y; 50 kg fresh fish and 28 kg fisheries products.
<b>Current trends availability</b>	In northeast Thailand there has been a steady decline in natural fish catch over the last six years in all water resources. Availability is strongly correlated with rainfall.	Evidence suggests the resource in Cambodia has been underestimated. An issue for the poor is access, constrained by the sale of fishing lots and in some cases, the exclusion of local fishers and reduced quantity and size of fish migrating.	Some Laotian riverine fisheries, as reported in 1984, had declined by 20%, and a 1994 report states that production in lakes and reservoirs has declined by 60% in the past 15 years.	There are indications that the catches from the Red River Delta and the Mekong River System have declined considerably over the last 10-15 years.

## Technologies and processes that enhance poor peoples' management of aquatic resources

Uncertainty in relation to the outcomes of technology use by poor aquatic resource users has been highlighted. Reference is made to the desirability of support systems that can integrate "local knowledge" and "scientific knowledge". Participatory approaches also have an important role to play. Local knowledge commonly includes:

- time and place knowledge of resource systems;
- people who use them;
- local needs;
- desires; and
- patterns of behavior.

### Processes that enhance poor peoples' management of their aquatic resources

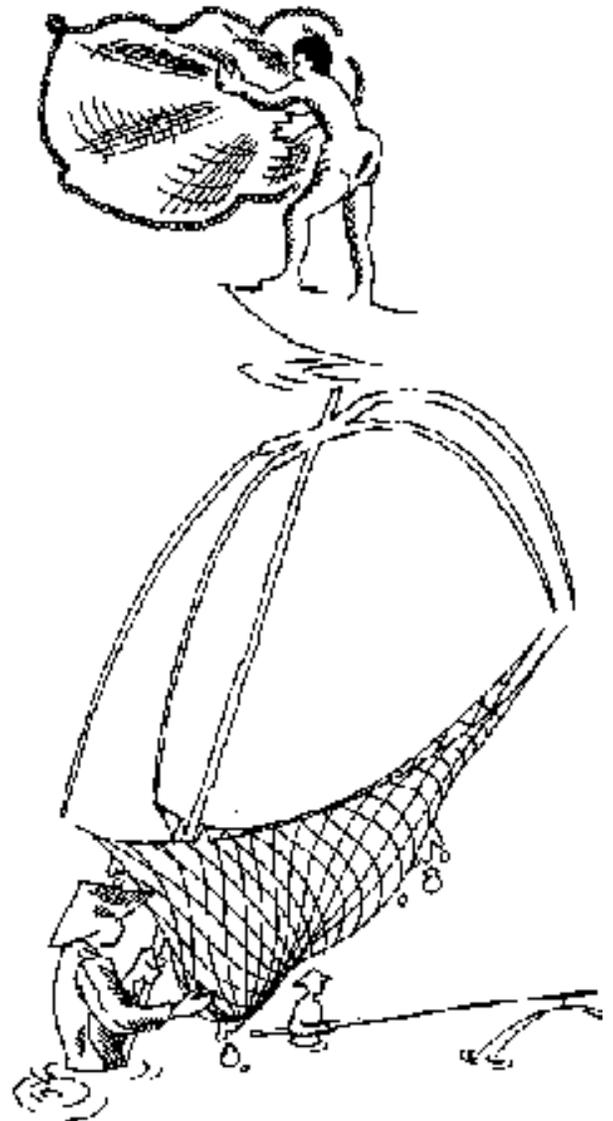
- Incremental
- Participatory
- Adaptive
- Flexible
- Building basic husbandry and basic management skills
- Limited financial capital
- Building institutional capacity and incentive structures
- Supporting operational budget at local institutional level
- Promoting networking among sectors of small-scale producers

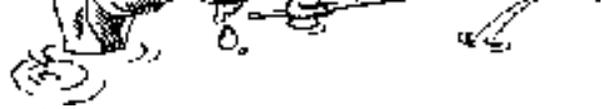


From fisheries, the management of ubiquitous small-scale water bodies is of particular interest. The water bodies play an important role in subsistence needs and income generation. Fisheries technologies exist to increase the standing stock and returns to fishing effort. However, initiatives to enhance the management of such systems, which catalyze changes in use patterns and access, raise important issues about managing the process, and whether benefits accrue to the poor.

Community-based co-management of fish resources can be useful in initiating more participatory approaches to the management of "nature conservation" through protected areas. In central southern Laos and Northern Cambodia, fish is the most important source of animal protein for villagers living in and around protected areas. Fisheries can be a good entry point for conducting community-based collaborative management of natural resources.

### Learning and communication processes that enhance the capability of poor people to manage their resources





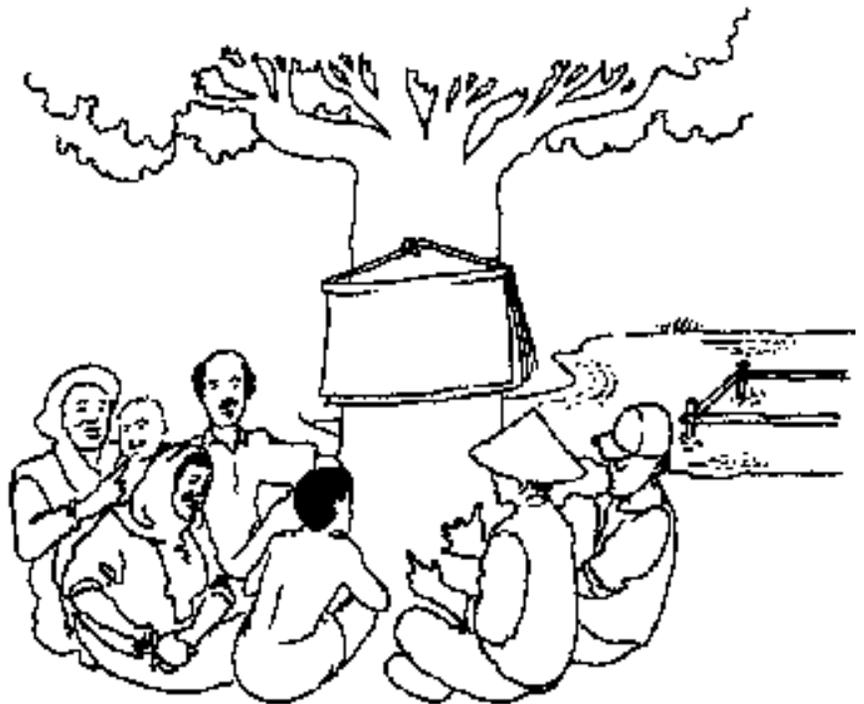
In the context of learning and communication, we are reminded of the plurality of knowledge that encompasses our “images of reality” and our “vision for the future”. A proper understanding of the differences in stakeholders’ knowledge is important for all those who play a role in communication and learning processes.

The traditional means of communication through extension services has tended to focus on information transfer from researchers to farmers. Perhaps one reason why aquatic resources management systems have been ignored and aquaculture systems have often favored wealthier farmers is a lack of investment in communication processes. Improving dialogue might help identify issues relevant to poorer resource-users. Organizations involved in traditional aquaculture extensions include NGOs, which work in relatively restricted areas, as well as government departments, which have a wider geographic coverage.



Developing the capacity to share information is particularly needed. It is also strongly advocated to involve support staff and aquatic resource users in developing recommendations, though top-down processes are reported to be still common place. Improving mechanisms for communication across sectors and between countries, provinces, districts and communities is important in creating awareness of good and bad management practices at various levels. A better sharing of what knowledge exists is needed, especially approaches and processes and the contexts in which they have been successful.

The weak institutional capacity of some government (and other) providers of services at local levels can limit their capacity to participate fully in learning and communication. Learning and communication processes should build on traditional systems of information storage and management already operating at local levels. Local support agencies should be assisted to be better able to record and manage the information they are expected to retain and process.



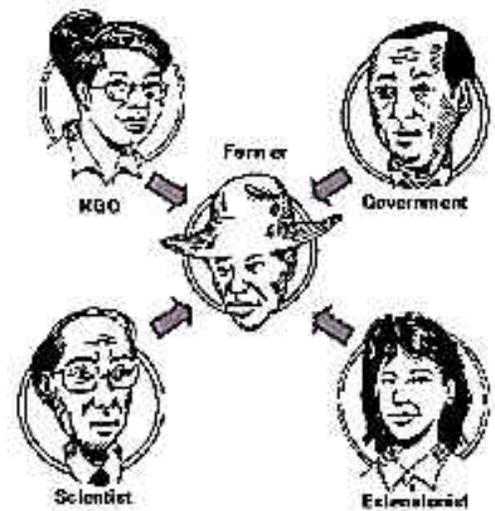
**Institutions, organizations, policies and legislation that shape**

## aquatic resources management for poor people

People who are poor find it difficult to draw down services that could support their aquatic resources management (and more broadly their livelihood options). Promoting pro-poor approaches within policies and institutions is a particularly valuable development objective. Understanding the livelihoods of the poor is essential to the proper formulation of policies that support their objectives. Once again, participatory processes have an important role to play in uniting the poor with policy formulation processes.

From a broad range of contributions one can characterize the following key requirements.

- Expanding the structure of existing support agencies (especially local government), allowing representation of the poor and facilitating a better understanding of poor peoples' livelihoods and their participation in policy development processes.
- Assistance (catalytic) from support agencies for local organizations and networking.
- The knowledge and skills required to administer and monitor even simple technologies can become limiting factors at provincial and district levels. Seeking opportunities to build upon existing capacity, at a rate consistent with the stage of institutional development, can be valuable. Where institutional capacity and operational budgets are limited, the process is likely to be slow and long.
- The development of a long-term vision and the coordination of donor support can often be complex for local institutions to manage. Regional development structures may have a role to play in administration.



In Southeast Asia, international collaboration within and between riparian countries will probably be a major determinant of aquatic resource sustainability with important implications for poor people's livelihoods. Stocks are shared among different parts of the region sometimes hundreds of kilometers apart because of migratory habits of most Mekong fish species. Processes leading to the formulation of policies and laws relating to the construction of hydro dams, irrigation structures and habitat conversion could benefit from information about the dynamics and value of aquatic resources.

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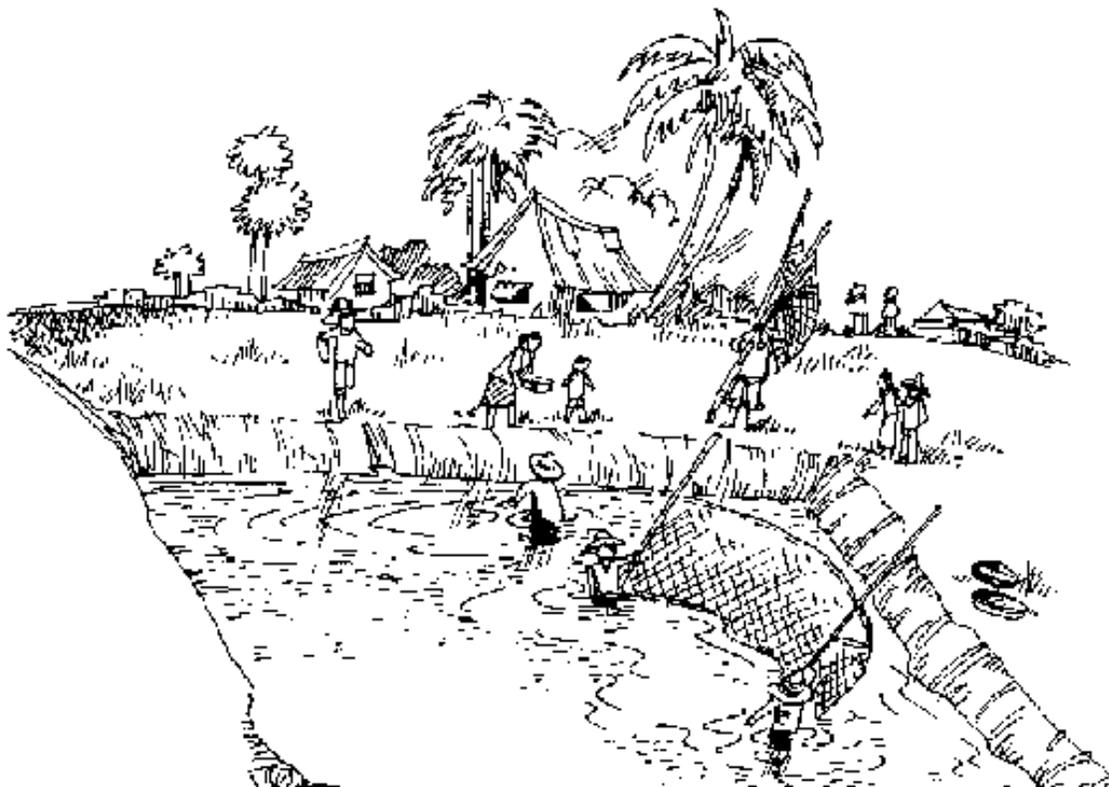
From the DFID-SEA Aquatic Resources Management Programme. 2000. Draft Final Report: Proceedings of the E-Mail Conference on Aquatic Resources Management for Sustainable Livelihoods of Poor People in the SE Asia, June 2000, Bangkok, Thailand, 131 pp. (Available upon request from [stream@eNACA.org](mailto:stream@eNACA.org).) Originally edited by Graham Haylor and repackaged by Matthias Halwart for this publication.

# Social and Cultural Considerations in Small-Scale Aquaculture

Aquaculture is a mode of production, which is part of a larger agriculture/fisheries/food production system. This larger system is both socio-economic and biophysical in nature. These two features are interdependent, interactive and mutually deterministic. Together, they can influence people's decisions and their success in new technology applications and development.

The production system also involves the local community. One cannot consider development as only individual. The household context has immediate impacts on women and men as well as on the old and young. The community, political and other factors may involve different social classes, castes, or ethnic groups.

The physical connections of aquaculture through the use of water form a close link to wider ecosystems. These wider ecosystems are used and influenced not only by a range of biological and physical factors but also by people.

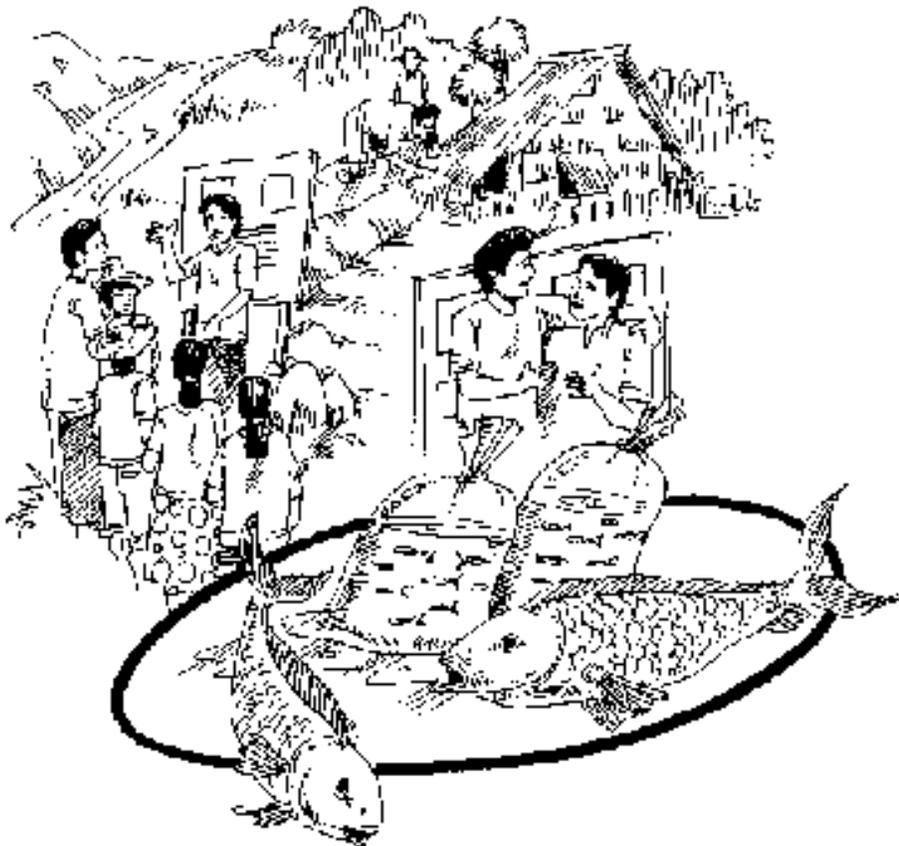


**Aquaculture and its development should be...**

<p><b>People centered.</b> Support should be provided only for what matters to people. The support must be sensitive to differences among groups of people and should fit their current livelihood strategies, social environment and ability to adapt.</p>	<p><b>Conducted in partnership.</b> Partnership is needed in the private and the public sectors for the development of the production system, marketing, finance, regulations, technical support, training, etc.</p>	<p><b>Multi-level.</b> Concerns at the micro-level, the locus of the production, must inform the development of policy (local government and other levels) for an effective and supportive enabling environment.</p>
<p><b>Responsive and participatory.</b> Poor people should be key actors in identifying and addressing priorities. Outsiders will have to listen to and respond to the poor.</p>	<p><b>Dynamic.</b> External support for aquaculture development must recognize the dynamic nature of people's current livelihood strategies and be flexible to changes.</p>	<p><b>Sustainable.</b> In addition to environmental sustainability, aquaculture must pass the test of social, economic and institutional sustainability.</p>

### Small-scale aquaculture

Aquaculture development intended as “small-scale” must be a poverty-focused development activity. As such, it should comply with the principles as adopted by DFID as core principles of sustainable livelihoods framework.



A useful framework to remember consists of the assets that people can draw upon for aquaculture development. These are:

- natural capital, e.g., water, soil, fish stocks;

- human capital, e.g., trained labor, leadership skills, artistic talents;
- produced capital, e.g., houses, roads, machines, money and financial resources;
- social capital, and e.g., relationships and trust, networks, organizations; and
- cultural capital. e.g., beliefs, shared world views, folklore.

People can use these assets to invest in aquaculture development. These are also the reserves that can be used as foundations for successful aquaculture. In other words, the benefits of aquaculture can create assets other than those reflected in the financial benefits.



### **Complementation of new technology**

Complementarity of new technology is essential in aquaculture development. Aspects to be considered include the following:

- **Technical complementation**

New technology added to a household must complement the technologies currently being used. Conflicts will lead to rejection of new technology.

- **Social complementation**

Social reciprocities exist and must be considered in introducing new technology. Labor exchange is integrated with seasonality and social obligations. Access to resources may be determined by previous social conventions or arrangements.

- **Economic complementation**

Small-scale producers are by definition resource-poor. Financial capital will be limited and new ventures may depend on availability of limited technical and human resources. Amount and timing of economic resources are important.

- **Political complementation**

Access to common property or other resources may be constrained by existing political structures in a community. It is important to know who holds and uses power in the community and how their power is linked to power structures outside the community. How can the disadvantaged in the community be empowered?

Participatory methods can be used to assist communities in identifying needs and setting priorities. Simple PRA methods such as focused group discussion or problem tree analysis are examples. See guidebooks, such as, the Participatory Methods for Community-based Coastal Resources Management (IIRR, 1998).



## **Participation**

People need to be involved in choices of aquaculture technology and the details of the technology. Participation in problem identification and solution will make the technology more suitable and acceptable.

People need to assess what resources are available for aquaculture development and how these might be used. They must be central in planning for collective action.

## **Availability of human resources**

We cannot assume that there will be enough labor, time and skills available. In poor villages the more entrepreneurial people (more qualified and better motivated) tend to leave. Fishing and farming are often low-status occupations.

## **Availability of time**

Current fishers/farmers will be very busy. Both women and men are occupied most hours of the day with current activities to maintain household welfare.

In aquaculture the benefits from investment will only be obtained much later. Investments of time and money will not return benefits of food and income until harvest. Fishers are accustomed to receiving the benefits of a day's work on the same day. Aquaculture requires a different attitude and planning for such fishers. Farmers may be more attuned to this condition.

## **Risk tolerance**

The risk factors to be considered are:

- Current lack of access to resources can make people averse to risk and less likely to take up new options.
- Options and decisions are usually based on experience. What is most meaningful is what “worked” in the past.

- Familiarity supports acceptance of risk. The lack of visibility of some aquaculture stock may decrease comfort.

### **Guide questions for appropriate technology**

A technology, to be adopted/adapted by the target beneficiaries, must be appropriate to existing conditions.

- Is it responsive to needs?
- Is it affordable?
- Is it ecologically sound?
- Is it socially acceptable?
- Are credit, training, and other support available?
- Would it require policy advocacy?
- Is it sustainable?

### **Ownership and management**

- Community ownership or individual ownership: Will the development result in units of production being owned and operated by individuals or households? Or will it result in some form of communal enterprise? In some cultures, individual or family ownership is more successful than communal efforts. One must ensure that the development is designed to fit the potential social organization of the community.
- Access to the resources: Who controls, owns and/or manages the resources necessary for production?
- Training, credit and other support services should get to the right people. These people must first be identified. Are women involved? Are there others not visible who play an important role in the production?

### **Social and cultural considerations in species selection**

The type of species to be used in aquaculture is critical in the investment process.

- Demand driven selection of species in aquaculture. What species are important to the potential users of aquaculture technology? Is there a market or household demand?
- Harvesting period: consider the timing with respect to religious or other festivals and holidays. Prices and availability of excess labor might be affected by

timing.

- Peak seasons of labor demand for other means of livelihood might be in conflict with the seasonality of introduced species.

### **Social and cultural consideration in technology choice**

- Availability of easily adaptable technology
- Cultural and religious acceptance of the technology
- Appropriate educational levels of users
- Technology may impact women and men differently. Consider who will be the most appropriate user of the technology.
- Consider special needs depending on the age of the expected participants.
- Children should not be involved in labor at the expense of their education.

### **Social considerations regarding required resources**

- Look closely into why the resources are being used for production. Are the resources (e.g., ponds) available for use because the owner intends them for aquaculture production?

### **Institutional support to the farmer**

- Social and cultural obstacles sometimes exist, particularly for government infrastructure, due to different classes of people.
- Appropriate groups should be mobilized where communal action is needed.
- Look for traditional or community-based institutions to support new development. These are likely to be more socially and culturally acceptable. But make sure they are not inclined to limit the spread of the benefits.

### **Demonstration of successful technology**

- Social recognition of the best farmers creates role models in the community.

- Role models are important and need to be identified so they will have the most impact.
- Be responsive to what people need.

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Prepared by:  
Gary Newkirk

# Socio-Economic Impact of Rural Pond Fish Culture



The “natural” development of aquaculture is influenced by such socio-economic factors as:

- the perceived need or desire for aquaculture products;
- the suitability of available resources for supplying these products and the availability of complementary factors of production; and
- the knowledge of techniques for aquaculture possessed by the society.

Technology and technology transfer are major issues in developing the fisheries sector in Bangladesh. Towards this end, an extension methodology called trickle down system (TDS) of aquaculture extension was developed and implemented on an experimental basis during the implementation of the project "Institutional Strengthening in the Fisheries Sector in Bangladesh". The approach was further applied on a pilot-scale with assistance from the Technical Cooperation Program of the Food and Agriculture Organization of the United Nations (FAO) to strengthen the extension services system in Bangladesh.

Continuous supervisory technological and institutional support catalyzed the farmers' interests in aquaculture. The homestead pond aquaculture assists poor families by providing additional income as well as nutritional benefits.



However, these factors are not in themselves sufficient to ensure the development of aquaculture. A society with assured and suitable sets of property rights also appears to be necessary. Peace, law and order and good environment, when combined with the above factors, are likely to be conducive to the development of aquaculture.

The following are the possible socio-economic impacts on the household of fish farming.

<b>Socio-economic factors</b>	<b>Possible impacts</b>
<p>Occupational changes</p> <p>Employment generation</p> 	<p>Aquaculture generates more income than rice farming does. Because of its profitability, rural farmers and under-employed often change their profession to aquaculture.</p> <p>Improved aquaculture generates full time employment for two persons per hectare and has multiple effects on allied activities.</p>
<p>Family Approach</p> 	<p>If a family approach is used, ponds are never unattended. Women are empowered because of their role in decision-making. Children, however, should not sacrifice opportunities for attending school.</p>
<p>Household livestock</p> 	<p>Households are encouraged to maintain livestock because of their role in fertilizing ponds.</p>
<p>Living standard</p> <p>Fund flow for fish culture</p> 	<p>Additional income from aquaculture often translates into improved housing and sanitation.</p> <p>Aquaculture improves access to institutional credit and increases savings.</p>
<p>Nutrition</p> 	<p>Aquaculture increases the level of fish consumption thereby improving family nutrition.</p>

<p>Changes in farming systems</p> 	<p>Aquaculture changes the culture pattern from fry/fingerling-rearing to fish culture.</p>
<p>Self-confidence</p> 	<p>The adoption of aquaculture technology increases the self-confidence of the farmers' family; they receive improved training on management. This also increases the capacity and understanding of the value of technical inputs.</p>
<p>Social relationships</p> 	<p>Aquaculture helps expand the social network of farmers. New relationships can emerge, through marriages and friendship. Farmers visit fishery officials for technical advice and vice-versa.</p>
<p>Better use of waste</p> 	<p>Household waste, poultry droppings and compost are used as feed and manure.</p>
<p>Religion</p>	<p>Religious factors sometimes affect aquaculture negatively. Appropriate training can improve this situation.</p>
<p>Information</p> 	<p>Information is crucial during fish disease outbreaks, scarcity of fry/fingerlings exists, limited marketing, etc.</p>
<p>Access to resources</p>	<p>Access to resources is fundamental to aquaculture. Multi-ownership of ponds and water resources should be settled amicably.</p>
<p>Availability of technology</p> 	<p>Easily adaptable, demonstrated and tested technologies are precondition to expanding aquaculture.</p>

<p>Education</p> 	<p>Education plays a major role in adopting and practicing new technology. For illiterate farmers aquaculture technology should be made understandable in easy to follow, pictorial guidelines.</p>
<p>Law and Order</p>	<p>Stable law and order is essential: it reduces the incidence of poaching, poisoning and disturbances.</p>
<p>Communication network</p>	<p>Good communication network, i.e., roads and transportation facilities is also beneficial in promoting aquaculture.</p>
<p>Institutional framework</p> 	<p>To expand and sustain aquaculture benefits to the society, an institutional framework must be present.</p>
<p>Health benefits</p>	<p>Fish contains high protein and vitamins and less fat and reduces cholesterol-related and protein-deficient diseases.</p>
<p>Human capital</p>	<p>The dissemination of aquaculture technology enhances human capital (i.e., knowledge, technical know-how, etc.).</p>
<p>Use of water resources</p> 	<p>Expansion and enhancement of aquaculture brings underutilized water-resources into production: ditches, depressions, borrow-pits and seasonal waterbodies.</p>
<p>Demand driven</p>	<p>Aquaculture should be demand driven otherwise losses are inevitable.</p>
<p>Interest/willingness</p>	<p>Willingness to undertake aquaculture as well as interest to adopt new ideas and/or technologies are important.</p>

# Involvement of Women in Small-Scale Aquaculture

Aquaculture is the fastest growing food sector in Asia. However, the vital role of women in aquaculture growth has not been adequately recognized. Many issues remain inadequately addressed. To ensure sustainability, it is necessary to understand issues related to both men and women and develop gender-sensitive interventions.

## Women and aquaculture

An ethnic women's group organized by CARITAS Bangladesh (with 18 members) in Pagalpara, Mymensingh district, has been practicing aquaculture successfully for the last five years. All aquaculture-related activities such as the excavation of four ponds, stocking, harvesting and marketing are done by the women themselves. Hatchery and market accessibility contributed to their success. The group makes an average profit of US\$49/member/year in a pond area of 0.34 ha. Though there are no strictly assigned gender-specific roles in aquaculture, work that involves heavy labor such as pond digging and harvesting is led by men. Women, on the other hand, lead activities such as stocking, feeding, fertilization and routine caring of pond. These roles interchange in different cultures and family environments.



Traditionally, women have been involved in different stages of small-scale aquaculture. They are active caretakers of fish in homestead ponds, cages or even in rice fields. The role of women has been especially prominent when the systems are located close to their homesteads. Restricted mobility, due to religion or security concerns, is a reality that must be considered.

### Benefits of women's participation in aquaculture activities

- Increased fish availability for family consumption, thus benefitting nutrition.
- Improved economic situation of the family resulting from increased fish production.
- Upliftment of social status attributed to adoption of new technologies.
- Children's education sustained because of improved family incomes.
- Enhanced social capital by establishing good relationships within the community (e.g., providing information to other women).
- Productive use of time without adding much to the existing workload.
- Increased status and participation in various decision-making process within the family.



### Gender issues that hinder women's participation in aquaculture activities

Societal and cultural issues can affect the participation of women in aquaculture. These issues need to be addressed through the formulation of plans suitable for various social and cultural environments.

- Restricted mobility limits the productive contribution of women. Mobility varies with different cultures, religion and societies.
- Apart from restricted mobility, norms in some societies limit women's contribution in economic activities.
- Men generally participate (and dominate) in trainings and cross-visits, excluding women from access to information and from the decision-making process.
- In many places women have very limited or no land ownership, limiting both access and control over the resources.
- Many agencies aim to improve women's status by increasing their access to credit. However, credit is not always accompanied by provision of skills. Hence,

women serve only as a conduit for men to procure loans.

- Low literacy rates among women in many countries hamper information acquisition.
- Very few organized women groups exist to articulate the needs of rural women involved in aquaculture.
- Lack of sensitivity to and respect for gender roles and responsibilities is a common problem.
- Data on women involvement in aquaculture is not available, and policies and programs often are not gender sensitive.

## Implemented strategies to address gender issues

### Family approach

The family approach was found to be successful because it answers the problem of not having adequate female participation. Both husband and wife take part in training. In conservative communities, early meetings with the family guardians proved effective in ensuring participation of female family members in training sessions. Establishing trust between the extension staff and villagers is also important.

#### **"Farmer field school" with family approach**

In the "farmer field school" approach adopted in some of the CARE Bangladesh Agriculture and Natural Resource (ANR) projects, both male and female groups meet separately (due to cultural restrictions) for sessions held every two weeks. Results indicate that this approach helps women acquire knowledge that enables them to take active part in decision-making.



### Gender day

After the first few sessions (conducted separately with male and female groups), both groups are brought together on a day designated as their "Gender Day". On that occasion, discussions of gender issues and local problems take place, and

action plans are developed. Later, a midterm review is conducted and necessary adjustments are made. At the end of the season, the groups meet to examine the progress and set new goals.

After the learning sessions (held once or twice a month), focus on gender issues is ensured. Information materials are used to create awareness and effect changes in perceptions and attitudes of both men and women.

### **Change in decision-making pattern in family**

A study conducted in the New Options for Pest Management (NOPEST) project of CARE Bangladesh indicated that gender awareness programs significantly influenced the decision-making process in the family. In the first season, a survey indicated that only about 44% of the men consulted their wives in making different decisions. However, at the end of the third season, more than 92% of the men reported that they consulted their wives in decision-making.



### **Access to information**

All women may not be able to attend training. For those women who fail to attend training sessions, individual attention and support have been found to be useful. During the sessions, interaction among women participants is encouraged. Fixing targets for each woman to train other women in the community on the techniques

and social issues discussed have shown good results.

#### **Sample issues discussed after the learning sessions**

- People's reaction to the birth of a baby girl
- Attitudes towards boy and girl
- Recreation time for male and female members
- Decision-making process in the family
- Barriers to women development in families
- Gender-based labor division
- Health of women
- Family conflict
- Savings utilization
- Recognition of women's work
- Decline in social values

### **Gender sensitive technology development**

In developing technologies, women's needs should be considered. Technologies should not add risk to the end-user and should be women-friendly.

#### **Gender sensitive technologies**

In Cambodia, termites and other available feed resources are used as fish feed. However, Cambodian women treat the task of termite collection as an additional work load. Moreover, because of security concerns, they are unable to move freely to collect termites. Instead, the green water technology, which is effective in promoting the growth of plankton feeding fishes, was preferred by women. They understood the benefits of this technology in influencing fish growth and began to advocate plankton as fish food comparing its effect to that of "mother's milk to baby".

In Bangladesh, several women are involved in making prawn/fish feed at home for their own use. It has also become an important income generating activity as they can sell feed to other farmers in the area.

Women are comfortable making feeds as they already know how to make rice noodles. In fact, they use the same noodle-making machine to make feeds.



### **Input supply**

Since mobility of women is sometimes restricted, the development of technologies emphasizing the use of available resources in the farm is especially suitable for women. When external inputs are necessary, they should be available in accessible places.

### **Division of labor**

Care should be taken to avoid giving women additional work. Proper planning by family members (in a threat-free environment) of the daily activities and labor distribution reduce the burden on women and increase efficiency.

### **Gender sensitive extension staff**

In many countries, there are very few female extension staff members. Male extension staff generally tends to serve primarily the needs of men. However, the provision of gender education to staff has been found to be useful in changing that attitude.

Studies conducted in different countries indicate that women work longer hours than men. Gender sensitization activities should enhance awareness of this issue in order to bring changes in work distribution.



### **Staff composition**

Depending on the local situation, having male and female extension officers might be a useful way to adequately reach women. A gender balance in extension staff recruitment is one of the strategies that have been tried successfully in many projects of CARE and CARITAS Bangladesh. To attract women, reserve positions for them. Development of gender sensitive policies and enforcing them with the active participation of staff have helped ensure gender sensitive outcomes.



### **Credit systems**

Credit, coupled with appropriate training, is usually helpful to farmers. In some countries, like Bangladesh, existing micro-credit systems have inappropriate repayment schedules. Most aquaculture species require a three to four months grow-out period. But the existing credit system requires commencement of repayment within a week after the loan is obtained. Changing the repayment schedules has been found to benefit women involved in aquaculture activities.

Credit systems need not depend only on available credit facilities. Established women's groups should initiate the formation of a self-help credit system for themselves. Each woman member can contribute an equal amount of seed money which they can avail of alternately. That way, money procurement is facilitated and interest is avoided.

Small aquaculture systems help improve the livelihoods of people. The provision of knowledge to fish farmers, particularly to women, contributes to women empowerment and an increase in family income.



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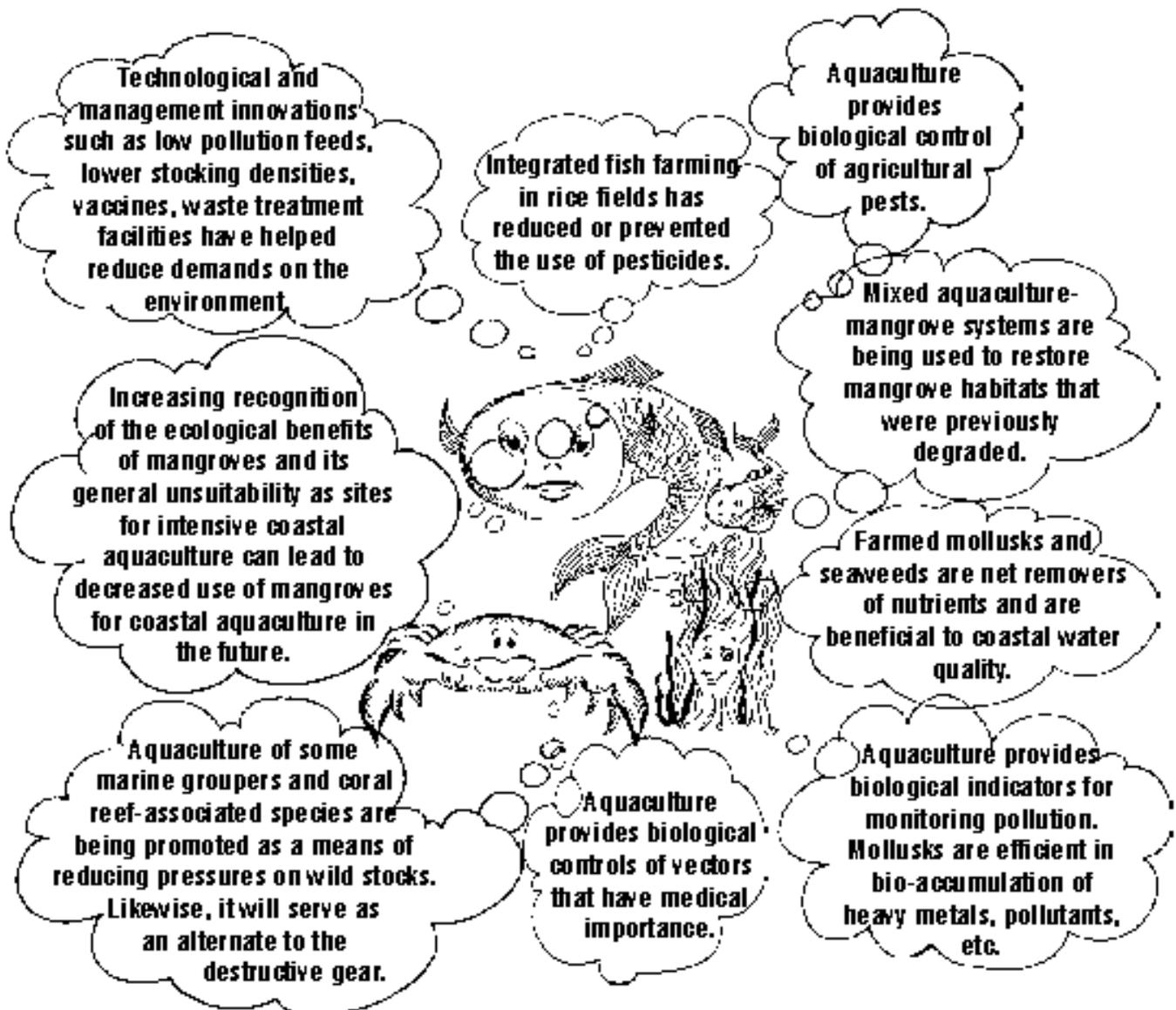
Prepared by:  
Anwara Begum Shelly,  
M. C. Nandeesh and A.K.M. Reshad Alam

# Impact of Aquaculture on the Environment

Most of Asia's aquaculture development took place over the last few decades. This is evident by the 244 percent increase in aquaculture production in Asia from 1986 to 1994. Aquaculture has many positive impacts on the environment. But it also has negative impacts, which often occur when there is overexploitation of environmental goods and services. The more intensive the operation, the greater the demands on the environment. This article discusses in depth some of the negative consequences.

## Positive impacts on the environment

Although aquaculture contributes a lot to improving the environment, the positive impact on the environment is not often realized (and documented). Some of these are represented below.



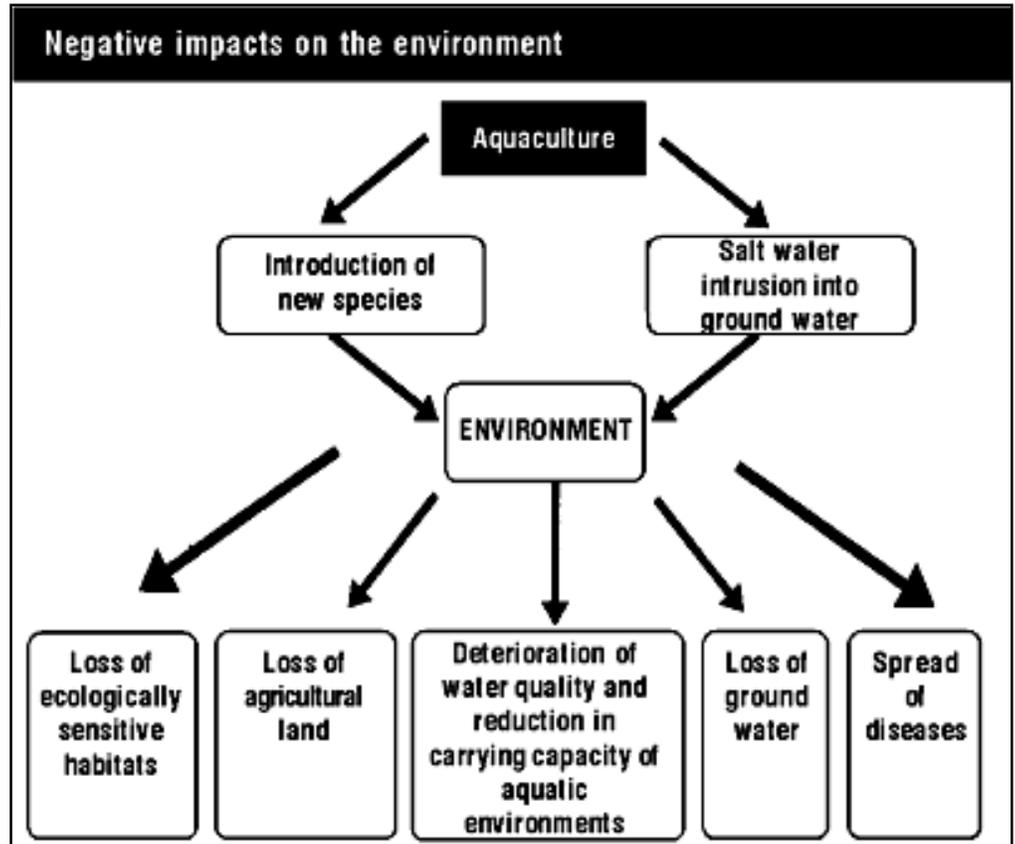
# Negative impacts on the environment

## 1. Loss of ecologically sensitive habitats

Coastal pond aquaculture, whether used for extensive shrimp culture, semi-intensive or intensive aquaculture, has been blamed for large-scale losses of mangroves and mud flats in several countries (e.g., Thailand, Indonesia, Philippines, Vietnam, etc.).

Though shrimp aquaculture is blamed for the destruction of mangroves, huge areas of mangrove vegetation in Asia were also lost due to community

development, agriculture, road and ports development, salt producing farms, mining, charcoal, fuel, wood extraction, etc. On the other hand, important wetlands, including keystone habitats, have been altered for aquaculture purposes. The alteration of coastal and inland habitats has negative impacts on fish and other aquatic organisms.



Keystone habitats are relatively rare but are ecologically significant.

Silvofisheries is an integrated mangrove tree cultivation with brackish water pond aquaculture.

### Areas of shrimp culture in former mangrove areas in Asia

Type of Farm	Total area in region (mangrove and non-mangrove in has.)	Percentage of area which were formerly mangrove
Extensive	691,303	43%
Semi-extensive	132,935	45%
Intensive	85,768	31%
<b>Total area</b>	<b>910,006</b>	<b>100%</b>

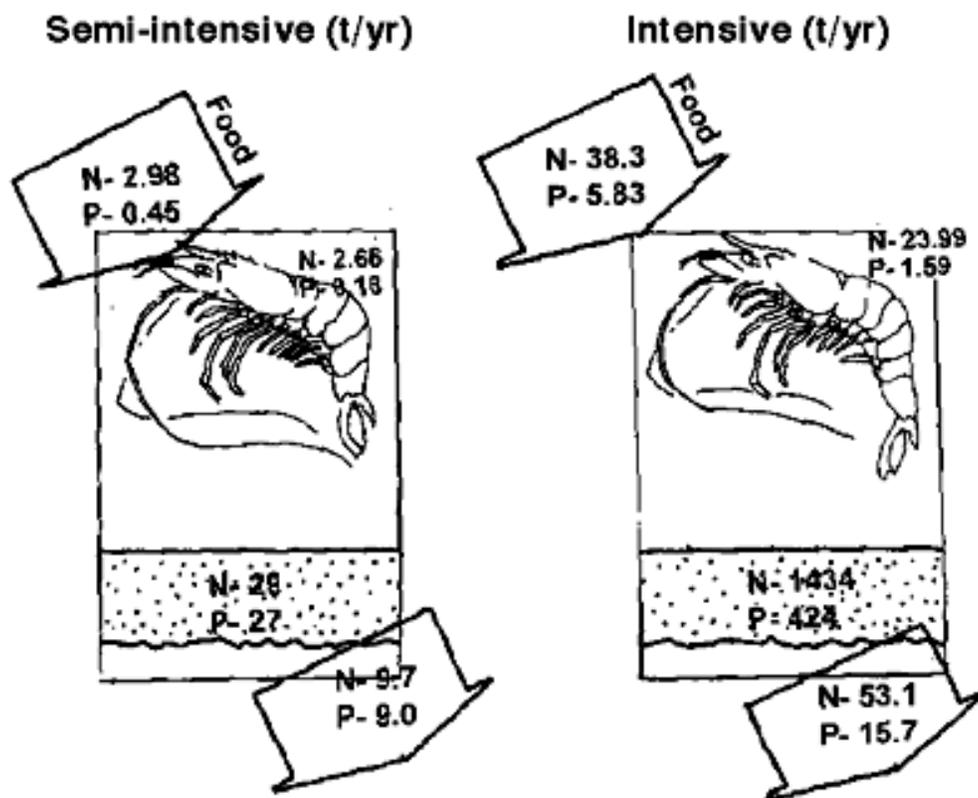
**General practices in protecting sensitive wetland habitats, as practiced in coastal pond aquaculture**

DOs	DON'Ts
<ul style="list-style-type: none"> <li>■ Retain mangrove patches between ponds and inlet water sources.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not use mangrove vegetated soil. It is not suitable for pond aquaculture due to its acidic nature and the extensive root system of the mangroves.</li> </ul>
<ul style="list-style-type: none"> <li>■ For extensive practice, use relatively small pond areas.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not use large areas for extensive shrimp culture.</li> </ul>
<ul style="list-style-type: none"> <li>■ To compensate for the reduction in pond area, utilize improved management interventions to increase productivity.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not encourage coastal aquaculture systems with low productivity in large areas.</li> </ul>
<ul style="list-style-type: none"> <li>■ Encourage silvofisheries model of alternating pond with mangroves.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not open new areas of mangroves for conducting pond aquaculture, except under exceptional circumstances.</li> </ul>
<ul style="list-style-type: none"> <li>■ Practice pond aquaculture in former mangrove areas.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not encourage coastal aquaculture in mangrove areas without alternating with mangroves.</li> </ul>
 <ul style="list-style-type: none"> <li>■ Recognize mud flats as important feeding habitat for migratory birds and various aquatic organisms and other wildlife.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not convert mud flats into aquaculture ponds.</li> </ul> 

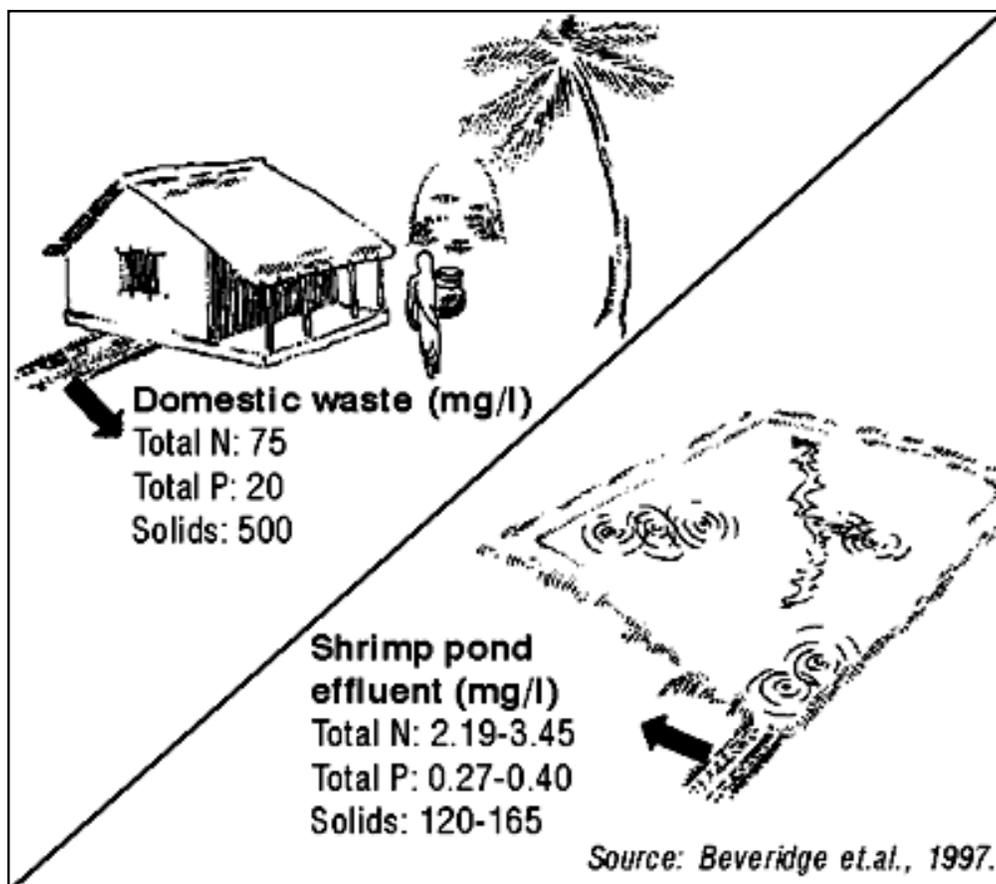
**2. Deterioration of water quality and the reduction in carrying capacity of the aquatic environment**

As aquaculture becomes more intensive, the amount of wastes released into the environment, especially in surrounding waterways, increases. Wastes enter the environment in the following ways:

- Direct effluent loading due to water exchange.
- Pond bottom sludge removal.
- Effluent water discharged into the source of water intake.
- Waste production from cages in lakes, reservoirs and marine environments
- Excess feeding, animal feces and uneaten food, which settled at the bottom of the cage and pen.
- Use of fresh fish rather than pelleted feeds as food

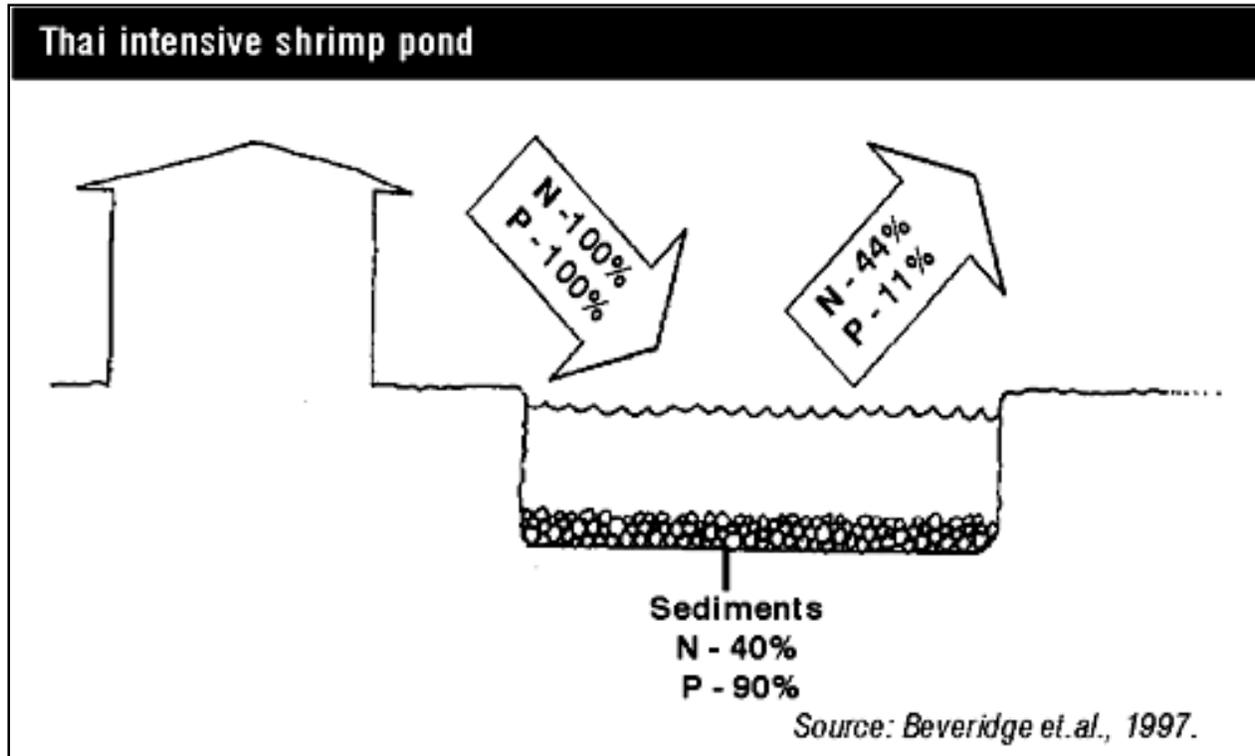


Source: Beveridge et al., 1997.



Source: Beveridge et al., 1997.

The higher the intensity of aquaculture, the more waste is accumulated. In the case of shrimp farm effluent, pollution loading is considerably less than from domestic or industrial waste. Although chemicals released into water ways can and do have an impact on water quality, the use and release of chemicals in aquaculture are less than in agriculture and most, but not all, are only marginally harmful to the environment.



### Impact of waste and nutrient loading on the environment

- Can cause eutrophication of water ways leading to plankton crashes and depletion of oxygen
- Self pollution of aquaculture systems
- Increase in the concentration of ammonia and a reduction of oxygen in the water ways reducing the carrying capacity of aquatic environments
- Excessive development of inland cage culture causes more significant reduction in the carrying capacity of the aquatic environment than pond aquaculture

### General practices in discharging effluent and maintaining water quality, as practiced in aquaculture

**DOs**

**DON'Ts**

<ul style="list-style-type: none"> <li>■ If effluent is not very abundant, discharge effluent water through a wetland area. Wetlands efficiently absorb and retain nutrients and organic matter from overlying waters.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not discharge effluent water directly into the waterways.</li> </ul>
<ul style="list-style-type: none"> <li>■ If wetlands are not available, discharge effluents into a pit or depressed area or into a settling pond to store it for a period of time before releasing it. If in coastal areas, release after storing with rain water, to reduce the salt content.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not discharge effluent water without allowing the suspended matter to settle.</li> </ul>
<ul style="list-style-type: none"> <li>■ In coastal areas, the disposal of effluents into mangroves located away from open waterways can be undertaken in order to exploit the capacity of mangrove soils to serve as "sinks".</li> </ul>	<ul style="list-style-type: none"> <li>■ In coastal areas, do not dispose of effluents into mangrove areas that are very close to open water ways and may transport nutrient load directly to the open sea. This might cause eutrophication.</li> </ul>
<ul style="list-style-type: none"> <li>■ Dry the pond bottom between two culture cycles to increase the microbial degradation of accumulated organic matter and to oxidize substances in reduced states.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not start the next culture cycle without observing a fallow period, which depends on how long it gets the pond to dry.</li> </ul>
<ul style="list-style-type: none"> <li>■ In coastal areas, use the shrimp pond waste sludge in the inter-tidal zone to fertilize mangroves.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not dump waste into non-salt tolerant agricultural lands, as it will contaminate the soil and kill plants.</li> </ul>
<ul style="list-style-type: none"> <li>■ Explore possibilities for using pond waste sludge to produce fertilizers for vegetable cultivation.</li> </ul>	<p>N/A</p>
<ul style="list-style-type: none"> <li>■ For cage culture, allow a 2 m distance between the bottom of the net cage and the bottom of the water body to minimize pollution and to allow nutrient recycling.</li> </ul>	<ul style="list-style-type: none"> <li>■ Avoid using fixed submerged cages, if it is not possible to retain a 2 m distance between the bottom of the net and the bottom of the water way.</li> </ul>
 <ul style="list-style-type: none"> <li>■ Determine the carrying capacity of the aquatic environment before expanding aquaculture activities.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not allow uncontrolled expansion of aquaculture activities.</li> </ul> 

### 3. Loss of agricultural land and salinization

- The lucrative nature of shrimp aquaculture has led to the conversion of many paddy fields and coconut-cultivated land into ponds.
- The innovation of inland culture of marine/brackish water shrimps has led to the conversion of rice paddy lands into ponds.
- The main environmental issues are the potential salinization of soil and fresh water wells as salt intrudes into ground water in coastal and inland areas after it is transported and added into the ponds.
- While economic returns are higher in shrimp aquaculture, the value of lost rice crops or coconut cultivation could become very high as they become scarce.

<b>General practices in protecting agricultural areas and preventing saltwater intrusion, as practiced in pond aquaculture</b>	
<b>DOs</b>	<b>DON'Ts</b>
<p>■ Use suitable sites for aquaculture according to the accepted site selection procedure. Utilize marginal and unproductive lands for aquaculture.</p>	<p>■ Do not use fertile agricultural lands for salt-based aquaculture that has the potential to impact the neighboring farms or the environment.</p>
 <p>■ Avoid inland areas for salt-water aquaculture.</p>	<p>■ Do not transport salt into inland areas in order to practice salt water aquaculture.</p> 

#### 4. Loss of ground water

- Ground water extraction is being done to dilute saline water in ponds where aquaculture is undertaken for low salinity tolerant species.
- Ground freshwater extraction in large quantities may lead to land subsidence.
- Ground freshwater extraction can lead to conflicts between users, for example agriculture and domestic ground water consumers.

<b>General practices in protecting ground water resources, as practiced in pond aquaculture in saline areas</b>	
<b>DOs</b>	<b>DON'Ts</b>
<p>■ Adopt a switch over strategy to culture high saline tolerant species in high saline areas.</p>	<p>■ Do not use low saline tolerant species in areas where high salinity prevails.</p>



■ Assess the ground water availability before extracting it for aquaculture.

■ Do not use ground water in large quantities to dilute saline water without assessing the availability of the resource, and the impacts it may cause.



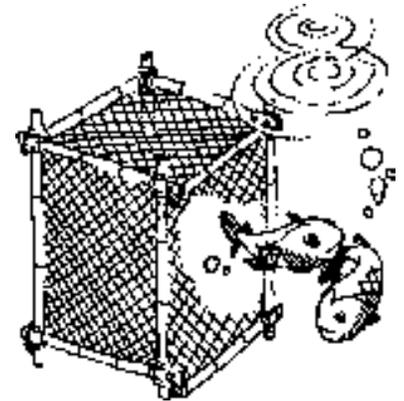
## 5. Spread of diseases

Diseases could be spread from one aquaculture system to another and to the wild. Disease is a very serious concern both for aquaculture and wild aquatic organisms. The use and sometimes abuse of antibiotics in more intensive farming has led to multiple drug resistance among pathogens, facilitating the spread of diseases. Every effort should be observed to control and prevent transmission of diseases.

## 6. Introduction of exotic species

The introduction of non-native fish species into the wild through aquaculture may lead to a serious problem in the long run.

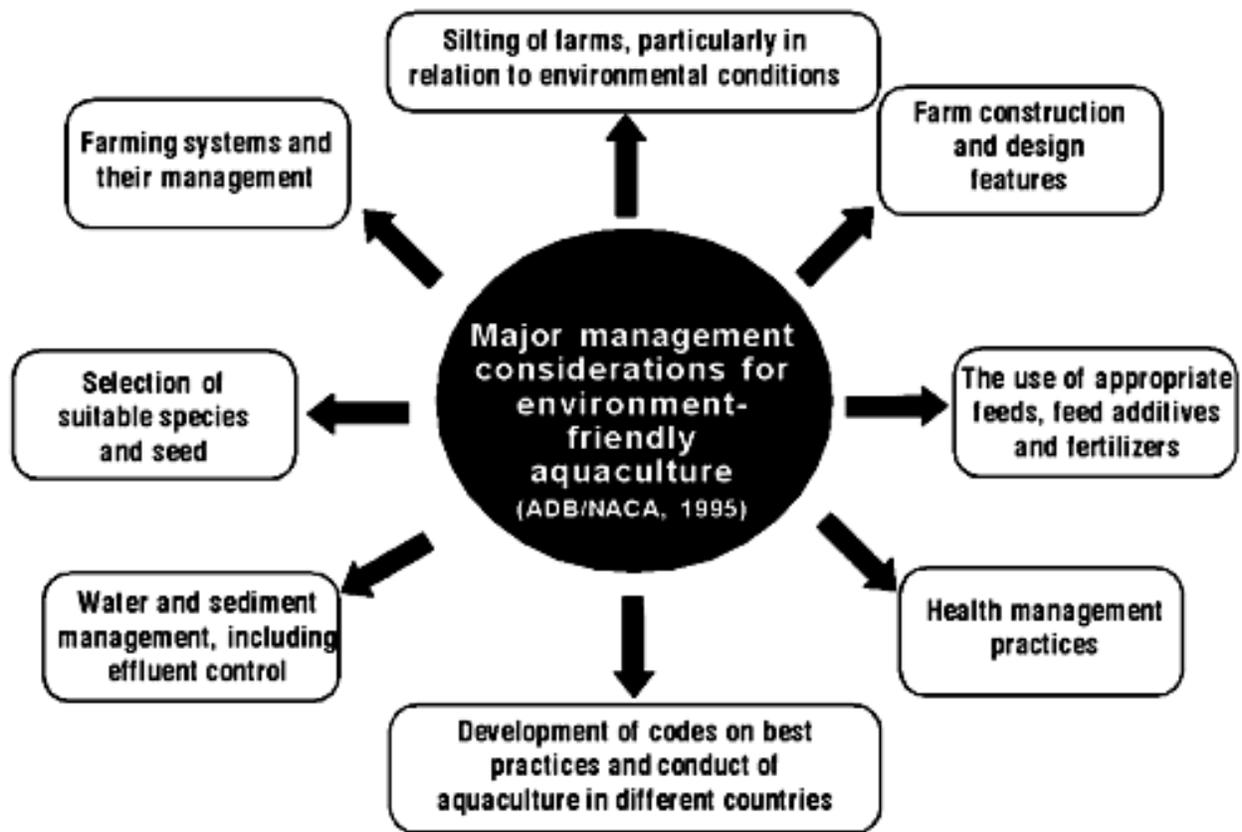
- The golden apple snail, introduced for aquaculture, has become one of Asia's most serious rice pests.
- Captive aquatic animals inevitably escape and can colonize natural waters: an estimated two-thirds of species introduced into tropical inland waters have become established, although many had positive economic benefits.



- Exotic species (African catfish, tilapia and silver carp) in inland water could pose such risks as habitat destruction, elimination of local species by competition or predation, and genetic degradation of local stocks. All this results in a loss of biodiversity.
- The introduction of genetically modified organisms (GMOs) can cause ecological damage and imbalances.
- Introduced strains can alter the gene pool of indigenous species, leading to genetic pollution and the loss of indigenous organisms and biodiversity.
- The accidental release of piranhas in Sri Lanka and

Vietnam and knife fish in Sri Lanka into natural water ways is now a serious environmental concern. The fish were obtained for ornamental fish breeding and culture farms.

DOs	DON'Ts
<ul style="list-style-type: none"> <li>■ Identify and promote native fish species for aquaculture.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not introduce exotic species, which have the potential to cause a negative impact on the environment.</li> </ul>
<ul style="list-style-type: none"> <li>■ Review strategies associated with the use of exotics and GMOs for aquaculture and further develop practical codes for risk assessment and management, as emphasized in the FAO Code of Conduct for Responsible Fisheries.</li> </ul>	
 <ul style="list-style-type: none"> <li>■ Focus attention on implementation of strategies/actions by signatories to the Convention on Biological Diversity. Check the prohibited or restricted list of species before using them for culture.</li> </ul>	<ul style="list-style-type: none"> <li>■ Do not culture or introduce prohibited or restricted species.</li> </ul> 



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Prepared by:  
**P.P.G.S.N. Siriwardena,**  
**Michael J. Phillips and Ian G. Baird**

# Conservation of Aquatic Genetic Diversity



Genetic variation within a population allows the species to adapt to environmental change or stress. It is important for the populations to be able to reproduce, survive, and successfully evolve in a changing environment. Populations with higher genetic diversity are more likely to have at least some individuals that can withstand uncertain changes of the environment. They can pass these genes to future generations. Genetic diversity has been shown to have a positive relationship with measures of fitness such as growth, fecundity and survival. It should be conserved because it is a fundamental component of adaptation and evolutionary success.

## Foods

In the fields of fisheries and aquaculture, conservation and utilization of genetic diversity are important as aquatic animals, including fish, are major food sources harvested from natural populations. Genetic diversity is very important in a species being bred for desirable traits. Likewise, it provides the foundation for the rapidly growing biotechnology industry.



## Medicines and tools for biomedical research



Long before the birth of modern medicine, shamans and herbalists have used aquatic organisms as medicines. The aquatic environment is home to many animal phyla that are not found on land, so its biochemical diversity is great. The pharmaceutical potential of aquatic organisms is very high especially in the tropics. Kelp is a very good source of iodine. Cod and shark liver oils were used as sources of vitamins A and D before other sources were developed.

## Genetic diversity and stock enhancement

Dwindling aquatic resources led to the development of hatcheries for rearing and releasing juvenile fish. Some populations of Pacific salmon are dependent upon hatchery seed. Stock enhancement is also being considered to rebuild the depleted stocks of the abalone and tuna. The following are some approaches that can minimize the loss of aquatic genetic diversity:

- The genetic structure of the hatchery stock should be as close as possible to the genetic structure of the wild population. Negative genetic impact is likely to occur when there are big genetic differences between the hatchery stock and the wild population.
- Use a large number of parents. The use of very few parents in the hatchery to produce numerous seeds for release into the wild also increases the risk of loss of genetic diversity.
- Avoid introduction of alien fish into the wild. Local varieties can be genetically contaminated if different varieties of even the same species are introduced into the wild to enhance natural stocks. Import of exotic breeds is one of the reasons for the disappearance of local breeds.
- Do not release seeds from stocks that have been made to adapt to hatchery conditions. The genetic changes, which occur in cultured fish, are expected to lower their reproductive success in the wild, as well as their offspring. Hatchery-reared fish also increase the spread of infectious diseases and parasites to wild fish.

The introduced eleotrid *Hypseleotris agilis* led to the local extinction of the endemic cyprinids of Lake Lanao, Philippines.

The introduction of the Nile perch *Lates niloticus* dramatically reduced the fish biodiversity of Lake Victoria, Africa.



## Genetic strategies for use in aquaculture hatcheries

The aim of aquaculture hatcheries is to select seeds that have specific production traits and should not be used for stock enhancement.

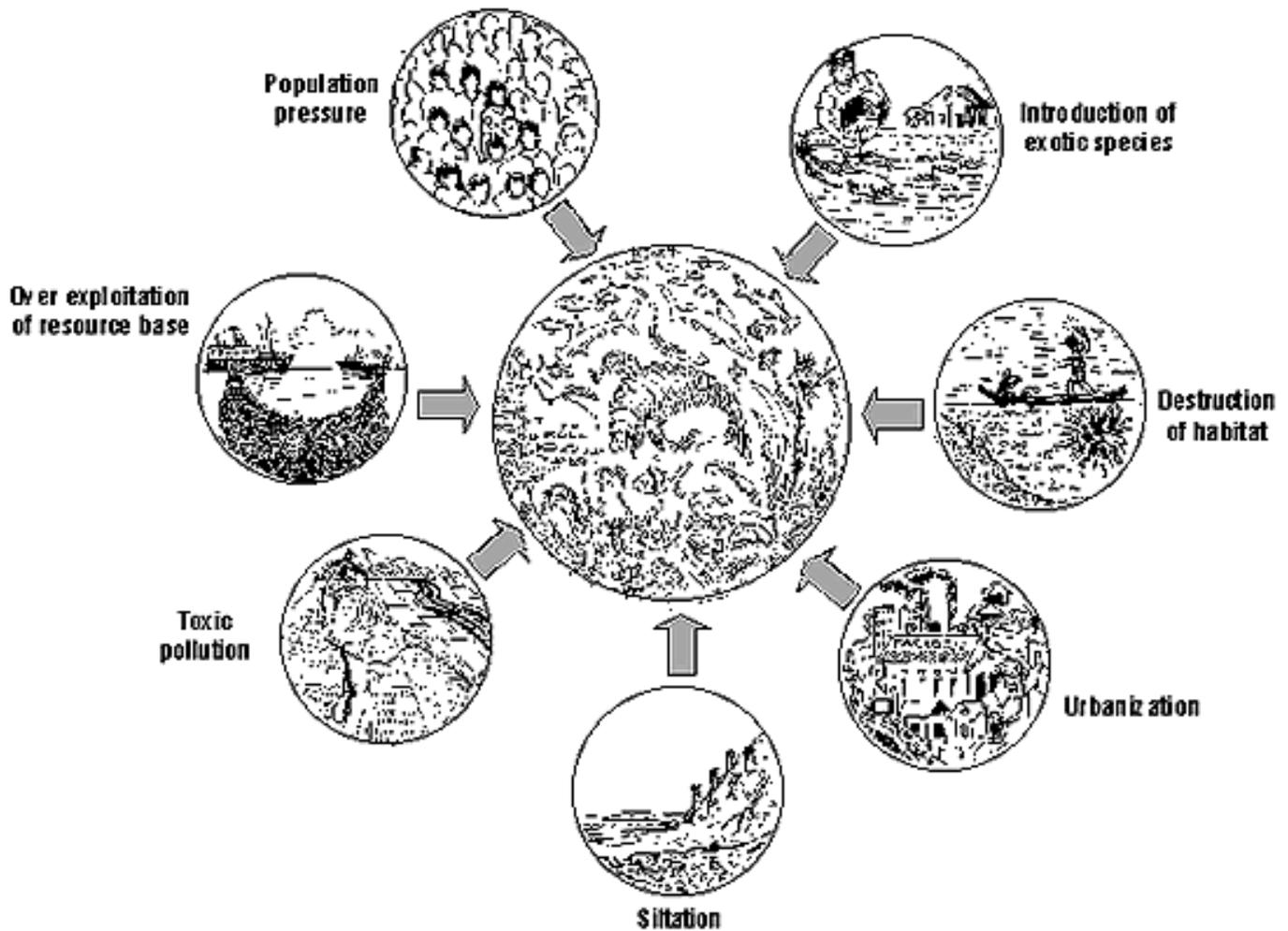
Some strategies that can be adapted to avoid inbreeding and loss of diversity

- Use a large number of parents. This becomes a problem in highly fecund species such as Indian and Chinese carps, where only a few broodstock can easily meet fry production needs. The general recommendation, for short-term period, is to use 50 males and 50 females.
- Keep the sex ratio as narrow as possible. The best effective population size can be obtained by a ratio of 1:1.
- Avoid mating of closely related individuals.
- Use a rotational mating scheme. This minimizes relatedness of parents.
- Avoid accidental release of fish from culture facilities. Culture of fish results in divergence from the wild type. Genetically altered fish from culture facilities represent a threat to the genetic diversity of wild populations.
- Avoid mixed spawning of different species.

## Threats to aquatic genetic biodiversity

Biodiversity is being lost from nearly all aquatic ecosystems at an alarming rate due mainly to the rising human population and anthropogenic processes associated with development. The three major threats to genetic diversity within species include extinction, hybridization, and loss of genetic variation within and between populations.

## Some activities that lead to loss of biodiversity



## Options for the conservation of aquatic genetic diversity

The conservation of aquatic genetic resources should be addressed in developing countries even if the immediate concern is to increase food production. It is feared that the genetic diversity of aquaculture species will decline as new improved breeds of fish are spread worldwide, replacing locally cultivated landraces and the remnants of wild populations.

## Ex situ genetic conservation in gene banks

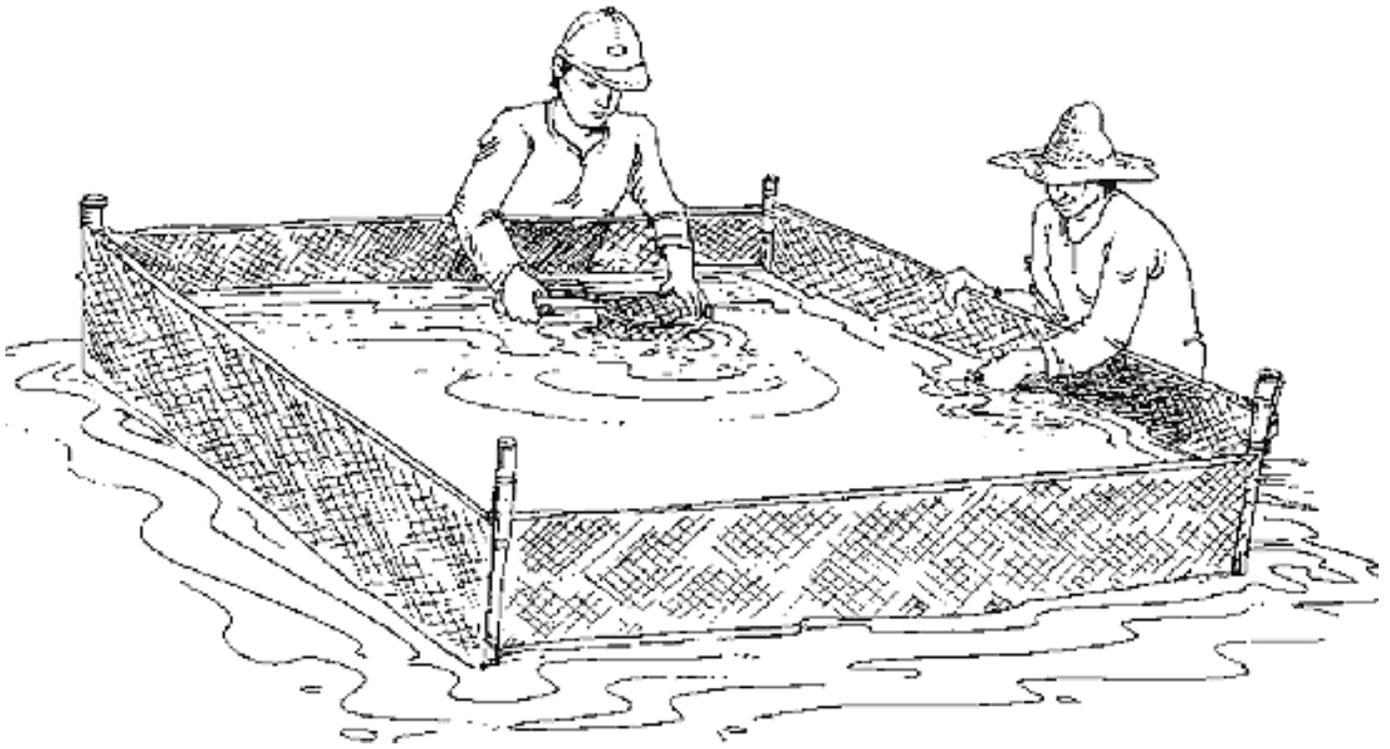
Ex situ conservation is the maintenance of a genetic resource either as frozen sperm, eggs or embryo in gene banks or as samples of living breeds in a secure environment. A national gene bank for salmon was established in Norway for the Norwegian wild Atlantic salmon. More recently, gene bank for tilapia has also been established in the United Kingdom. Ex situ conservation may not be feasible in developing countries because of the large amount of genetic diversity available and the expensive maintenance of collection.

## On-farm genetic conservation

One conservation option for developing countries is on-farm in situ conservation of genetic resources. An important feature of sustainable, on-farm genetic conservation is that relatively simple genetic technologies can be used to develop a variety of aquaculture breeds specially adapted to local conditions and diverse farming systems. For example, a simple farm-based tilapia selection procedure developed by SEAFDEC, Philippines with a tilapia farmer using locally available tilapia breeds generated a 6-9% response to selection for increased length, after only one generation of selective breeding.

Use of local breeds adapted to local conditions is a conservation tool that allows the maintenance of multiple qualities. Likewise, this will minimize the dependence of farmers on a franchise-dealer type of seed distribution. In the desire of developing countries to increase fish production, perceived superior breeds of fish are often imported. Local and (frequently) better adapted breeds for local conditions are displaced.





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Prepared by:  
**Zubaida Basiao**

# Development Assistance for Small-Scale Aquaculture



People who want to start or improve small-scale aquaculture activities often look for help in the form of better information or financial assistance. An extension agent, even a generalist, should be alert to opportunities to steer these people towards good information based on their knowledge of possibilities and resources available.

**Means to develop assistance for small-scale aquaculture**

- **Appropriate extension literature should be available.** This could include “how to” information, lists of sources of seed stock or production inputs, etc. The literature has to be simple and well illustrated for easy understanding. Much extension literature has already been developed and could be adapted to local conditions, including translation into the local language. Likewise, centrally located subject matter specialists with more specific technical knowledge could produce bulletins, leaflets and other teaching aids with the help of media specialists.



- **Rural banks have to prepare for loan applications for small-scale operations.** Many poor people cannot borrow for lack of collateral to back up their loan requests. Sometimes, seed sellers or other suppliers can also serve as sources of informal credit and production information, especially when they want borrowers to succeed and be able to repay their loans. In some settings, groups have been formed with savings plans or credit guarantee capacity that have helped people enter into small-scale aquaculture enterprises. Caution is needed because some lenders may impose unreasonable conditions on loans or charge usurious rates for credit.

- **Extension workers should promote proven practices adapted to local conditions.** An important extension responsibility is to dissuade people from ill-advised schemes not founded on valid principles.



- **People need to know where and how to access available technical support.** Aside from government programs, literature or advice on how to use products or services may be provided by feed retailers or other related businesses.

- **Where aquacultural development has been targeted, specific projects are in place to provide assistance, often with support from international donor**

**organizations.** The nature of such projects varies and care is needed to ensure that support systems provide assistance on a long-term basis and not merely for the duration of the project.

- **Group teaching, learning and participatory opportunities should be explored.**

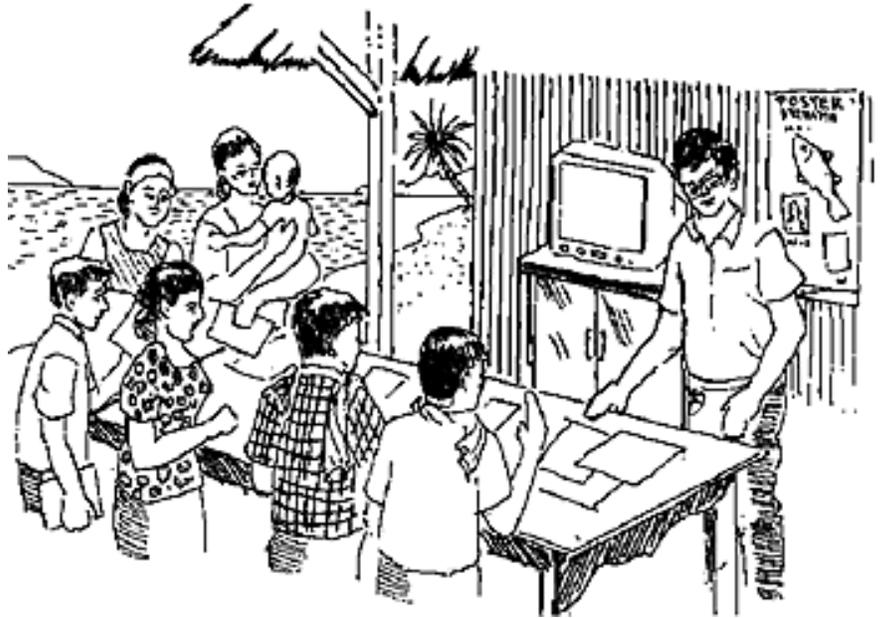
Producer organizations are often helpful and special programs involving women need adequate consideration. Some of the most successful technology transfers have occurred when extension workers facilitated the formation of groups where producers can share information and seek collective representation in addressing their needs.

- **Media campaigns through radio, television and newspapers often generate interest if accompanied by information about where and how a person can get further assistance.**

Posters, large signs or small signs on demonstration ponds can get attention. Traveling folk theater presentations have been used in some cultures. Even portable loudspeaker systems

passing through communities, a process called “miking”, has potential for communicating in rural areas.

- **School curriculum models can create public awareness.** Children often bring information to their families. They represent the generation of future aquaculture adopters. Children may also have the reading and computational skills lacking in older generations. They can apply these skills to family fish farming operations.



Caritas-Bangladesh organized 17 landless farmers in Rajshahi District who were interested in starting an aquaculture enterprise. The group met fortnightly and contributed a small fee at each meeting for the training received from Caritas. After a few months, the group had built up enough funds to lease a 4,000 sq m pond, with Caritas advancing 80% of the credit needed. The operation was so successful that the group quickly expanded their operation by adding three additional ponds. The group was also able to start a small fish hatchery through Caritas' encouragement, training, and credit support. Five years later, the group had repaid all its loans. Now, it operates 11 ponds and a commercial fingerling nursery system using seed from its hatchery. It employs three full-time laborers to assist in maintenance of facilities.

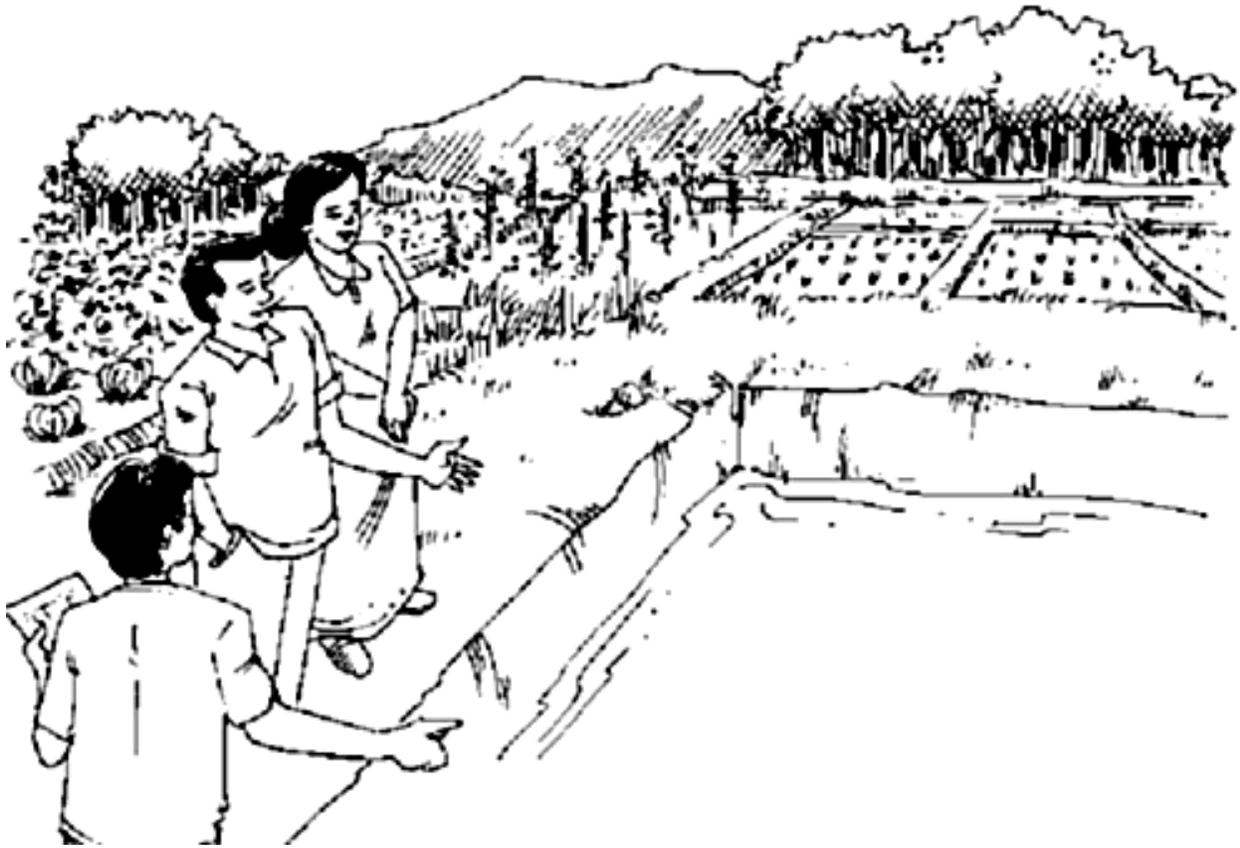


- **Research agencies need to participate in outreach programs.** Such participation helps researchers learn the real problems faced by producers and where research efforts need to focus.

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Prepared by:  
**John Grover**

# Introducing Aquaculture into Farming Systems: What to Look Out For



Integrated farming systems have been the subject of extensive research because of their socio-economic, institutional and environmental implications. If aquaculture is considered as an additional component of a farming system, a re-assessment of the system's conditions is necessary, especially if aquaculture is not a traditional pursuit.

The guide questions presented in this paper are aimed at farming communities. However, they can be adapted to other situations like river, estuary, and marine communities.

Unfortunately, there is no quick and easy blueprint on how to successfully integrate aquaculture into the diverse range of smallholder farming systems. Social, economic, cultural, institutional and environmental factors vary between places and will always need careful study and understanding before aquaculture can be introduced into existing farming systems. In China, where people have been successfully integrating aquaculture with other farming systems, the setup evolved in harmony with specific social, economic and cultural conditions. If these specific systems were to be transferred to other regions, there is no guarantee that they would succeed due to different resource availability, know-how and traditional farming practices.

Below are some of the important considerations in integrating aquaculture into smallholder farming systems:

## Sufficient incentives

- Are fish part of the diet of farming households? Are fish an important food item in the community? If so, where do the fish come from - capture or culture? At what price? Is there a perceived need for additional fish?
- Would aquaculture fit well into the existing farming system? Would it make use of and complement the existing crop and livestock activities? Would the aquatic produce improve the nutritional status of the farming household? Would aquaculture be a new income source in addition to existing ones (e.g., poultry, ducks, livestock, vegetables and plant nursery)?
- Can the produce be marketed at relatively low cost? Can poorer consumers afford it? If the product is consumed at home, does it substitute for a good or item that would otherwise have to be purchased by the household?
- Would the additional income derived from aquaculture be sufficient incentive for the farmer to make the additional investments in terms of money, labor and time?
- Do farmers have access to the market? Is it easy to bring produce to the market? Do price structures provide for economic feasibility, considering instrumental and operational costs? Are there alternative/wider market implications? Are there other markets – nationally or internationally – that may be tapped?



## Sufficient resources

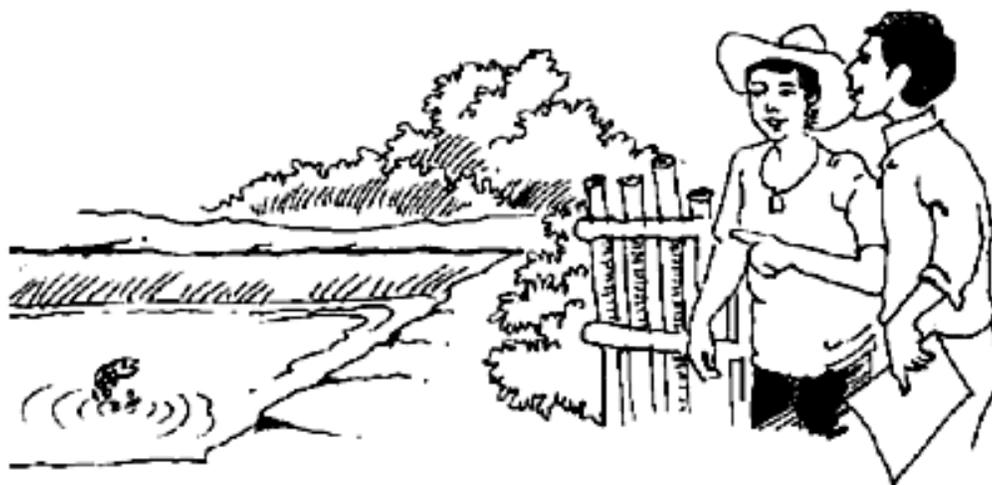
- Are there sufficient farming systems resources (labor, water, land, initial capital, etc.) to support an additional aquaculture component? What are these resources? Can aquaculture replace an existing farming system component and provide more returns with equal or less opportunity costs?
- Will the use of natural resources for aquaculture take away resources that are important for wild capture fisheries or aquatic biodiversity?
- Are the natural resources necessary for aquaculture being shared by other users? Could this create conflict between users?
- Is credit needed? Would it be available at interest rates affordable to the farmers?

## Sufficient know-how

- Is there sufficient know-how within the household to successfully manage an aquaculture component? Is it available from outside on a sustainable basis or can it be brought in from outside?
- What are the skills/knowledge required? Is the technology robust, simple, easy to use and appropriate to farmers' capacity? Are farmers likely to sustain adoption?
- Will the acquisition of knowledge and skills involve all members of the farming household?
- Do local people/government know about potential impacts of aquaculture on other aquatic resources? Can they control the situation to avoid or mitigate potential impacts?

## Reliable supply of production inputs

- Are essential inputs, such as fish juveniles or breeders, feed and fertilizer locally available? Are these inputs available at costs that will make production economically viable?



- Are there sufficient surplus agricultural products that may be used in aquaculture as inputs? Are they available on-farm? Do they have to be purchased? If so, is there an affordable and reliable supply?
- If juvenile/small fish are being used as feeds, does this practice have ecological and/or social implications (e.g., diminishing the natural food for

other native fish species or as food for poor disadvantaged people)?

## **Reliable and effective development support**

- Is development support for aquaculture available and accessible to the farmer? Is it reliable and efficient?
- What are the costs involved in receiving this support? Who will pay? Can it be delivered on time and is it cost-effective?
- Is there sufficient government support in terms of extension work and training? How could the private sector be involved? Does the farmer have the capacity to consider all aspects in a balanced manner pertaining to aquatic resources use and management?

## **Sufficiently developed and stable market**

- Is there sufficient and stable demand for the produce? Can peak harvests be absorbed?
- Can peak harvests and periods of low supply and related market problems be avoided by culturing several species throughout the year?
- Will the setting up or use of present cooperatives (community based operation) facilitate marketing?
- Does communication support quick marketing? What processing or preservation alternatives are there? Are there any value-adding opportunities?
- Will the increased availability of aquaculture fish result in decreased value of natural fish? Will it impact those who harvest wild fish?

## **Social and cultural factors**

- Is the inclusion of aquaculture in the targeted farming system socially and culturally acceptable? Does aquaculture conflict with given value and behaviour patterns (e.g., sense of ownership or negative impacts of livestock-fish integration) on religious norms (e.g., in Muslim societies)?
- Can it create new problems regarding the existing resource use system?
- Does it imply changes in existing production systems, for example from individual farming-based systems to collective production? Or can it have negative consequences for the existing gender specific division of labor system, for example, by putting additional burden on women? Will it inadvertently promote the use of cheap child labor?
- Will an introduced technology change the distribution of control, decision making or sharing of benefits within the household (gender and age consideration)?

- Is there a potential for social conflict because of the multiple use of resources?
- Would management practices of neighboring farmers affect introduced aquaculture, e.g., through the use of pesticides?
- Are the beneficiaries convinced and committed to improve their status (health and income, empowerment through aquaculture)
- Is the fish culturally important to the community?
- If aquaculture is community-based, would it be possible to go for social action establishing human right/equity after the project?
- Do the beneficiaries have other alternatives to allow the fish to grow?
- If the resources are common property, how can they be accessed for aquaculture? Are there opportunities for aquaculture to provide a focus for communal efforts (seed supply, training, sharing labor, etc.), which can enhance social relationships? Will aquaculture options resolve existing conflicts by providing a forum for people to reach consensus on resource allocation or use?"
- Land ownership

## Environmental factors

- What are the potential environmental impacts (carrying capacity of the local resources)?

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Prepared by:

**Matthias Halwart and Julia Lynne Overton with workshop participants**

# Importance of Fish in Household Nutrition



Rice often constitutes up to 60% of the daily food intake of most Asians. It is often the major source of energy and nutrients in their diet. However, only traces (and sometimes none at all) of some essential nutrients like Vitamins A and C, iron, calcium, zinc and iodine are found in rice. These nutrients, therefore, must be supplied by other foods. The relationships among food, energy and essential nutrients must be seriously considered in order to ensure food and nutrition security.

The "Green Revolution" averted some problems of starvation. But efforts to increase the production of staple cereals, and the energy and protein that they provide, failed to address health problems related to nutritional deficiency. Advances in agricultural production have, therefore, not been clearly linked to human nutrition and health needs. The problems of malnutrition and health, to a great extent, can be addressed by improving access to quality and diverse food types. Fish has the potential to ensure a quality diet.

Diet-related health problems in developing world			
Problem	Links to health*	People affected	Impacts
Insufficient food	Energy, protein and nutrients deficiency	At least 480 million	Lesser work productivity, impaired physical and cognitive development; increase in morbidity and mortality; social unrest
Low birth weight (<2 kg.)	Insufficient bio-available zinc, iron	35% of children 0-5 years	Impaired physical development; increase in morbidity and mortality
Vitamin A deficiency	Insufficient pro-vitamin A-rich foods	250 million (14 million with xerophthalmia)	Impaired cognitive development; increase in morbidity and mortality
Anemia	Insufficient bio-available iron	2.1 billion (including 42% of all women)	Lesser work productivity; impaired cognitive development; increased morbidity
Goiter	Iodine deficiency	200 million cases	Lesser work productivity; increase in still births; abortions and infant deaths

\* Other deficiencies, notably those of energy, protein, calcium and some vitamins (e.g., Vitamins A and C, riboflavin) also contribute to

many of these and other less widespread problems of malnutrition.

**Source:**

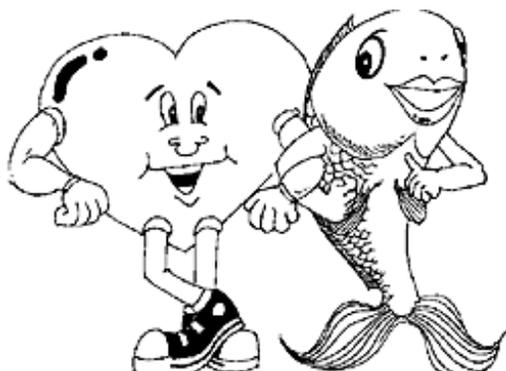
1 Administrative Committee on Coordination-subcommittee on Nutrition. 1992. *Second Report on the World Nutrition Situation, Vol. 1: Global and Regional Results. Micronutrient Deficiency - The Global Situation.* United Nations, New York, p. 80.

2 United Nations Administrative Committee on Coordination-sub Committee on Nutrition. 1993. *Micronutrient Deficiency: The Global Situation.* SCN News 9: 11-16.

## Fish protein

- Fish protein is of high quality as it contains all the essential amino acids necessary for physical growth and maintenance.
- It is highly digestible (85 - 95% digestibility) and has favorable taste.

In Bangladesh, only 6% of the daily food intake is of animal origin, with fish accounting for about 50%. By contrast, rice constitutes 60% of the daily food intake and contributes 78% of the protein in the diet (Ahmad and Hassan, 1983). But rice protein is poor in lysine, an essential amino acid. Hence, rice protein must be supplemented with lysine from fish protein. The combination would provide a high quality protein diet.



## Fish oil

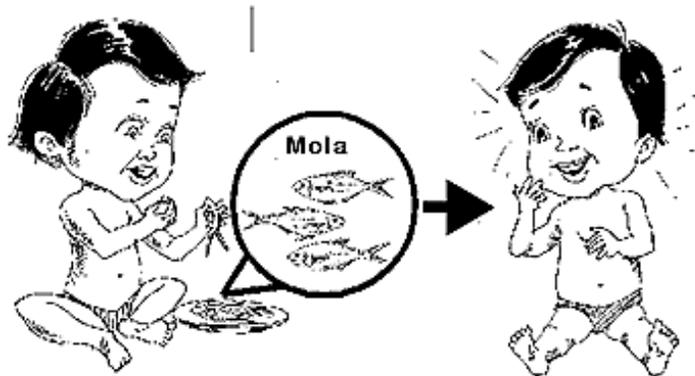
- Most fish are relatively low in total fat and relatively high in polyunsaturated fatty acids. Polyunsaturated fatty acids, such as omega-3 fatty acids in fish oil, have been found to decrease blood triglyceride and cholesterol in animals and humans. Thus, adequate consumption of fish helps maintain a healthy heart and lowers the risk of stroke and heart attack.

## Vitamins and minerals

<b>Fat soluble vitamins</b>
■ Vitamins A and D
<b>Water soluble vitamins</b>
■ Thiamin
■ Riboflavin
■ Niacin
■ Vitamin B <sub>12</sub>

- Fish is a fairly good source of fat and water soluble vitamins. Vitamin A is present in fish as retinol, which is readily absorbed and utilized by humans. In vegetables, Vitamin A comes as B-carotene, which is not as readily absorbed as retinol and, to some extent, is lost in cooking. Among the local fish in Bangladesh, Mola (*Amblypharyngodon mola*) and Dhela (*Rohtee cotio*) stand out as rich sources of Vitamin A.
- Fish contributes enormously to the mineral supply in the diet. Minerals such as iron, copper, zinc, magnesium, calcium and phosphorus are essential for several vital metabolic functions of the body.

A meal with 23 g of Mola can supply the recommended daily dietary allowance of a 4-6 year old child and can prevent his going blind.



– Iron is necessary for hemoglobin formation in the blood. Unlike iron in rice and other plant sources, fish iron is more readily available. Moreover, fish protein improves the utilization of rice iron for hemoglobin formation. Thus, when taken together, fish and rice enhance hemoglobin formation in the blood and can therefore address the problem of iron deficiency or anemia.

– Calcium and phosphorus are essential for bone formation. Small fish, that can be consumed with their bones and heads, constitute good sources of these minerals. In Bangladesh, small fish are important

calcium sources as milk and milk products make up only a small portion of the diet.

**Marine fish and sea weeds are excellent sources of iodine, so it is advisable to incorporate them in the diet to protect against iodine deficiency disorders.**



– Iodine deficiency is a major problem in Bangladesh causing goiter and cretinism and retarding growth. About 70% of the population are deficient in iodine, of which 47% have goiter with 9% having visible goiter. The goiter rate was reported to be higher (51%) in flood prone areas.

Recent studies conducted in both rats and humans showed that small fish was as good a calcium source as milk.



## Small indigenous species (SIS)

Fish and rice constitute the major components of the Bangladeshi diet. But majority of the fish eaten by the rural poor are the small indigenous species (SIS) that grow to a maximum length of about 25 cm. However, many SIS are less than 10 cm. long (Felts et al, 1996) and are typically eaten whole, with organs and bones. Analysis of SIS showed that they contain large amounts of (often limited) micronutrients and minerals.

Vitamin A, Calcium and Iron Content in fish			
Fish species (per 100 g raw, edible parts)	Vitamin (ug)	Calcium (mg)	Iron (mg)
<b>SIS</b>			
Mola ( <i>Amblypharyngodon mola</i> )	1960	1071	7
Dhela ( <i>Rohtee cotio</i> )	937	1260	-
Darkina ( <i>Esomus danricus</i> )	1457	-	-
Chanda ( <i>Parambassis</i> spp.)	341	1162	-
Puti ( <i>Puntius</i> spp.)	37	1059	-
Kaski ( <i>Corica soborna</i> )	93	-	-

Large fish			
Hilsha ( <i>Hilsha ilisha</i> )	69	126	3
Silver carp adult ( <i>Hypophthalmichthys molitrix</i> )	17	268	-
Rui ( <i>Labeo rohita</i> )	27	317	-
Silver carp juvenile ( <i>H. molitrix</i> )	13	-	-
Tilapia ( <i>Oreochromis niloticus</i> )	19	-	5

Source: S.H. Thilsted, N.Roos and N. Hassan. 1997. *The Role of Small Indigenous Fish Species in Food and Nutrition Security in Bangladesh*; ICLARM Quarterly, July - December 1997.

Unfortunately, over fishing and deterioration of natural habitats, largely due to indiscriminate use of pesticides, have resulted in a decline in the number of SIS. The importance of SIS is also often overlooked. The species are often called "wild" or "weed" fish and there are no available statistics on them. Agricultural systems, including flood plains, fisheries and aquaculture, must protect and promote the production of small fish along with carps in order to make them accessible in greater quantities for consumption. Nutrition education popularizing the production and consumption of SIS can help enormously in improving food and nutrition security.

Advantages of utilizing SIS
<ul style="list-style-type: none"> <li>■ Unlike large fish, SIS are eaten in small amounts many days per week thereby becoming a part of everyday diet.</li> <li>■ With a little oil and vegetables, a variety of dishes can be made.</li> <li>■ Small fish are also more equally distributed among family members. With a big fish, the man gets a larger share.</li> </ul>
Future research needs
<ol style="list-style-type: none"> <li>1. A feasibility study on the polyculture of carps with small indigenous fish species in Bangladesh.</li> <li>2. Analysis of the nutrient composition of all commonly consumed fish species in Bangladesh.</li> <li>3. A study on the linkages between fish biodiversity and human nutrition.</li> </ol>

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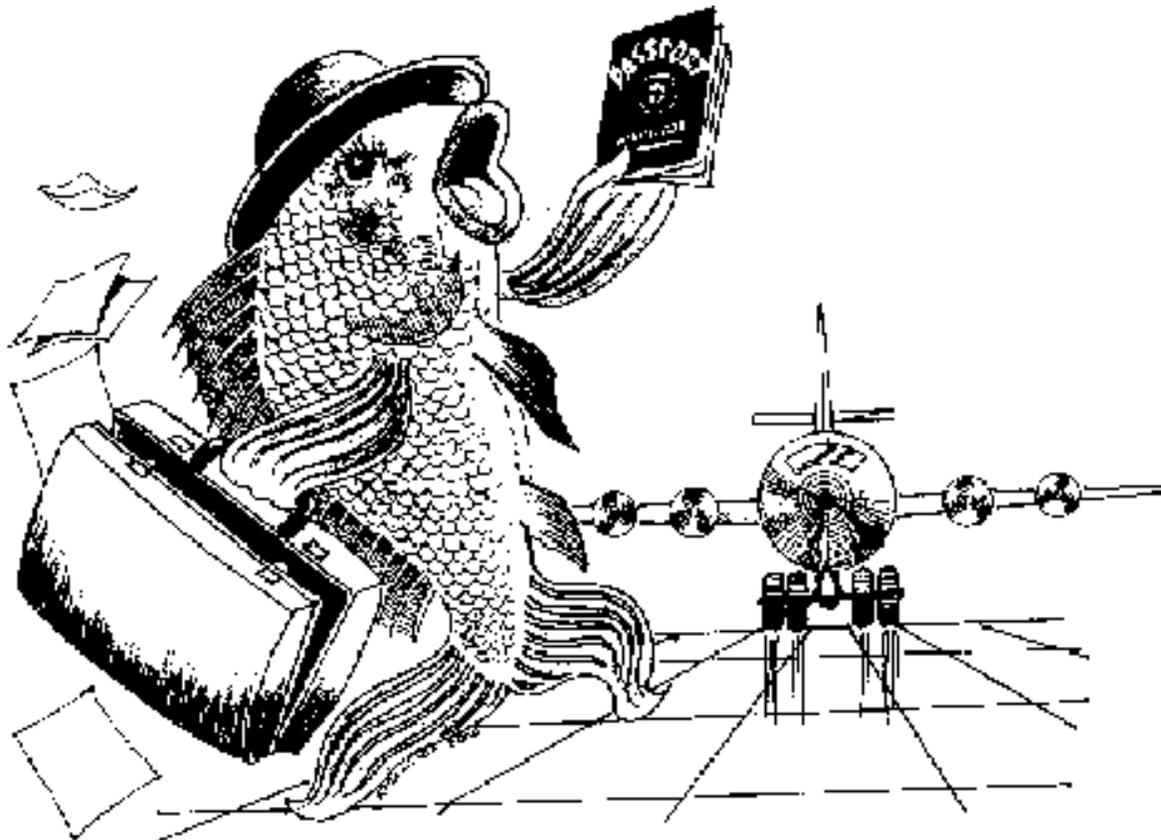
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Prepared by:  
**Nazmul Hassan**

# Managing the Introduction of Exotic Species



Globally, introductions of aquatic species have been undertaken on a wide scale. The FAO Database on Introductions of Aquatic Species (DIAS, <http://www.fao.org/fi/statist/fisoft/dias/index.htm>) has 3,150 records on introductions of 654 aquatic species from over 140 families. Aquaculture is one of the primary reasons for the deliberate introduction of aquatic species. Other reasons include:

- biological control
- trade
- accidental introductions
- establishment of wild populations
- sport and recreation
- research
- forage and bait
- commercial fisheries
- food security
- unknown reasons

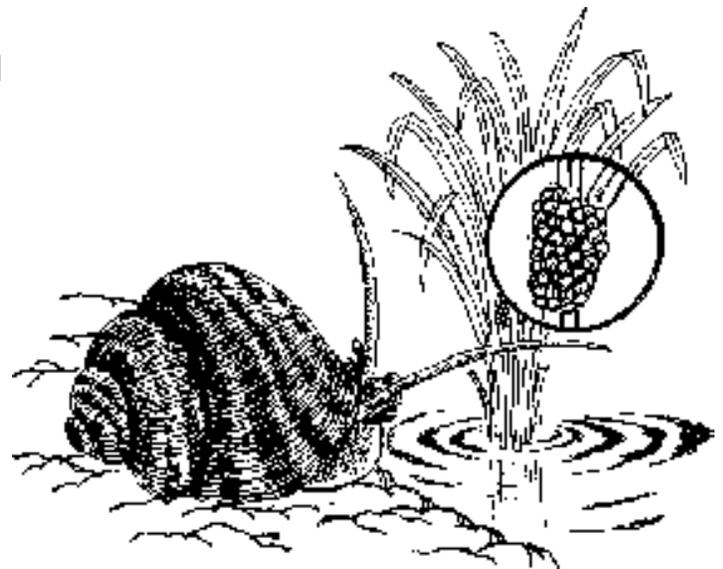
**Introduction of species** is defined as the human assisted movement of an organism to an area outside of its present range, so not necessarily crossing national borders.



## Examples of introductions

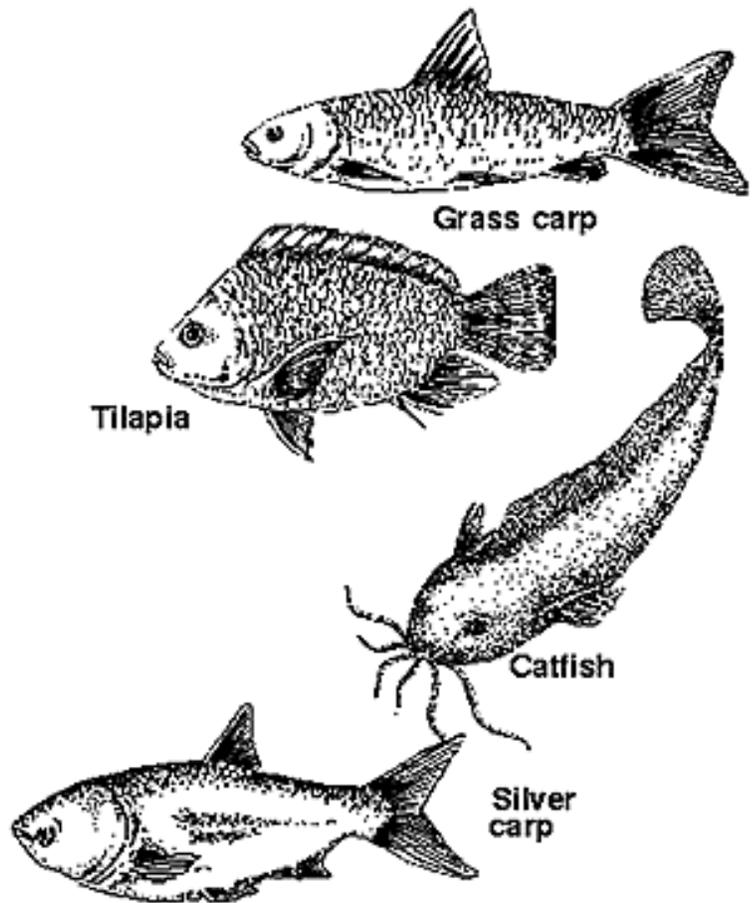
Examples of introductions of exotic species are many. Following are a few examples of introductions of aquatic species, in particular:

- The introduction of ice fish (*Neosalanx tangkahkeii taihuensis*) from Taihu Lake to other lakes and reservoirs in China to exploit the underutilized zooplankton resources, resulted in the rapid establishment of natural populations of this species. For example, the yearly yield in Dianci Lake, where the ice fish was introduced in 1979, increased by an average of 1500 tons.
- The silver carp (*Hypophthalmichthys molitrix*), introduced in the Gobindsagar reservoir in India, improved fisheries production from 160 tons in 1970-71 to 964 tons in 1992-93 (V.V. Sugunan, 1995).
- On the other hand, the introduction of the common carp (*Cyprinus carpio*) into the upland lakes of Kumaon Himalayas, the Dal lake in Kashmir, Gobindsagar and the reservoirs in the northeast of India, led to the extinction of several snow trouts (*Schizothoracichthys nigor*, *S. esocinus* and *S. curvifrons*) from these habitats.
- The introduction of the clupeid fish (*Limnothrissa miodon*) from Lake Tanganyika to Lake Kivu in Africa to exploit underutilized zooplankton resources resulted in the formation of a significant artisanal fishery with an estimated sustainable yield in excess of 13,500 tons per year, apparently with minimal side-effects. Higher benefits have also arisen from the introduction of the same fish into Lake Kariba in Zimbabwe.
- The golden apple snail (*Pomacea canaliculata*), indigenous to tropical and temperate South America, was imported into Asian countries, including Taiwan, the Philippines, Vietnam and Thailand, in 1980s mainly as food for humans. It soon escaped into the wild and attacked rice voraciously. Myanmar, Bangladesh and India, are currently threatened with infestation of this snail (Halwart, 1994).
- The widespread use throughout Asia of tilapia (*Oreochromis* spp.), indigenous to Africa, has resulted in significant aquaculture production of low-cost protein especially for the rural poor. Similar benefits have arisen from the widespread culture of the common carp (*Cyprinus carpio*).
- In other areas, these same fishes are considered noxious pests that disrupt both natural ecosystems and, in the case of tilapia, the aquaculture sector itself, highlighting the complexities of introductions.
- Introductions have been used successfully to help control nuisance aquatic species. For example, grass carp (*Ctenopharyngodon idella*) is used to control submerged weeds in lakes, reservoirs and irrigation canals. The introduction of



snail eating fishes and mosquito fish (*Gambusia affinis*) assisted in the control of vectors of major water-borne diseases, like schistosomiasis and malaria.

- Results of an introduction are not completely predictable nor always positive. Introductions are now considered among the main threats to natural aquatic populations. The introduction of Nile perch (*Lates niloticus*) into Lake Victoria, Africa, changed primarily small-scale artisanal fisheries into multi-million dollar commercial fisheries that support industrial processing and export ventures, but threaten to make extinct several hundred indigenous species of fish. Similarly, the accidental introduction of *Hypseleotris agilis* in Lake Lanao in the Philippines led to the extinction of most endemic cyprinids in the lake.
- Widespread movement of cultured tilapia in Africa has resulted in so much interbreeding with wild species or strains that natural populations are now extremely difficult, sometimes impossible, to locate.



### Caution!

The effects of introductions can take a long time to develop as in the case of the almost 100-year delay between the sea-lamprey (*Petromyzon marinus*) gaining access to the North American Great Lakes and the subsequent decimation of fish stocks there through predation and parasitism.



## Management of introductions

The adverse impacts of introductions are not limited to conspicuous predatory species: examples of non-predatory interactions include the aquatic weeds, crayfish, tilapias and carps.

Reports on the adverse effects of introductions are many. These include devastating effects on biodiversity, reductions in production from capture fisheries, aquaculture or other sectors, and significant physical disturbances of both natural and man-

made environments, resulting in serious socio-economic hardships and economic costs.

Due to the conflicting outcomes of introductions, codes of practice to assess their benefits and risks have been developed and adopted by a number of countries or regional bodies.

While there are considerable benefits from introducing aquatic species (17% of world finfish aquaculture production is from introduced species), risks are also involved. As such, a set of guidelines on eventual introduction of a species<sup>1</sup> is proposed here.

Experience has shown that animals eventually escape the confines of a facility, thus, introduction of new species for aquaculture should be considered as a purposeful introduction into the wild, even if the quarantine or hatchery facility is a closed system.

Before considering the introduction of a particular species, seriously look for a local alternative first. Delay the introduction if a local species shows promise. Study what potential use the local species is intended for. This point cannot be stressed enough because, often a local species is available but it is not known to fulfill the identified purposes.

When the introduction of a species is considered, someone, an organization, private business or government agency, hereafter called the introducing entity, must be responsible for the transport of the species. To ensure that introduction of aquatic species proceeds responsibly, the following guidelines are proposed, based on the ICES/EIFAC codes of practice, which have been adopted in principle by FAO regional fishery bodies.

The introducing entity should develop a proposal, which includes:

- Planned use of the species, planned benefits and constraints
- Location of the facility/waterbody where the species are going to be introduced and who the stakeholders are in that facility/waterbody (national or international)
- Biological information on the species
- Geographical location of the species being proposed and information on that area
- A description of similar introductions of the considered species in other areas, if available

The **review panel** should be independent, and not linked to the introducing entity. The formation of an external review panel, with the potential participation of foreign experts, may be considered. Another option is a panel, with the participation of those knowledgeable in local conditions and priorities. Of course a combination of the two is another possibility.

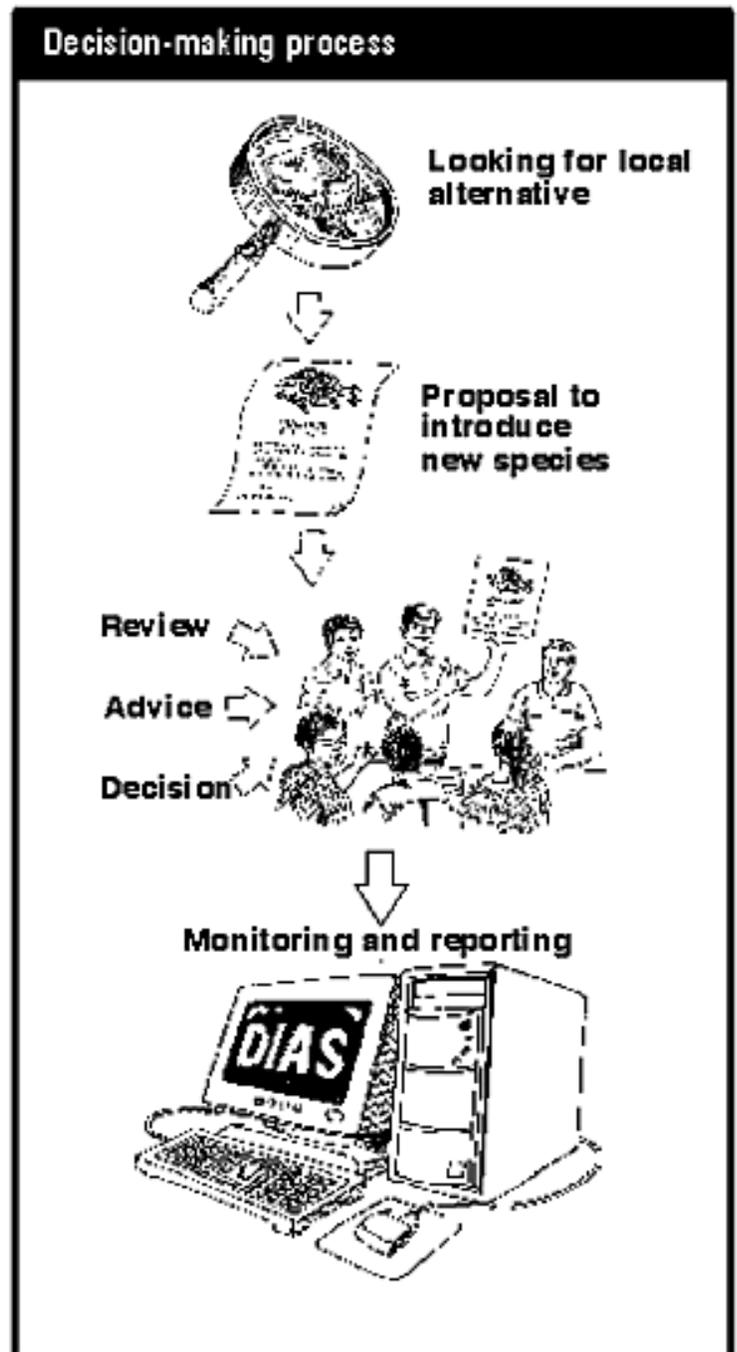
The review panel should be multidisciplinary and should include experts in:

capture fisheries, aquatic ecology, aquaculture, fish health and quarantine, human health, socio-economics, conservation, genetics, agriculture, private sector development, and rural development.



An **independent review** should be conducted by a panel to evaluate the proposal, the impacts and risks/benefits of the proposed introduction. The panel can look into:

- Ecological requirements/ interactions and genetic concerns:
  - the potential range of establishment
  - the potential ecological consequences
  - the potential genetic consequences of the introduction
  - desirable genetic bases of stocks used, and
  - unintended or undesirable impacts on resident genetic resources
- Socio-economic concerns:
  - clearly define and quantify the intended purpose of introduction
  - clearly identify and quantify the problem the proposal aims to rectify
  - clearly identify and quantify



alternative methods of addressing the same problem

- identify and quantify the target beneficiaries
- identify and quantify the non-target people at risk
- assess the economic costs of undertaking the introduction itself

- Pathogens

- Minimizing the spread of diseases and parasites and quarantine arrangements

The findings and advice should be communicated to the review panel, the introducing entity, and the decision-makers, after which all parties, including communities from the concerned area, will be given the opportunity to comment. The review panel **comes up with its recommendation** -- to accept, refine, or reject the proposal -- so that all parties understand the basis for any decision or action. Decision-makers will use the advice to make a **decision**.

If the introduction of a species is approved, quarantine, containment, monitoring and reporting programs have to be implemented.

#### Decision maker(s)

This can be a person or group of persons with legal authority to decide whether or not an introduction can be made.



#### Education

Countries should endeavor to publicize and improve public awareness of both the issues involved in introductions and the procedures adopted to deal with such issues.

Education should be aimed at all sectors, including fisheries and aquaculture managers and scientists in both public and private sectors, users of aquatic resources, especially business communities (who often have the most to lose from inappropriate movements yet are often the most vocal supporters of inappropriate introductions), as well as the general public. This reduces the incidence of unapproved introductions, and reduces the frustration of those

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whose proposals were denied. When people understand a rational system and think it is fair, they have less cause to complain, and are less likely to ignore regulations and agreements.

For more information concerning the introduction of exotic species and the guidelines, please contact local authorities and The Asian Fisheries Society (P.O. Box 2725, Quezon City, Central Post Office, 1167 Quezon City, Philippines), the Chief of the Inland Water Resources and Aquaculture Service of the FAO (Viale delle Terme di Caracalle, 00100 Rome, Italy), or the Database on Introductions of Aquatic Species (DIAS):  
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# Primary Health Care in Aquaculture



As in crop and livestock farming, a disease outbreak is considered one of the associated risks in aquaculture. Hence, the principle "Prevention is better than cure" is strictly followed to prevent disease-associated losses. However, aquaculture systems are more complicated, as the aquatic environment, which is relatively more dynamic than the terrestrial environment, plays an important role in the disease process and in determining the type and effectiveness of treatment and other management measures.

Aquatic animal health management includes steps to fight the three causes of diseases, namely:

- pathogen
- farmed animal's susceptibility to diseases
- environmental stress

Primary health care emphasizes the first two aspects of health management. By resorting to simple and practical measures, the risk of disease outbreak can be minimized. Treatment measures to control and cure the disease is the last resort as they are complicated, expensive and, at times, may not succeed. Success depends

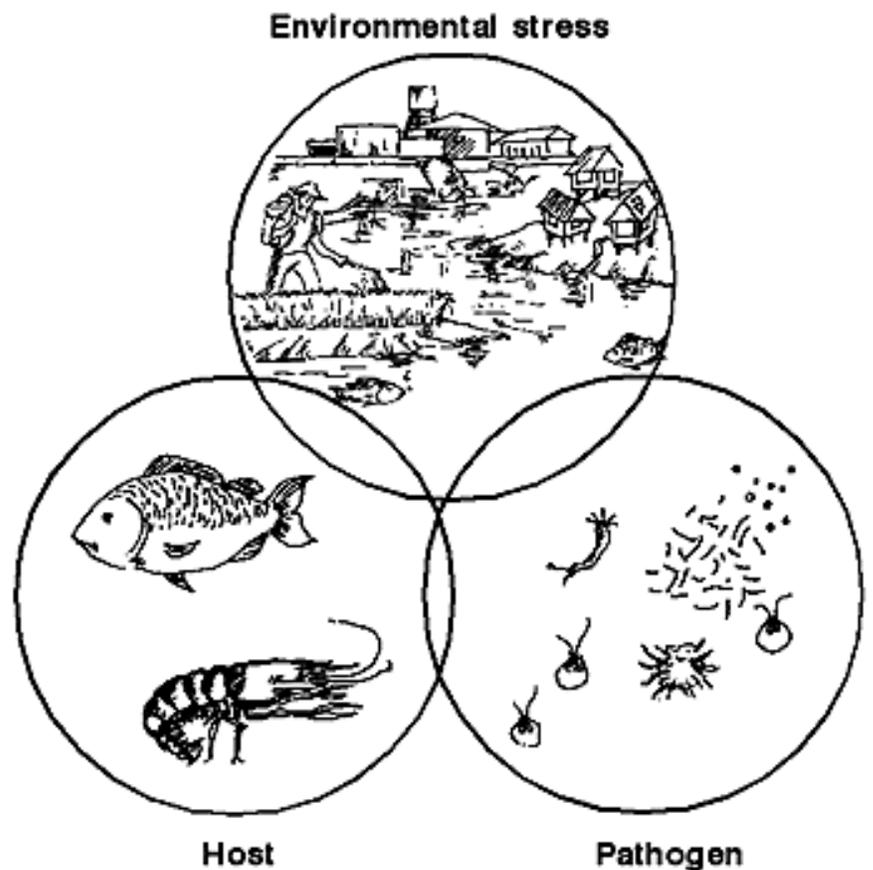
on quick and precise diagnosis, proper selection of therapy, accurate calculation of doses, route and method of application, etc. It also requires expertise, skill and resources that small-scale farmers might not be able to mobilize. Primary health care, on the other hand, is simple and cost-effective and must be incorporated into farming practices.

## Management of rearing environment

Management of rearing environment is the most vital area in disease prevention and control. It helps eliminate various stress factors to maintain the proper health of farmed animals as well as strengthen their defense system against disease-causing organisms. Management of rearing environment includes the following measures:

### ● Disinfection of pond

Before initiating the farming operation, it is essential to disinfect the pond by draining and sun drying until the pond bottom cracks. If possible, the bottom should also be scraped and the upper portion of the sediment removed. As an alternative, certain disinfecting materials such as quick lime (200-500 kg/ha depending upon soil pH) or bleaching powder (25-30 kg/ha) may be applied over the freshly dewatered pond bottom and left to react for a week before refilling the pond with water. An interval of about seven to ten days between filling the unit with water and stocking should also be observed to eliminate most of the obligate pathogens (those that will not survive without finding a host) from the environment.



### Commonly encountered environmental stressors

- Polluting agents (pesticides, industrial wastes, city sewerage, etc.)
- Algal toxins
- Toxic gases (ammonia, hydrogen sulphide, excessive free carbon dioxide etc.)
- Nitrite
- Abrupt changes in environmental parameters like temperature, pH, dissolved oxygen, salinity, etc.

In the case of cage culture, it is important to disinfect the cage before and after harvesting. After the crop is harvested, the cage is lifted and thoroughly washed with quick lime solution and allowed to dry in the sun for two to three days. During the culture period, the cage should be cleaned once a week by wiping out all the dirt and wastes that remain.

### ● Eradication of wild fish and other aquatic animals

Wild fish and crustaceans are potential sources of disease-causing agents. In case dewatering is not feasible, as with undrainable pond, certain safe piscicides are applied to the pond to eradicate the existing fish and other aquatic animals. Quick lime (1000-1200 kg/ha/m), bleaching powder (50-60 kg/ha/m), Mohua (*Bassia latifolia*) oil cake (2500 kg/ha/m), and tea seed powder (100-150 kg/ha/m) are some of the commonly used materials for this purpose. After the application of piscicides, the entry of fish and other animals into the pond should be prevented. As some fish eating birds and mollusks also serve as intermediate hosts for many parasites that infect fish and humans, care should be taken to keep the pond clear of vegetation that provide substrate for molluskan larvae. Introducing some species such as black carp or any native species of mollusk-eating fish helps prevent digenetic trematode infections to a considerable extent. Hanging wide meshed net over the pond prevents entry of birds.

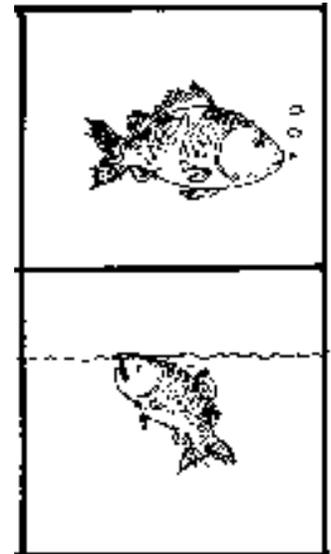
### ● Selection of stocking materials

It is advisable to stock only healthy and physically vigorous seed material to ensure better survival and growth. Before accepting the seed, know the source and reputation of the production unit in maintaining health and hygiene. Check the health status of the batch on a random sampling basis to avoid the risk of introducing infected stock.

	Some tips for selecting fish seed		
	Desired	Undesired	



Vigorous and actively swimming	Lethargic, abnormal swimming behavior
Normal body color Soft to touch	Darker or abnormal color Rough to touch, excessive mucous secretion
No sign of any patch, spot or lesion	Appearance of discolored patch, spots, cysts, lesions, etc.
Fins - intact/complete	Broken fin tips
Gills - deep red and without any sign of hemorrhage, spots or cysts	Discoloration/broken gill lamellae, appearance of hemorrhagic spots, cysts, etc.
Quick response to external stimuli such as tapping, touching, etc.	No or feeble response to external stimuli



**Tips on the selection of healthy shrimp postlarvae**

- Actively swimming with straight body
- Dark color (gray, brown to black) with dark pigmentation in the tail area
- Red to pink color indicates sign of stress so the seed should be discarded.
- Normal shape of appendages and rostrum. Seeds that show black color and erosion of the appendages should be discarded.
- Quick response to external stimuli.
- Swimming against the current when the water of the container is stirred. When the current subsides, they cling to the sides to avoid being swept into the center of the container.

### **Selection of shrimp post larvae for stocking by conducting formalin stress test**

- Take 2-3 liters of adequately aerated formalin solution (100 – 150 ppm).
- Introduce 150 randomly selected post larvae (PL) from the batch of seed to the solution and keep for 30 minutes (150 ppm solution without aeration) to two hours (100 ppm solution with aeration).
- Observe the mortality.
- Discard the seed if the mortality is more than 2%.

### **● Separation of young from brood fish**

Brood fish may serve as carrier of disease-causing organisms without exhibiting any pronounced clinical symptom. Sometimes, they survive the occurrence of epizootics due to built-up immunity and may retain some pathogens. To avoid such risk, separate the young from the brood fish.

### **● Removal of dead fish**

The virulence of pathogens often increases with passage through the host. Remove dead fish and those specimens showing pronounced symptoms of diseases.

### **● Prevent overcrowding**

Overcrowding results in waste build up, decreased availability of space, feed and oxygen, and deterioration of water quality. Follow proper recommendations on stocking density for nursery, rearing and stocking ponds.

### **● Water quality**

Abrupt and wider fluctuations in some of the environmental parameters such as dissolved oxygen, pH, carbon dioxide, turbidity, etc., cause intense stress on the farmed aquatic animals. Some of the naturally generated toxic materials like hydrogen sulfide, ammonia and dinoflagellate toxins also often exceed the tolerance limit of the farmed animals and cause serious problems. Anaerobic condition of the pond bottom sediment may result in excessive production of marshy gases like methane, ammonia, hydrogen sulfide etc. Periodical raking of pond bottom at noontime, when the dissolved oxygen level is at its peak, helps aerate pond sediment, thereby reducing the formation of toxic gases. However, bottom raking is not advisable for shrimp ponds.

Excessive application of fertilizers and the accumulation of nutrients in the bottom sediment induce the appearance of algal and bacterial blooms leading to dissolved oxygen depletion. To maintain proper health and optimum utilization of feed, the dissolved oxygen level should not drop below 3.0 mg/l in freshwater fish culture and 5 mg/l in brackishwater shrimp culture ponds. The toxicity of carbon dioxide, ammonia and hydrogen sulfide increases with the decrease in dissolved oxygen levels. Similarly, the toxicity of hydrogen sulfide increases with decreasing pH.

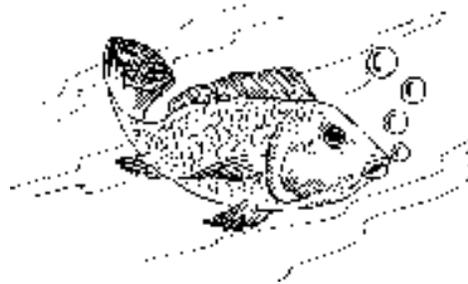
When pH values remain above 9 and below 6 species may survive but do not grow well. For shrimps, it is important to maintain the pH of the rearing environment between 6.5 and 8. Liming helps maintain the desired pH and also prevents daily fluctuations. Proper and timely management of soil and water by manipulating feeding, fertilization, liming, addition/exchange of water, aeration, etc., eliminate most causes of environmental stress.

### ● Proper feeding

Any reduction in quantity and quality of feed may cause deficiencies or diseases in the fish or make them susceptible to infections. It is important to follow the recommended feeding rate for specific stages of farming. Feeding is more critical during the early stages (larvae and fry) of high density rearing when the availability of natural fish food is limited. Balanced feed, with desired levels of macro and micronutrients and vitamins, should be given to prevent diseases like lardosis, scoliosis, etc. Proper feeding also helps prevent cannibalism in catfish and shrimp culture systems.

#### Note

- Early morning (dawn) surfacing of fish and gasping for air indicate depletion of dissolved oxygen.
- In China, some farmers test the dissolved oxygen level by introducing some small fish known for their high oxygen demand. If the fish start



surfacing soon after their release in the water being tested, the water

must be deficient in oxygen.

- A moderate level of phytoplankton in both nursery and grow-out ponds must be maintained for better health of shrimp. Light green color indicates moderate level of phytoplankton.

### ● Proper handling

The rougher the handling, the greater is the stress and the risk of disease outbreak. Farmed aquatic animals should not be handled and transferred under hot weather conditions as high temperatures raise metabolic activity and place additional stress on the animals. In the case of fishes, care should be taken not to break the protective mucous coating of the skin.

## ● Disinfection of net after its use in infected pond

After using the net in an infected pond, be sure to thoroughly wash and dry it before use in another pond. It is also advisable to disinfect the net using disinfectants.

## ● Water supply and drainage

In designing a farm, be sure to provide separate water supply and drainage facilities for individual ponds to avoid the flow of water from infected ponds into the other ponds.

## ● Disinfection of hatchery and other facilities

All hatchery jars, troughs, tanks, utensils, tools, water holding and supply systems, nets and transport facilities should be thoroughly cleaned and disinfected before and after each hatching cycle to eradicate pathogens. Disinfection, through washing/emersion, can be done by using a concentrated solution of disinfectant. Some of the effective and commonly used disinfectants are chlorine, sodium hydroxide, salt, potassium permanganate, etc. Chlorine is probably the most widely. It is easily available in liquid form as sodium hypochlorite and in powdered form as bleaching powder. Solution of 1-2% chlorine is effective against bacterial, fungal and viral pathogens. However, it is also toxic to farmed aquatic animals, thus, disinfected items should be rinsed thoroughly of chlorine residues before use.

## Prophylactic measures

Application of drugs and chemicals before the onset of a disease is very effective in preventing the outbreak of diseases. This method aims to eliminate pathogens, which may be in the host or the culture facility. Several methods are employed for chemoprophylaxis. Baths, oral and injection routes of administration of drugs are most common. Again, several types of baths such as dip, shot and long bath, flush, constant flow etc. may be used depending on the need, the availability of the facilities and the farmers' own experience.

## ● Treatment of eggs

Fish eggs may be treated by dipping in potassium permanganate solution (50-100 ppm) for one to two minutes. Formalin is another commonly used therapeutant (250 ppm).

## ● Treatment of fry/fingerlings

It is important to acclimatize and treat the fry/fingerlings before stocking. Discard the

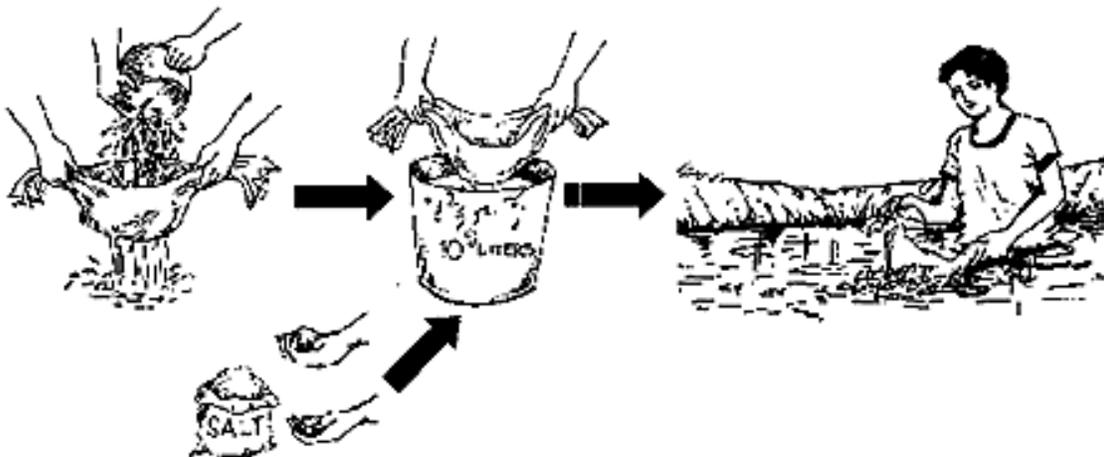
water and dip the fry/fingerlings in 1-2% of common salt solution or 50 ppm of potassium permanganate for one to two minutes before releasing them into the culture facility. Stocking should always be done during cool morning or evening hours.

### ● Treatment during sampling

It is advisable to conduct periodical sampling, at least once a month, to check the health and growth of the seed. Periodical netting should be avoided during warmer parts of the day. Before the seeds are returned to the pond, they should be bathed in 50-100 ppm of potassium permanganate solution.

#### Steps in pre-stocking acclimatization of seed

1. Place the plastic bag containing seed material in the water of the culture facility and allow to float for 30-60 minutes.
2. Add equal amounts of water from the facility where seed is to be stocked and keep for another 20-30 minutes.
3. Give the seeds a prophylactic treatment before releasing them into the culture facility by dipping them either in salt or potassium permanganate solution.



### ● Treatment of broodstock

Give prophylactic treatment to shrimp/fish broodstock by bathing in 150-200 ppm of formalin for about five minutes before release. Other commonly available therapeutants like potassium permanganate (50-100 ppm) and common salt solution (2-3%) may be used as dip treatments (1-2 minutes) for fish brooders.



### Caution

Handle formalin with care.

## Conclusion

By following these practices, the outbreak of diseases can be avoided. As soon as there is a sign of any disease, it is better to consult a specialist for help in diagnosing the disease and for treatment and environmental measures. It is equally important to discuss the problem with neighboring farmers as an early warning. Measures can be taken individually and collectively to avert any larger catastrophe. If the disease is spreading fast and no immediate assistance is available, it is advisable, depending on size, to harvest the entire stock.

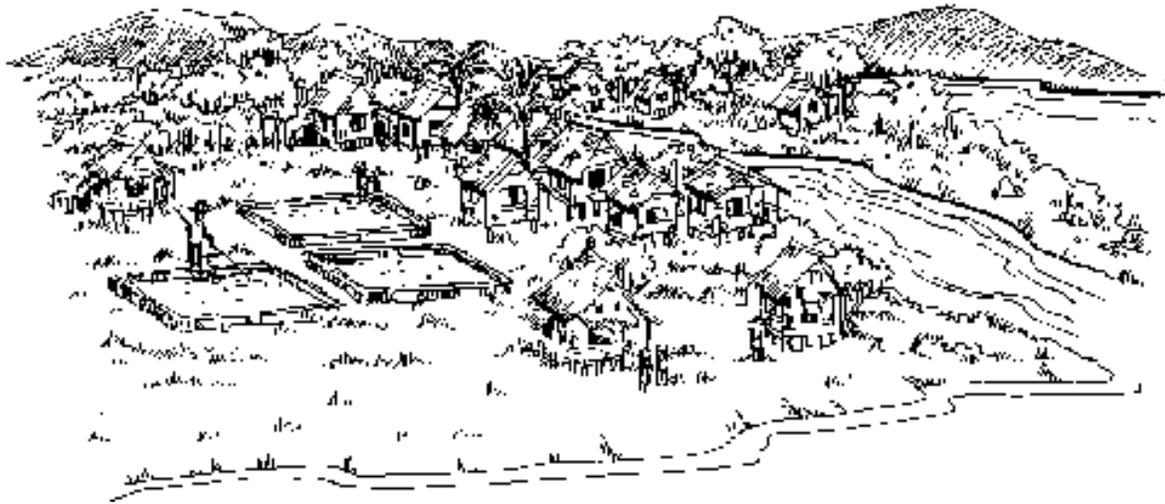
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Prepared by:

**Dilip Kumar**

**P.P.G.S.N. Siriwardena**

# Fish as Biocontrol Agents of Vectors and Pests of Medical and Agricultural Importance



Small-scale aquaculture in ponds and rice fields is generally considered valuable because of its contributions to food security, income generation and better nutrition for the farmer. However, it has been argued that an expansion of aquatic environments such as ponds or rice fields may also provide additional breeding grounds for various vectors of medical importance. At the same time, based on initial field observations, there have been studies examining the potentially beneficial role and contribution of fish to the management of pests in rice. Promising as well as disappointing results have been documented. This paper summarizes important findings, assesses the important reasons for success or failure, and provides recommendations on maximizing the positive impacts of aquaculture production and development.



## Fish as biocontrol agents

The most common fish species found in paddies and ponds include common carp (*Cyprinus carpio*), Nile tilapia (*Oreochromis niloticus*) and silver barb (*Barbodes gonionotus*). However, there are a large number of both stocked and additional wild fish species with potential for biocontrol in ponds and rice fields.

Among these are larva-feeding and mollusk-feeding fish, which are of considerable importance in the control of vectors that cause human diseases like malaria and schistosomiasis. Other species of fish appear to be effective in controlling agricultural pests, for instance, common carp which consume a lot of immature golden apple snails and therefore directly impact the population dynamics of this rice pest. Some fish eat plants and, thus, help in weed control.

The effectiveness of fish in rice fields is hard to document and there is no evidence for an optimal rate for fish stocking density in pest control. High densities are presumed to be more effective. Understanding the role of fish in the rice field ecosystem is important if they are to be used as biocontrol agents, especially if they are introduced only for that purpose.

## Selected vectors of medical importance

### Insect vectors and related diseases

#### Malaria

- Caused by single-celled protozoan parasite of the genus *Plasmodium*; four species infect humans
- Malaria is transmitted by the bite of the infected female mosquitoes of the genus *Anopheles*.

#### Arboviral diseases

- Transmitted by insects, e.g., *Culex* species that have previously fed on infected vertebrates (mammals or birds)
- Aquaculture allows close contact between the virus' original host, the vector, and humans.

### Selected control measures in pond and rice field aquaculture

- Construction of steep banks
- Removal of vegetation
- Removal of small pools of water around the pond
- Maintenance of rich biodiversity
- Intermittently irrigation
- Synchronous rice planting
- Crop rotation (wet/dry)
- Proper weeding
- Biological control with fish:

- larvivorous fish feeding on mosquito larvae; and
- herbivorous fish feeding on vegetation.

For biological control it is important to understand the vectors' ecology. *Anopheles* species breed in stagnant water bodies and sunny partly shaded pools of water. Several *Culex* species are found in marshes, ponds and ditches. When fish are stocked which not only inhabit the same environment, but also are known to feed on these vectors, the chances of successful biocontrol are good.



### Assessment of biological control with fish

*Gambusia affinis*, the so-called mosquito fish, is the most widely used species for this

purpose. In California rice fields, this fish is introduced each year shortly after fields have been flooded. The live-bearing *Gambusia* produces several broods during the summer months and an initial stocking rate of 750 fish/ha has given good results in the United States. Good results were also achieved in several other countries.

As *Gambusia* has no economic value, the Chinese have tried to combine mosquito control and production of food fish. This dual-purpose rice-fish farming has been successfully practiced with common carp at a stocking rate of 8250 fish/ha. Anopheline and culicine larval populations were reduced by 90% and 70%, respectively. In Indonesia, a similar approach was followed. Fingerlings of food fish were given to farmers as an incentive so they would cooperate in the use of the guppy *Poecilia reticulata*, which had no food value, for biocontrol purposes. Good results in mosquito vector control have been obtained in Korea using indigenous fish species.

### Caution!

- Care should be taken that introduced fish do not replace indigenous fish by filling the same ecological niche.
- Not all mosquito species are equally controlled and the impact of introduced exotic fish on non-target organisms, including natural enemies of mosquitoes, may be significant.

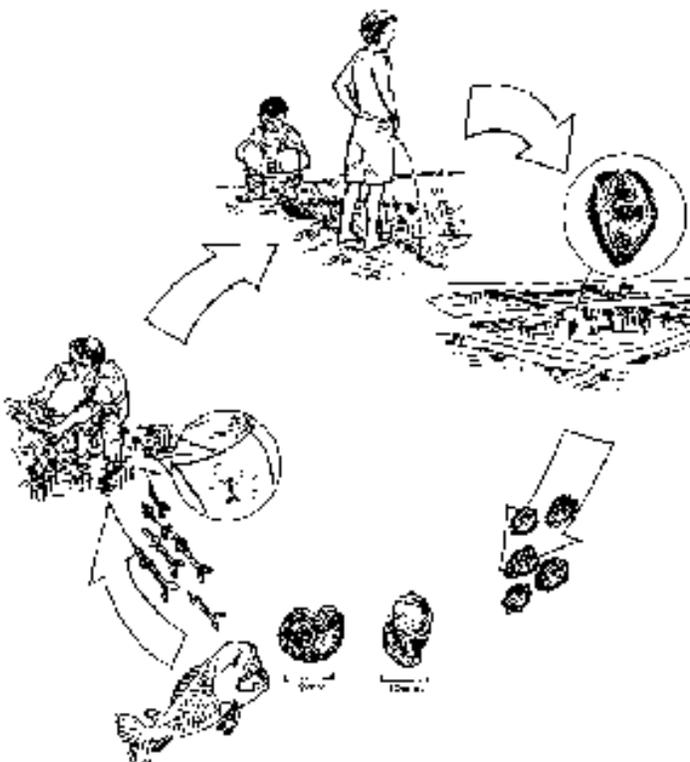


Combinations with other control measures are recommended particularly where fish seed is hard to obtain, e.g., a combination of stocking fish and applying *Bacillus thuringiensis* has been successful in mosquito control in India.

## Snail vectors and related diseases

### Schistosomiasis

- In several Asian countries, *Schistosoma japonicum* is endemic.
- In Africa, two forms -- urinary schistosomiasis caused by adult worms of *Schistosoma haematobium* and intestinal schistosomiasis caused by *Schistosoma mansoni* -- are found.
- Eggs of the schistosome worms hatch when they come into contact with freshwater. Larvae infect certain species of freshwater snails (*Oncomelania*, *Biomphalaria* and *Bulinus*).
- After multiplication, cercariae are



**The life cycle of *Schistosoma japonicum* is complex and encompasses development in two hosts and two short-lived water-borne forms. When fish feed on these intermediate host snails the life cycle of the disease is interrupted.**

released from the snails, which when they come into contact with humans, penetrate the skin and migrate to abdominal blood vessels.

### **Ecological requirements of the snails**

- Snails are generally aquatic, are found in shallow waters near the shore and slow-moving. They dry out when water levels fall and plant shelter is lacking.
- They are highly tolerant of temperature differences.
- *Oncomelania* snails are amphibious and prefer floodplain forests, swamps, waterlogged grasslands, stream, rice fields, irrigation canals, road ditches and borrow pits.

Wetlands around the Mekong River in Southern Laos are inhabited by many different snails species. At least one snail *Tricula aperta*, acts as the vector for the parasite *Schistosoma mekongi* which can infect humans.

### **Selected control measures in pond and rice field aquaculture**

- Construction of steep banks
- Removal of vegetation
- Proper water management
- Screening of water inlets
- Pond drying
- Cleaning and lining of irrigation canals
- Biological control of snails using fish
- Use of molluscivorous fish feeding on snails and mosquito larvae
- Use of planctivorous fish feeding on snail cercariae
- Use of herbivorous fish feeding on vegetation



### **Assessment of biological control of snails using fish**

Fish and crayfish may successfully control snails in ponds and reservoirs. Some fish species have specialized on snail feeding such as the black carp *Mylopharyngodon piceus* from China or various cichlids from Africa. The black carp has powerful pharyngeal teeth adapted to crushing mollusks and has been traditionally used in countries like China to control species of snails, which are nuisance organisms or intermediate hosts in parasite transmission.

Systematic studies on the performance of fish as snail eaters in water bodies are rare. After three years of observation, it was found that in rice fields in Katanga majority of snails were controlled by *Haplochromis mellandi* and *Tilapia melanopleura*, stocked at 200 fish/ha and 300 fish/ha, respectively. The snail-eating ability of *Sargochromis codringtoni*, a cichlid, was successfully tested in laboratory studies in Zimbabwe.

Good experimental results were achieved when the *Louisiana* red swamp crayfish was introduced into small rain-filled quarry pits to control the schistosome-transmitting *Biomphalaria* and *Bulinus* snails in Kenya. However, trials with another promising African cichlid, *Astatoreochromis alluaudi*, revealed that the fish were only successful at reducing snail populations if "there was nothing better to eat". Further investigations showed that the fish (from juvenile age one) need solid jaws to crush the snails but do not develop such jaws if they can find other, preferable foods.

## Selected pests of agricultural importance and their control

### Stemborers

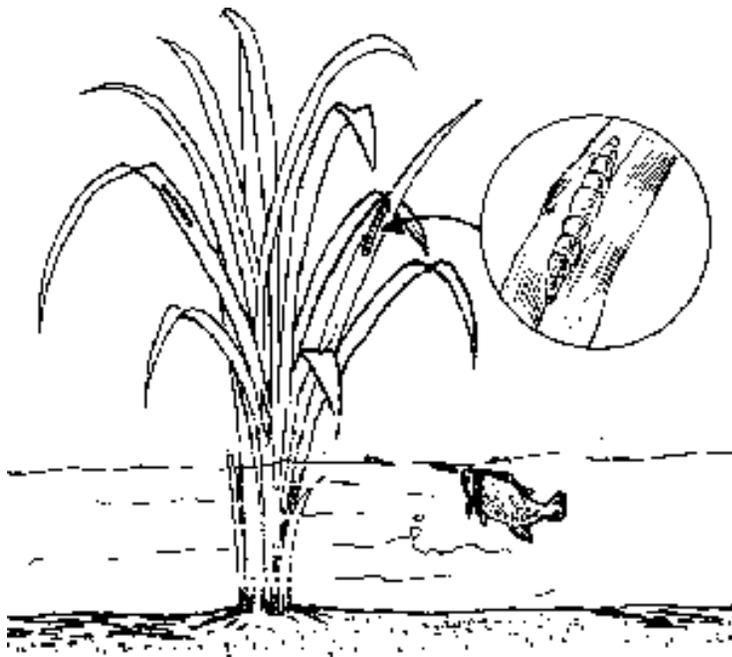
There is evidence of a lower incidence of stemborer damage when fish are stocked. Some recordings include:

- In China, damage of the young rice plants (deadhearts) was reduced from 0.37 to 0.33% with the presence of common carp and damage of the mature rice plants (whiteheads) from 0.50 to 0.25%.

#### Caution!

When infestation is very high, fish cannot serve as a single biocontrol agent, but needs to be supported by other control measures to limit rice yield losses.



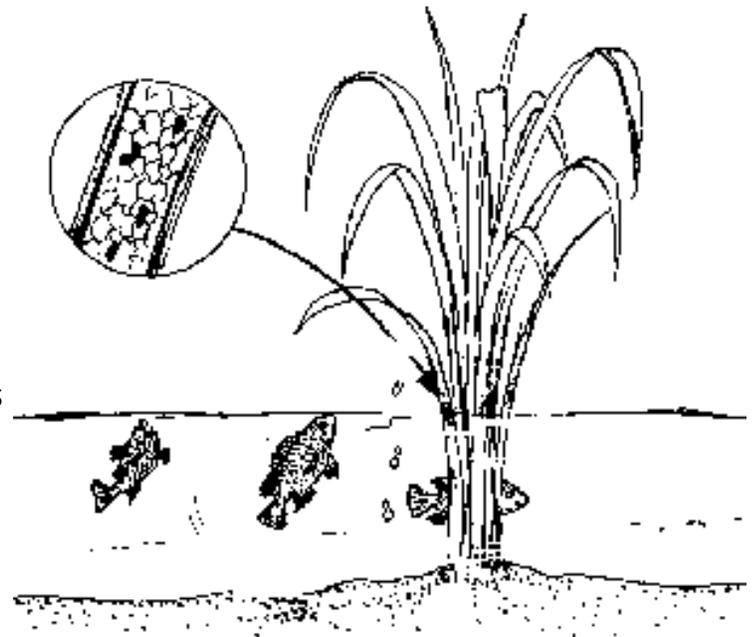


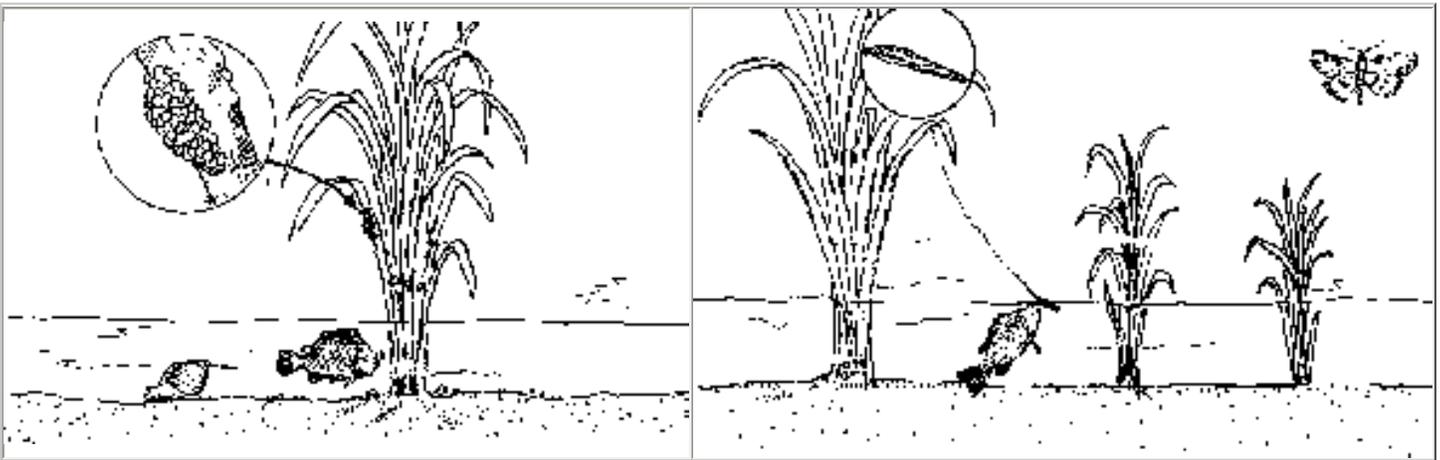
In the Philippines, during a period of heavy stemborer infestation (between 10 to 20% whiteheads), damage was significantly reduced from 18% in the control (no fish) to 13% and 15% with the presence of carp and tilapia, respectively.

- In Indonesia, when an outbreak of stemborer was predicted, farmers and their families went to the fields and collected the egg masses manually to control the stemborer populations. Such flexible approaches are needed for exceptional years.

## Others

There are several reports documenting either reduced numbers of agricultural pests or less damage caused by pests and diseases with the presence of fish. The pests include gall midges, caseworms, brown and whitebacked plant hoppers, sheath blight, brown spot and bacterial blight. Most of the work was done in concurrent rice-fish systems. In some cases, the underlying mechanisms were described. The control effect generally was the result of direct feeding by the fish when pests came into contact with the ricefield water during one of their development stages. Golden apple snails, for example, fall into the water immediately after hatching on the rice stem, planthoppers try to escape the predatory attack of spiders by letting themselves fall into the water surface then climbing back on to the plant, and stemborer larvae disperse by floating on the water to reach uninfested rice hills.





### Observations from the field on the biocontrol of snails using fish

- When common carp was stocked in Philippine rice fields, where there were large numbers of the golden snail (an introduced aquatic pest of rice in Asia) there was an observed sharp decrease in the snail population.
- When using tilapia on snails, increasing the stocking density can compensate for their poor feeding efficiency.
- Predation depends upon the size of both fish and snails, and larger snails have a higher probability to escape predation.
- *C. carpio* consumes the small snails so the number of big snails may increase in rice fields stocked with carp. Additional manual control measures will be needed (initially) for the big snails as these are most damaging to the rice crop.



## Vector control using fish will be more effective if the following are taken into consideration

### Choice of fish species

Each fish species has a distinct feeding habit, which may be useful for biocontrol purposes. Indigenous fish fauna should be screened for this purpose.

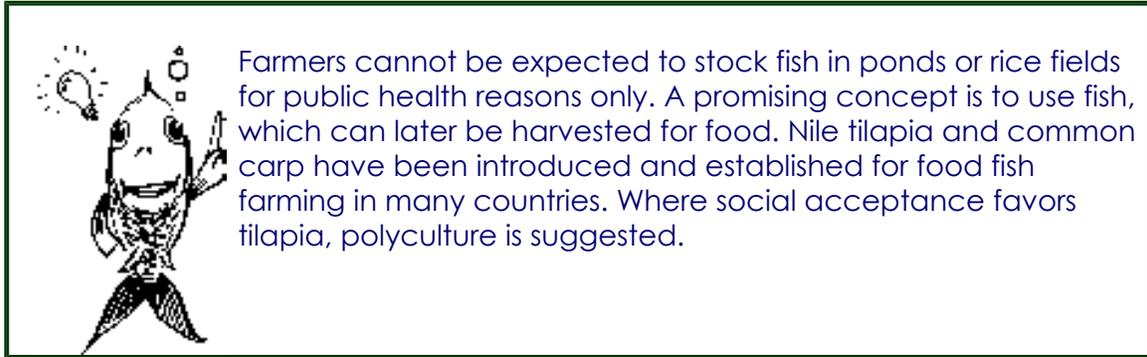
### Fish density

Fish density becomes more important when the fish species are less efficient in eating and controlling a particular organism (the fish would prefer to eat organisms other than the disease-causing organisms). This is particularly true in the case of small vectors such as chironomid, mosquito and stemborer larvae or juvenile snails. However, high stocking densities affect fish growth and harvesting small fish may discourage farmers. This practice is therefore suggested for areas where ponds and rice fields are used as fish

nurseries and fish grow-out operations demand a regular fingerling supply.

## Fish size

Size is important when vector can outgrow predation. It is suggested to stock bigger fish in areas where golden snails are a problem.



## Conclusion

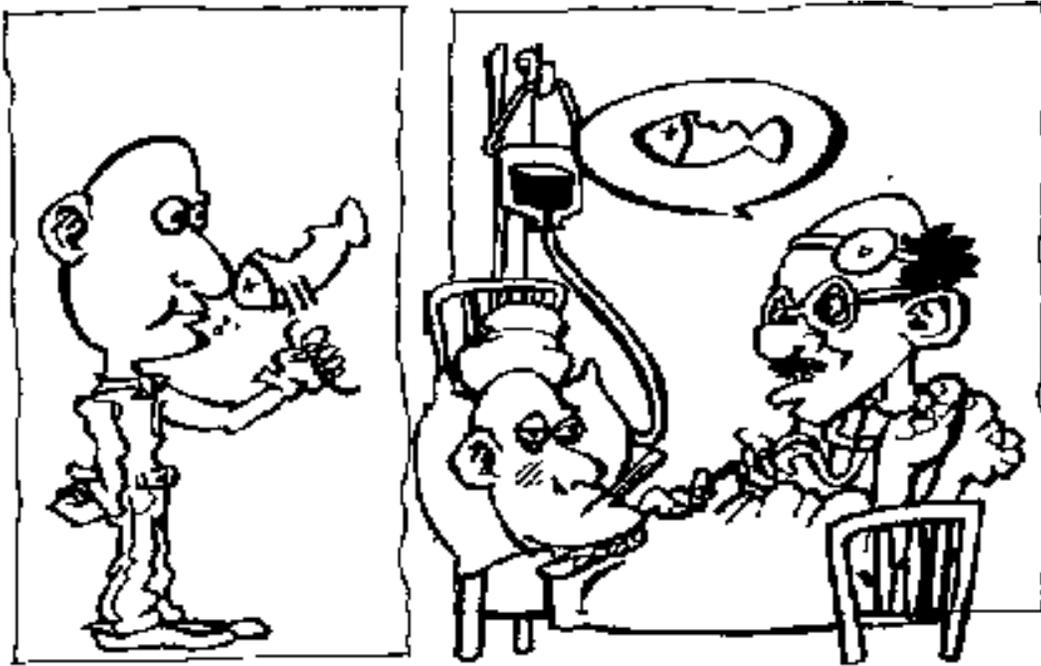
Well-maintained aquaculture operations do not increase but rather contribute, often significantly, to the control of insects and snails of agricultural and medical importance.

Vector populations can exhibit changes in life history. Traits may change in response to predation. Therefore, the complete elimination of a target organism by fish cannot be expected. Biological control should not aim at the eradication or elimination of an organism. Rather, integrated vector control and integrated pest management programs should be pursued where vector populations are managed so they do not cause significant problems.

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Prepared by:  
**Matthias Halwart**

# Possible Public Health Hazards Associated with Farmed Fish and Shellfish



Aquaculture system is a confined system. In spite of the best environmental monitoring and control measures, several types of contamination are likely to take place in farmed fish and shellfish.

## Importance of aquaculture

Most of the developing countries contributing significantly to aquaculture production are situated in the tropics and subtropics and most of the information available on the hazards and public health aspects of fish and fishery products concentrate mostly on the marine fish and fish products of tropical waters. Information on hazards associated with aquaculture products from warm waters is sparse.



## Microbes and parasites

Food-borne diseases mostly come from consumption of fish infected by pathogenic bacteria, viruses or parasites. However, these become significant only when raw or inadequately cooked fish is consumed. Trematode parasites that can cause illness ranging from debilitation to cancer or even death are the most important. Infection caused by such parasites is found in geographical areas where they are endemic in the natural fish population.

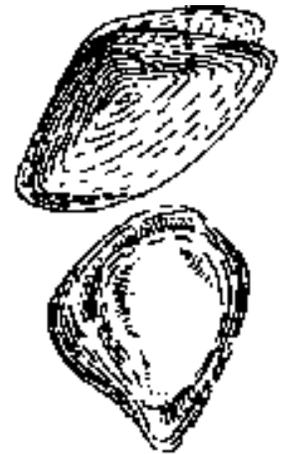
## Hazards associated with culture system

- Infection by food-borne trematodes
- Infection by pathogenic bacteria, viruses or parasites
- Contamination by agro-chemicals used for pest control
- Contamination by residues of growth promoters, antibiotics, veterinary drugs, etc.
- Contamination by heavy metal residues

Bacterial contamination, especially by the pathogenic species, is a potential hazard in aquaculture systems. The level of contamination of farmed fish and shellfish will depend greatly on the bacterial quality of the water body as well as the environment. Proximity to human habitations can result in increased levels of contamination by several pathogenic bacteria as well as fecal indicator organisms. Contamination by the bacterial population naturally present in the environment such as *Aeromonas hydrophila*, *Clostridium botulinum*, *Vibrio cholerae* etc. is also common. Bacterial flora such as *Salmonella* sp., *E.coli*, *Enterobacteriaceae*, *Shigella* also show up because of contamination by human waste/animal excreta. The latter species can get introduced into an aquaculture system, even through birds or animals.

## Bivalves as pollution indicators

Molluscan bivalves such as clams, mussels and oysters are considered indicators of environmental pollution by bacteria and heavy metals. They are filter feeders and accumulate such contaminants in their internal organs. Hence, they present a potential threat to the health of the consumers much more than crustaceans or finfish. The level of these pollutants in bivalves available from an area can give a clearer idea about the extent of pollution. Paralytic shellfish poisoning (PSP), diarrhetic shellfish poisoning (DSP) and amnesic shellfish poisoning (ASP) are also risks associated with molluscan bivalves, whether from cultured or wild source.



## Pest control chemicals

The pest control measures in culture systems employ chemicals to treat the fish as well as control diseases and pests. The residues of such chemo-therapeutants, if employed indiscriminately, can become a potential source of danger to consumer's safety.

## Antibiotic residues



Another threat to consumers comes from the residues of antibiotics used to control fish diseases and residues of growth promoters used in the feed. Many organisms may become resistant to antibiotics. Humans infected by such antibiotic-resistant organisms find treatment complicated.

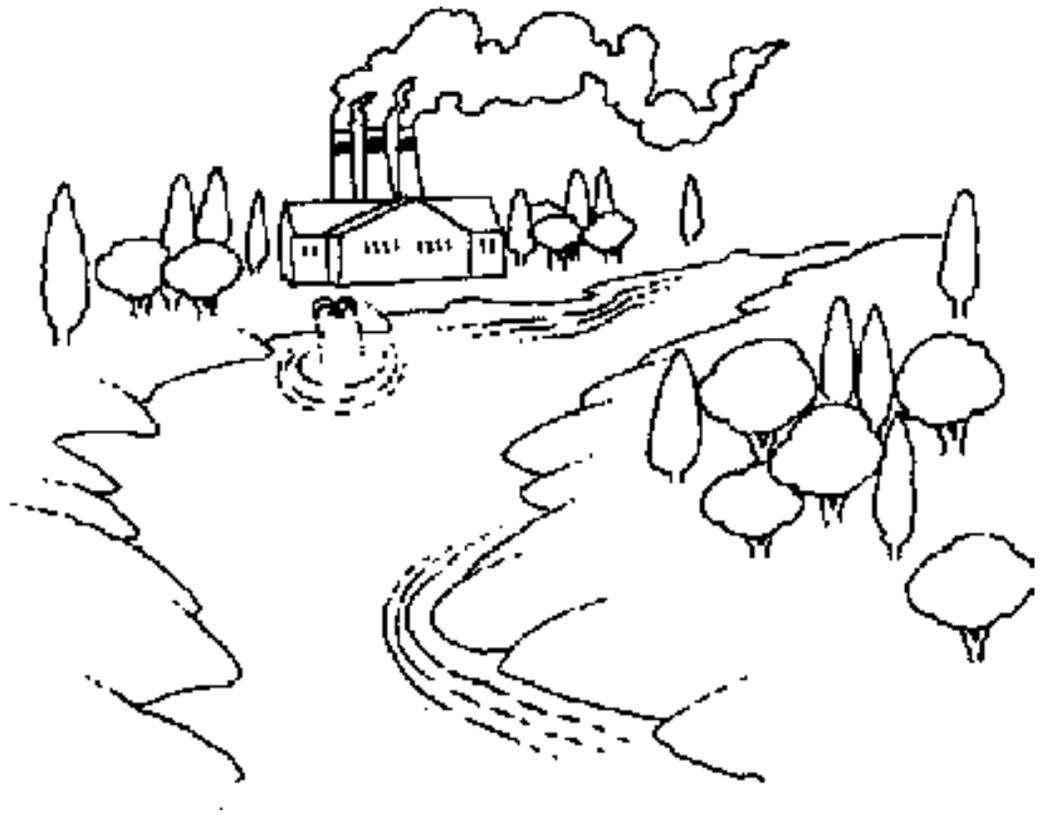
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- Contamination by heavy metal residues

## Toxic chemicals from industrial effluents

Another problem in cultured products is the contamination caused by industrial pollutants and agro-chemicals. Heavy metal type industrial pollutants are not considered a very significant risk in aquaculture but contamination by polychlorinated hydrocarbons and similar highly chlorinated industrial chemicals poses a real threat to cultured products.

As with any other human activity, hazards and risks which may adversely affect human health, are inherent in aquaculture production. Cultured fish and shellfish should therefore be handled and processed carefully.



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Prepared by:  
**K. Devadasan and K. Gopakumar**

# Improved Handling and Quality Assurance of Fish and Fishery Products



Aquaculture, whether in freshwater, brackishwater or coastal marine waters, appears to be the only viable solution to the growing demand for fish. Production alone, however, is not enough. Proper handling, transportation, processing and marketing are also essential to ensure the judicious and profitable use of farmed aquatic resources.

## Handling of harvested fish

Proper pre-process handling is very important to ensure quality. Fish must be handled properly because it is a highly perishable food susceptible to contamination by pathogenic bacteria. Depending on the species, there are various enzyme systems, which can play a vital role in causing spoilage. An understanding of the activity of the bacteria and enzymes is essential to retard spoilage.

Causes of fish spoilage

- Bacterial action
- Enzyme action
- Oxidative reactions involving fat that cause rancid flavor



## Shrimp

Shrimp are important species for culture, as they give good returns to the farmers. Shrimp harvested from the wild come from unknown stock. Likewise, wild sources may contain a mix of species with different sizes and stages of growth.



Farmed shrimp, on the other hand, often belong to the same species, can be reared to desired level of growth and can be harvested according to a predetermined schedule. The delay between harvesting and processing may cause the loss of some intrinsic qualities of the shrimp. Cultured shrimp is often packaged individually in quick frozen (IQF) form that gives more returns and value to the shrimp as a product.

## Microbiological quality

Around 30% of the frozen shrimp processed out of traditionally farmed species contained salmonella and other pathogens, whereas similar incidences were observed in only 10% of the samples processed out of their marine counterparts. It was also observed that among the cultured species, the bacterial load was higher in the traditionally farmed shrimp than those cultured in intensive systems even though the former had low stock density and no supplementary feeding, pond fertilization, and aeration. The bacterial load of shrimp farmed in the intensive systems was lower because of the scientific approach to pond management.

It is recommended to keep the shrimp in ice-cold water containing 5 ppm chlorine (allowing a contact time of five minutes before packaging and transport) immediately after harvest to improve its quality.



### Soft shell

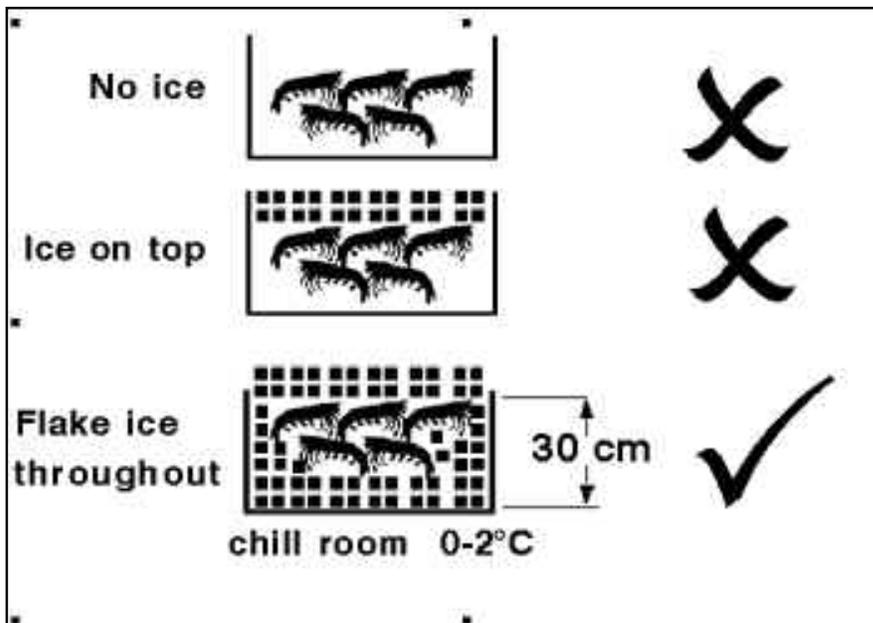
Shrimp generally molt at night when food, temperature and light conditions are satisfactory. Shrimp shell generally contains protein, calcium compounds, particularly calcium carbonate, chitin and fat. Prior to molting, considerable amounts of protein and chitin as well as negligible amounts of calcium carbonate are withdrawn from the shell as new shell forms underneath. The entire shell is replaced and the new shell is almost hard after five hours. If the shrimp is harvested without allowing enough time for the hard shell to form after molting, the crop may contain several soft-shelled specimens.

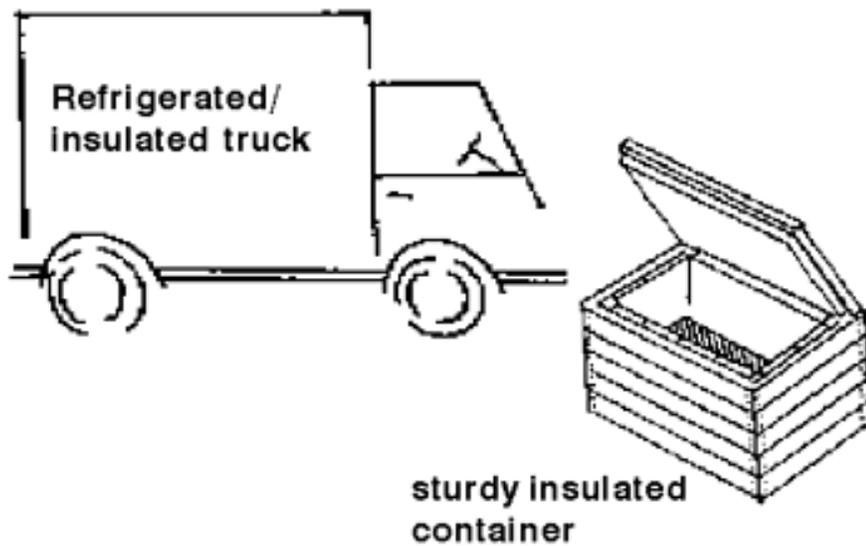
The high calcium content and the thinness of the shell make the shrimp vulnerable to damage by acidic components (ascorbic acid, sodium bisulphate) as well as physical damage. Soft-shelled shrimp may also harbor a higher bacterial load.

### Handling and transport

Farmed shrimp is very delicate and is best suited for processing as whole IQF products.

Therefore, the handling practices should ensure that no damage occurs. Increased bulk density and height of package may result in loosening the head and damaging the shell. Such incidents will worsen if crushed ice is used. Higher packing density is also known to cause white patches in cultured shrimp processed in frozen whole, cooked whole or headless styles. A pack height not exceeding 30-35 cm is recommended and flaked ice should be used instead of crushed ice. The shrimp should be covered with sufficient quantity of ice so that the melted water forms a film over the shrimp and prevents oxygen from coming in contact with the material. The surfaces on which the shrimp is placed and the hands of workers handling the shrimp should be clean.





Shrimp should be transported in refrigerated/insulated vehicles. If facilities for chilling are not available, sufficient quantity of ice should be ensured. If the location of the processing plant is far from the culture area, facilities for augmenting ice supplies should be arranged en route. Sturdy containers should be employed to avoid damage during transport.

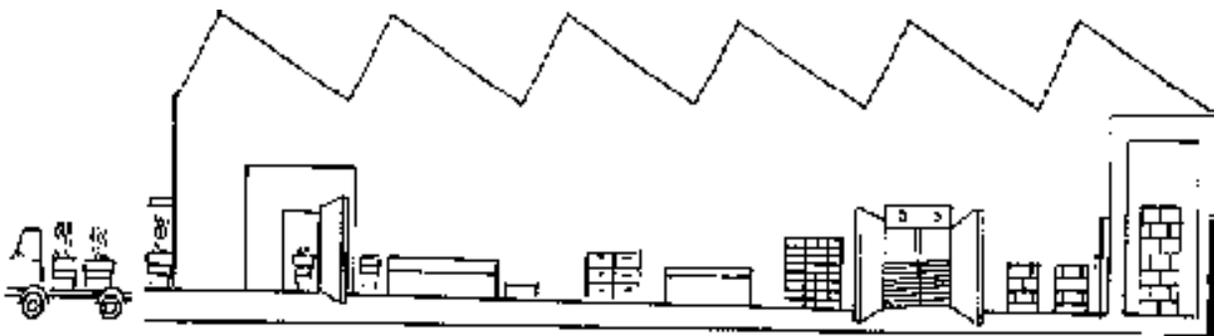
## Blackening and prevention

Blackening, though not a serious problem in farmed shrimp, may take place if the shrimp is held for longer periods without ice and if the duration of transport under ice is unduly long. As a precautionary measure, ice should be applied (preferably flaked ice) after harvest and/or the shrimp should be dipped in 0.4% sodium metabisulphite solution (for a contact period of 30 seconds).

## Processing and storage

### *Freezing*

An important method of cultured shrimp preservation is by individually quick freezing in whole/headless or cooked form. Other value-added products such as battered and breaded shrimp can also be processed out of farmed shrimp. Frozen materials other than battered and breaded types are given a protective glaze coating and appropriately packaged and stored at  $-20^{\circ}\text{C}$  or below.



### *Canning*

Cultured shrimp, when canned, generally yield a very soft product. Treatment with chemicals, partial drying or mild smoking after blanching is found effective in

ensuring a soft and firm texture.

## Live transport

Important species of finfish that are transported live are the carps, salmonids and tilapias. Catfishes are also transported live in Thailand. The market for live fish is increasing, perhaps influenced by cultural preferences and growing affluence. At present, such markets are becoming predominant in countries like Singapore, Malaysia, and China. Expansion into other places is indicated. Therefore, transportation of fish in live form is emerging as an important method of post-harvest handling. The transport requirements may vary with individual types of fish depending on whether they are of marine or fresh water origin. Transportation generally employs the tank method, which is suitable for bulk transport of live fish. The method involves shipping live fish in boats or tankers. Tanks are often equipped with circulation and aeration systems. The circulated water is aerated before feeding it back to the tank. Water can hold more oxygen at lower temperatures. Fish, however, require more oxygen at higher temperatures. A tank of a given volume can, therefore, hold more fish at lower temperatures than it can at higher temperatures. Therefore, the temperature of water in transport tanks is always kept low, but at levels the fish species concerned can tolerate. Fish with empty guts transport better.

For finfish, live transportation is an important method. It is extensively practiced in China, Thailand and Malaysia.



However, in the case of high value products like shrimp, transport in polythene bags containing water and oxygen is increasingly practiced, particularly in transport by air. Finfishes are more prone to enzymatic problems. But it depends on species because the nature of enzymes varies from fish to fish. Maintaining low temperature helps to reduce bacterial as well as enzymatic action. Exclusion of oxygen by keeping the fish in chilled water reduces fat oxidation problems also.

## Freezing preservation

Most of the cultured species of fish are suitable for freeze preservation. Air blast or spiral type freezers are the most suitable type for these fish. It is better to process them as IQF, chunks or fillets. It is advisable that the fish, (whether whole, chunk or fillet) are glazed and individually wrapped in polythene paper before cold storage.

The fish fillet can also be processed into value-added battered and breaded

products. However, fillets are skinned and treated with a dilute solution of sodium chloride before battering so that the color, flavor and taste are improved.

Some types of fish like carp have bones in the flesh, which adversely affect eating quality. Even though fillets of good size and shape can be made out of them, they cannot be processed as battered and breaded products. Processing fish mince by getting rid of the bones, using bone separators, is a better way of utilizing such fish. The mince prepared from cultured fresh water fish such as catla (*Catla catla*) and rohu (*Labeo rohita*) has been successfully used in preparing value-added products like battered and breaded fish fingers, burgers, cutlets, that are now popular items in the fastfood trade. Likewise, other low value fishes have been used in producing sausages and paste products although farmed fish are not used much for these purposes.

### **Canning preservation**

When canned, the meat of farmed fresh water fish like rohu becomes very soft. In order to enhance texture, treating the fish fillet with 15% brine containing 0.25% calcium chloride prior to canning is found useful.

### **Bivalves**

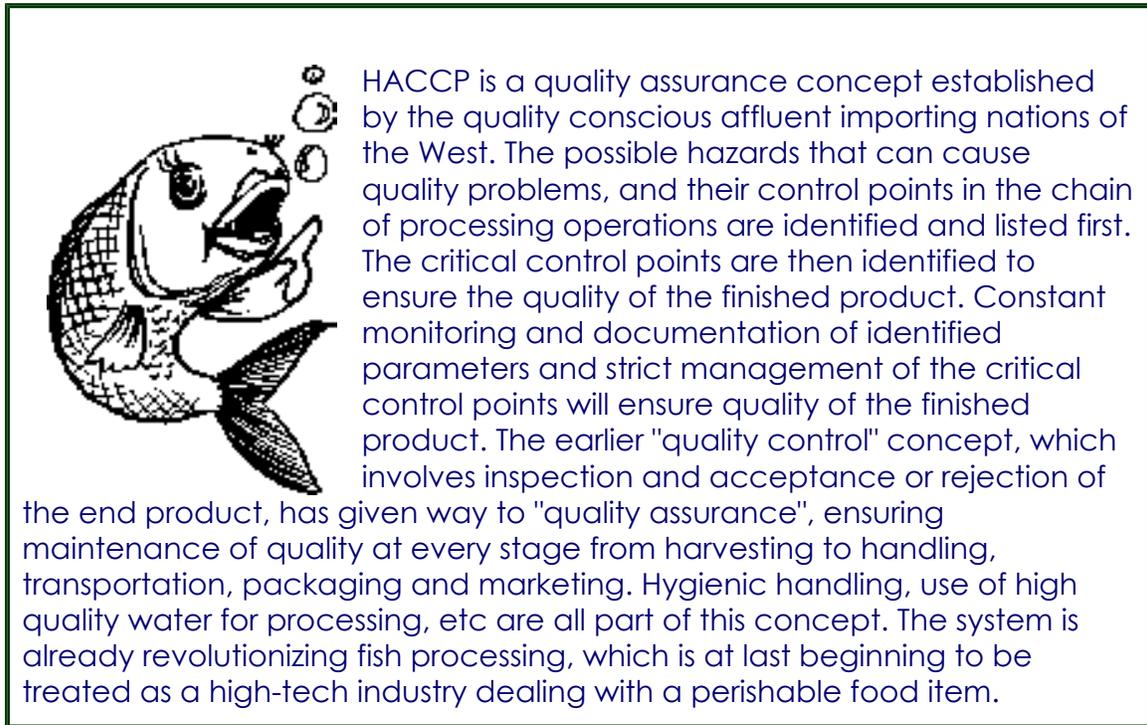
Bivalves are known to accumulate pathogenic bacteria and heavy metals in their internal organs due to their filter feeding habit. Being filter feeders, their stomach at any time may contain gritty materials like sand. Therefore, it is a pre-requisite that these animals are biologically cleansed before they are processed or consumed. One of the best and easiest methods of biological cleansing is to depurate them by starving in clean water from their natural habitat. By doing so, the grittiness can be brought down to non-detectable levels and the bacterial quality improved by freeing them of all pathogenic bacteria.



Whole mussel as well as meat shucked from fresh mussel yielded the best products. However, whole mussel stored under ice for two days also yields meat suitable for canning. Other preservation processes applicable for mussel meat are smoke curing, drying and marinating. Washing the meat of cultured edible oyster in 5% brine containing 0.1% acetic acid is considered a necessary pre-treatment to avoid formation of lumps and to yield meat with soft and firm texture. Processing clam meat in pickled form has been found to be economically viable. The pickle can be made to suit the taste of the intended market.

## Quality assurance

Aquaculture is an important sector that contributes substantially to fish production. Though majority of the produce is consumed domestically by the producing nations, there is a significant increase in their processing for export. Because of the inherent health hazards and the regulatory requirements of the importing countries, strict observation of quality measures becomes important in the production, harvesting, handling and processing of these fishery products, whether it is for internal consumption or export.



The hazard analysis critical control point (HACCP) approach has to be applied for cultured products, from culture to consumption, to avoid risks associated with consumption of such fish and shellfish. Most of the hazards associated with fish processing have been detailed above. However, systems may have to be developed separately for the culture and handling of each fish and shellfish because the environment and habitat of the species under culture are different.

Development and application of HACCP based quality assurance program in the culture may not be very difficult in commercial large-scale operations. However, there are a vast number of small holdings under aquaculture, which mainly aim at distribution of the fish for domestic consumption. Operational limitations of such small systems of aquaculture may impede the development and adoption of proper HACCP based quality assurance programs.

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## **Participatory Approaches and Extension Strategies**

[Participatory Approaches for Aquatic Resources Management and Development: Thoughts and Lessons Collected by DFID and FAO during 2000](#)

[Scaling Up the Impact of Aquaculture: The CARE Experience in Bangladesh](#)

[Scaling Up the Impact of Aquaculture: AquaOutreach at Asian Institute of Technology](#)

[Participatory Approach to Extension and Training in Aquaculture](#)

[A "Farmer Field School" for Aquaculture](#)

[Aquaculture Development and Information Processes](#)

[Rural Aquaculture Development and Mangrove Conservation Projects \(Initiated by Fishers in Collaboration with Various Institutions in Sri Lanka\)](#)

[Use of Geographic Information Systems \(GIS\) for Planning and Management of Aquaculture](#)

## Participatory Approaches and Extension Strategies



# Participatory Approaches for Aquatic Resources Management and Development Thoughts and Lessons Collected by DFID and FAO during 2000

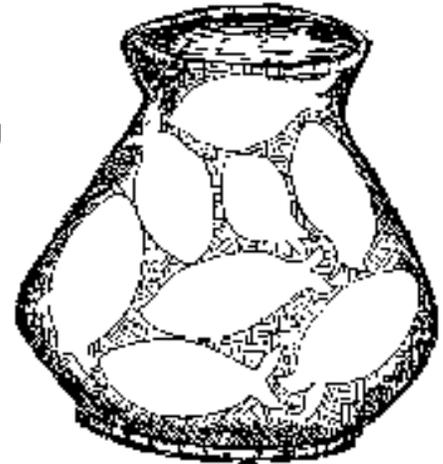


Aquatic resources management in the context of poverty is not limited to a particular technology or to different forms of aquaculture. It also includes the concentration and capture of wild fish and the foraging of aquatic resources such as crabs, prawns, snails, insects, aquatic plants, etc. in paddies and other water bodies. Many of these activities remain invisible to researchers and rural developers because dispersed and small-scale production data, which are difficult to collect by conventional approaches, do not appear in official statistics. As the emphasis in aquaculture development now shifts from purely technical to extension and poverty alleviation issues, there is a considerable need for more widespread application of participatory approaches.

The term "participatory approaches" is used to describe a wide range of development and research approaches, methods and tools that can improve the practice of development. Relatively novel approaches include the consideration of aquatic resources management in the context of livelihoods, working with poor aquatic resource-users, building on their strengths in the context of environmental, social and economic issues that impact on their livelihood strategies. Much can be learned not only from recommendations based on knowledge generated, but also on the methodologies used.

## **Guiding principles of participatory approaches**

Participatory approaches might best be described as a set of "guiding principles" that can help practitioners develop a different kind of relationship with the people that are supposed to benefit from their work. The guiding principles that really make up participatory approaches were reviewed in the FAO Fisheries Report No. 630 (2000).

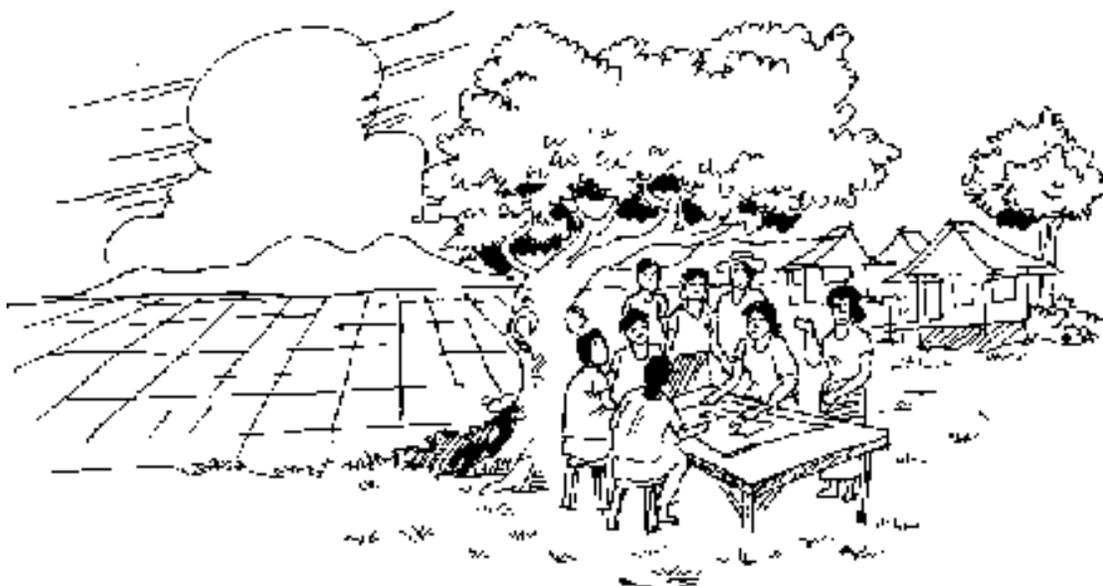


Guiding Principles of participatory approaches	
Organized process	While participatory approaches make use of a flexible "basket" of different methodologies, those methodologies are guided by objectives and responsive facilitation.
Systemic learning	The methods used in participatory approaches emphasize learning about systems and the relations between different elements in those systems. Participatory approaches need to be "holistic".
Multiple perspectives	Participatory approaches take into account the fact that different people have different perspectives and try to accommodate these different perspectives.
Group learning	Participatory approaches emphasize the value of learning in groups as a means of coming to consensus decisions regarding action to address commonly identified objectives. (Understanding the "group" and the power relations within the group is important so that "consensus" decisions reflect the needs of weak group members as well as the strong ones.)
Context specific	Each community and its context are different. Participatory approaches accommodate their specific characteristics. (From experience, the importance of recognizing the differences within communities, and between social and economic groups, is also being emphasized more and more.)
Facilitating	The use of participatory approaches by development practitioners involves the adoption of a facilitating or catalytic role, rather than a protagonists.
Leading to change	While participatory approaches accommodate local knowledge and skills, they are focussed on facilitating changes that people regard as appropriate.

The terms for participatory approaches and methodologies are as numerous as the locations where they have been put into practice. Being "context specific", there can be no "blueprint" for participatory approaches. They need to be constantly

adjusted, refined and adapted based on the local setting.

<b>A selection of participatory methods and their uses</b>		
<b>Participatory</b>	<b>Brief description</b>	<b>Examples of particular use method</b>
Timelines	Historical profiles of longer-term events or trends	Fish catch over time, productivity changes, policy changes
Seasonal calendars	Graphical representation of seasonal events or trends	Labor availability, hydrographic changes
Transect walks and through particular areas	Land- and water-use maps based on walking capital, local knowledge of microhabitat, current use of aquatic resources	Quality and quantity of natural resource maps
Social maps	Maps locating key social features	Access to services and infrastructure
Wealth ranking	Socio-economic categorization of households	Assets, income
Preference ranking	Ordinal ranking, e.g. based on pairwise comparisons, based on defined criteria with scoring	Livelihood strategies, assets and matrix ranking access to services (e.g., fish for conservation)



Adaptability has led to a large number of variants in participatory approaches. This means there can be no single definition of what constitutes a "participatory approach". What is important is that the approach and methodology have been planned systematically, bearing in mind the guiding principles of participatory approaches. The following are two different examples of these approaches:

1.

### **Experiential learning in farmer field schools in rice creates opportunities for the integration of aquaculture**

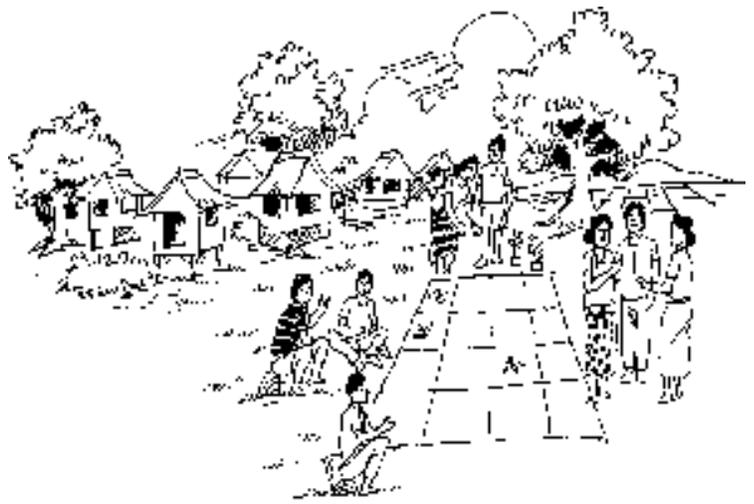
- The approach to reach and enhance human expertise for better rice crop management, particularly in relation to integrated pest management (IPM), is via farmer field schools (FFS) with about 25 farmers each. Farmers in Bangladesh, Indonesia, Vietnam, Cambodia, Ghana, Burkina Faso, Mali, Côte d'Ivoire spend 5-6 hours together every week. Two hours are spent in the field observing the ecosystem. The process is facilitated by trainers, who themselves have spent a whole season in the field learning about the ecosystem and designing curricula for the FFS.

The approach described here is from the FAO's Intercountry Program on Integrated Pest Management in Rice in Asia and draws much from the experience gained in the implementation of the National IPM Program in Vietnam.

*Source:* Kenmore, P. and M. Halwart. 1998. Functional agrobiodiversity, Integrated Pest Management, and Aquatic Life Management in Rice. In: Proceedings of the FAO/CBD International Workshop on Opportunities, Incentives, and Approaches for the Conservation and Sustainable Use of Biological Diversity in Agricultural Ecosystems and Production Systems. FAO, Rome, Italy.

- The equipment needed in FFS are plastic bags, pencils and paper. Farmers put samples of arthropods in plastic bags and after the field work they discuss in small groups what they have observed, prepare poster diagrams, and present findings to their fellow farmers.

- Farmers observe populations in the field but also test their trophic linkages by setting up "insect zoos". These answer questions on "what eats what" and "how many are eaten", etc. Such experiments are interventions that advance farmers' knowledge and lead to further experimentation.



- Elimination of nearly all pesticides results in a higher biodiversity, which is frequently used by farmers in a sustainable manner. Snails, frogs, aquatic insects and others constitute an important part of the diet of many rice-farming households. Where wild aquatic resources are declining from habitat change then culturing fish in rice fields or adjacent water bodies becomes increasingly important.
- Farmers' advanced knowledge about rice field biodiversity, together with vastly reduced pesticide levels, opens new opportunities for food security and income generation; many rice farmers decide to double the use of their fields and the rice field aquatic ecosystem by raising fish.
- They experiment with different management options, growing a "crop" of fish together with the rice in the same field, using the field to grow a crop of fish between two rice crops, or growing fish after rice instead of a second rice crop.
- Farmers experiment with physical modifications of the fields to accommodate the fish such as digging trenches in different shapes and sizes or small ponds at different locations. They are innovative in adapting their production systems to local market conditions – growing bigger fish for sale or their own consumption or smaller fish, if they can sell them to grow-out operations nearby.
- Better utilization of resources, increased income, and a healthy crop of rice and fish reinforce farmers' acceptance of integrated pest management and rejection of pesticides. Experience shows that many groups of farmers decide to continue the process of information exchange in self-organized "farmer clubs" long after the FFSs have ended.

## 2. A participatory approach to aquaculture research and development in Laos

- The Lao People's Democratic Republic is very poor, and people depend heavily on the natural resource base, especially rice and fish consumption. The Provincial Livestock and Fisheries Section (LFS) provides support services including extension. It was anxious to become better

equipped to fulfill its role. The UK researchers and the LFS agreed to develop recommendations together with the farm families who might use them. A participatory situation analysis was conducted in which LFS staff identified and characterized eight different rice paddy agro-ecosystems that could incorporate fish.

Experiences from a DFID research project coordinated by the Aquaculture Research Program, managed by the Institute of Aquaculture, University of Stirling and carried out in collaboration with the staff from the Livestock and Fisheries Section (LFS), of Savannakhet Province, Laos, the Lao Women's Union (LWU) and the AIT Aqua Outreach Laos project. The research aimed to address technical, social and economic constraints to rice fish culture in Laos.

Source: Haylor, G., A. Lawrence, E. Meusch, and K. Sidavong. 1999. Addressing technical, social and economic constraints to rice field fish culture in Laos, emphasizing women's involvement. Final Technical Report DFID ARP Project R6380Cb.

With institutional strengthening support from AIT Aqua Outreach Laos and Stirling University, the LFS set up a formal procedure for formulating, recording, monitoring and upgrading recommendations, using the rice-fish recommendations as a test-case. Special forms (for recommendations and trials) were discussed and developed by LFS staff. A key change is that the district staff now records the recommendations they make in response to farmers needs. If a recommendation is a best-guess option (not the result of testing by farmers or other research), it is recorded as a trial and monitored. Recommendations and trials are discussed annually at village-based workshops so that an iterative process exists to upgrade and refine promising recommendations and discard or amend those that fail.

- To assess the wider implications of the recommendations, the Lao Women's Union developed indicators and a system of participatory monitoring and evaluation. Members of the farm-household compare their perceptions of the farming system before and after.
- This case highlights a novel mechanism, which encapsulates different roles for the key players and devolves the research and development process to farmers and field workers. It values local knowledge while acknowledging the role of outsiders and focuses on identifying and characterizing different



recommendation domains. Sustainable impact is attempted by instigating an iterative process that leads to the documentation and refinement of the existing system of research and development support at a rate consistent with local capacity.

- The process is considered relevant to countries with developing economies that are characterized by NR research and development institutions at an early stage of development, with limited communication with the communities they have to work with, and where standardized or single technical recommendations are commonplace. It applies particularly to the communities that manage diverse, risk-prone natural resource systems.

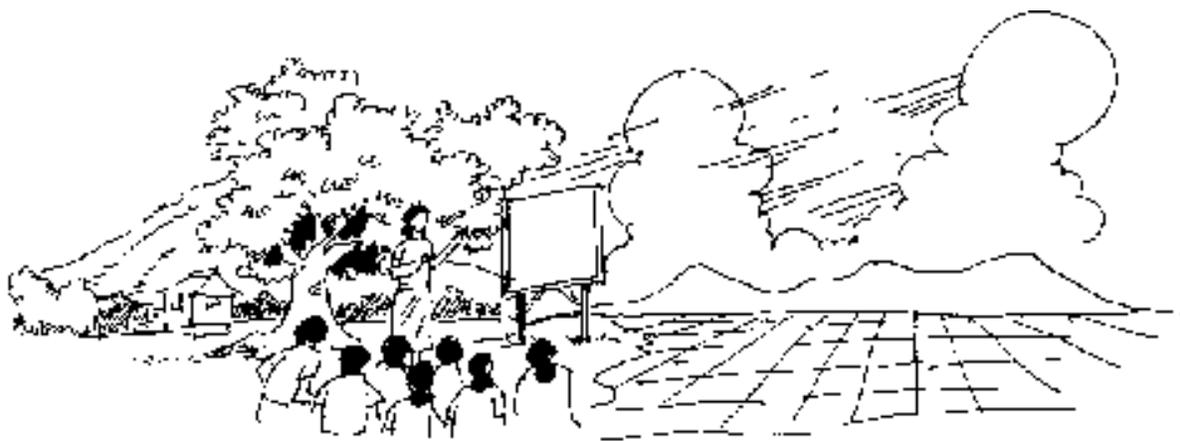
## Lessons learned

Significant lessons have been learned from participatory approaches related to aquatic resources management during 2000. Below lists learning gained as presented in an FAO workshop on participatory approaches used for aquaculture development held in Bangkok in March 2000. The issue of learning and communication processes also featured prominently in the recent E-Mail Conference on Aquatic Resources Management for Sustainable Livelihoods of Poor People in the SE Asia, in July 2000 (*see related topic on Aquatic Resources Management for Sustainable Livelihoods of Poor People, page 11*).

Clearly there can be no definitive "conclusion" regarding the appropriateness of using participatory approaches in aquaculture but the points listed below can be taken as issues and, in some cases, indicators that can help people decide how to incorporate participatory approaches into their work.

- The use of participatory approaches in aquaculture development activities can add value to those activities. During the research phase, they can ensure a better understanding of a wider range of issues and the context in which aquaculture is being considered or applied. They can also help ensure that aquaculture development addresses real issues and needs of potential users. During the implementation phase, they can ensure better implementation and better monitoring of impacts.
- Participatory approaches cannot be applied across the board to all types of research at all stages. They can make an important contribution to the identification of the research subject by helping researchers understand what the problems and priorities of potential users are. However, some forms of "basic" research are better carried out in a "non-participatory" way as participation by people in the field, particularly the poor, may expose them to increased risk. Once the results of basic research have been established, participatory approaches are an essential part of the adaptive research, which needs to refine solutions and make them appropriate to local conditions.

- In the implementation of aquaculture development activities, participatory approaches are important in ensuring that activities are implemented in an appropriate way and can increase the sustainability of activities by giving users the leading role in developing and adapting new activities. But participatory approaches require different forms of management compared to more "traditional" or top-down approaches. They require changes in skills and attitudes among those involved in aquaculture development, which require time.



- The adoption of participatory approaches, and the specific approaches used, need to take into account the capacity of the institutions and practitioners involved. Familiarity with the principles of participation, an acceptance of adaptive management of field activities, good planning and decentralized decision-making are all important in effectively supporting participatory activities. Time and resources have to be devoted to developing these skills and capacity.
- The adoption of participatory approaches is not a panacea. It does not make other approaches unnecessary nor is it always the best approach in all situations. The costs and benefits compared to alternatives need to be carefully assessed.

Learning and communication processes are important in enhancing the capability of poor people to manage their resources. This issue featured prominently in the recent DFID SE Asia Aquatic Resources Management Programme E-Mail Conference. (See related topic on Aquatic Resources Management for Sustainable Livelihoods of Poor People)

- Participatory approaches in aquaculture have been used primarily to contribute to research. Their use as a means of improving understanding of conditions, problems and issues is important but, by concentrating on participatory research, some of the wider potential of approaches may be missed. The real potential of participatory approaches lies not just in the

improvement of aquaculture development workers' knowledge, but in the building of the capability of the end-users to make decisions about aquaculture and its place in their livelihood strategies. This area of application of participatory approaches needs to be further developed in the aquaculture sector.

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Prepared by:

**Matthias Halwart and Graham Haylor**

# Scaling Up the Impact of Aquaculture: The CARE Experience in Bangladesh



Aquaculture is contributing significantly to the total fish production of Bangladesh. To increase production from the aquaculture sector, it has been suggested that major shifts in extension strategies are necessary. The agriculture and natural resource sector of CARE-Bangladesh has been exploring alternative approaches to develop extension systems appropriate to the needs of small farmers. The processes experimented in promoting aquaculture development with small and marginal poor farmers have resulted in improved productivity from the different systems. The experiences gained in scaling up the impact of aquaculture indicate that to empower farmers and sustain development, it is necessary to change the focus of extension systems from technology transfer to helping farmers understand the principles and processes. With the knowledge acquired, farmers should be encouraged to develop by themselves systems appropriate to their farm using their own resources.

## Why scale up the practice of aquaculture?

Aquaculture has been recognized as one of the activities that can have a significant impact on the livelihoods of the people and bring measurable changes. Scaling up such an activity would help in the efficient use of unused water resources or to improve existing practices, so that more people can derive benefit quickly from aquaculture and sustain the activity.

Research results obtained from partnerships with farmers were found to have substantial benefit to the farming community chosen for pilot scale testing. Based on the results obtained from the pilot phase, necessary adjustments were made for scaling up. Farmers are kept at the center in deciding what is appropriate for scaling up and sustaining the program.

### **Magnitude of scaled-up activities**

On average, about 40,000 families annually are covered by a direct delivery system, where CARE extension staff directly work with farmers. Among these farmers, 20-30% only are generally involved in aquaculture activity, particularly rice-fish cultivation. There are six projects funded by DFID and European Union, with aquaculture as one of the components, and these are spread all throughout Bangladesh covering several hundred villages. Coverage through partnership is gradually increasing. Partnerships have been established with more than 150 NGOs and CBOs for the implementation of the activity either on contract basis or collegiate basis. Working through partners has different dimensions from working directly with farmers.

## **CARE-Agriculture and Natural Resource Program principles**

- **Focus on people and not on technologies.** Understand the livelihoods of people and the contribution (or potential contribution) of aquaculture to livelihoods through the existing farming practice
- **Recognize and respect the innovative potentials of farmers** (Farmers are also scientists). Give them confidence and opportunity and do not underestimate the potential of farmers for innovation.
- **Provide farmers with the science behind the technologies and not just technologies.** Provision of principles encourages people to adapt/innovate technologies appropriate to their own farming system.
- **Do not promote risky systems.** Avoid heavy external input activities and help farmers to use locally available resources.
- **Organize farmers.** Help farmers to organize themselves and address problems on a community basis by establishing access to information: markets, formation of self-help groups, etc.

The scaling up process used by CARE can be grouped under two categories: horizontal scaling up (people to people) and vertical scaling up (institutions to people).

### **Horizontal scaling up**

CARE has been involved in scaling up the aquaculture activities by directly working with farmers. About 800 staff members are involved in scaling up aquaculture activities throughout the country. However, these staff members are not exclusive to aquaculture, but are integrated agriculture development professionals who treat aquaculture as part of a larger farming system.



### **Vertical scaling up**

To reach more people and ensure sustainability of the activity, partnerships with different institutions like non-government organizations (NGOs), community-based organizations (CBOs), youth/cultural organizations in the villages and government departments involved with agriculture/fisheries are developed.

#### **Extension agents**

CARE experience has demonstrated that farmer-centered and process-oriented approaches require staff with strong facilitation skills and a passion for participatory approaches. Staff with diverse backgrounds are recruited and trained to work as extension agents. Often experienced farmers can also play this role. There is a small group of technical staff for aquaculture, agriculture, forestry, environment, economics, sociology, monitoring and evaluation. These specialists help the extension agents in understanding the principles of technologies and issues. Extension agents with holistic approaches address the issues and provide support to farmers in solving the problems. This differs from the predominant extension approach wherein technical departments from each area like agriculture, horticulture, fisheries, provide support independently. The new approach is useful in reducing cost and meeting the needs of farmers.

**Research/information partnership:** Partnerships with universities, national and international research institutions, agencies involved in development work within and outside the country are developed. These partnerships have been mutually beneficial and will become productive when there are well-defined frameworks. The partners serve as good sources of information as well as good centers to disseminate

information so that it will reach the right people involved in such activities.

## **Horizontal scaling (people to people)**

This process' major focus is the transfer of information from people to people. For effective upscaling, good institutional structure and people with clear vision are essential.

### **Human resource development**

Importance is attached to human resources since the extension system revolves around the staff's capacity to enhance the knowledge of farmers and their interest in learning from each other. To bring the fundamental change in the attitude of staff from "I know everything" to "I learn with you" requires considerable amount of time and energy.

Foundation training for the staff usually covers one full crop cycle (like rice-fish, about 120 days). It focuses on improving facilitation skills; building staff skills in using the experiential learning cycle; self discovery; enhancing staff knowledge on the livelihoods of people, social and gender issues; discovering the principles of technologies; gaining confidence in the use of extension strategies.

Staff development is considered a continuous process and resources are allotted to build staff capacity. Self-evaluation at the end of each crop cycle is undertaken (What was achieved? What could not be achieved?). An enabling environment must be created where staff members feel free to express themselves without fear and where they are encouraged to learn from mistakes. Staff development and management are core elements of scaling up activities.

### **Working with farmers**

Working with farmers generally consists of the group approach following a farmer field school strategy, wherein farmers meet at regularly to learn together, through action-oriented educational approaches. CARE projects treat aquaculture as a component of the farming system. In a village where groups of 25-30 farmers are formed, there could be only four to five farmers who might be interested in aquaculture. In such occasions, small sub-groups are formed. The general principles in farmer field school approaches are as follow:

- **Learning contract.** Each group is encouraged to establish a learning contract in which the commitment of all parties is included.
- **Field is the classroom.** Farmers identify the problems and areas where issues have to be addressed. Plans are developed by the farmers to meet their own needs.
- **Curriculum focuses on science, not just technology.** Based on the identified needs of the farmers, curriculum is developed to increase their knowledge. Sometimes, progressive farmers are used to develop a curriculum appropriate to the village. Learning sessions could vary in

number depending on the importance farmers attach to the issue.

- **Meet on set days and set time.** Generally, each group meets at least once in a fortnight and undertakes observations collectively. In addition to these fixed meetings, extension staff also provides follow-up support.
- **Make time for analysis and synthesis.** At the end of the session, results are analyzed by the farmers and shared with others. Farmers' science congress is also becoming popular. In these meetings, farmers share and analyze results with other farmers.
- **Working duration.** The cycle of direct interaction with the farmers generally covers 12-24 months. This provides opportunity to cover 2-3 cycles of rice-fish and at least one full cycle of annual crops like pond fish.

### **Extension agents**

Consider these processes in scaling up aquaculture

1. Farmer field school extension strategy – group learning opportunity for adults organized in fields.
2. Family approach – involve both male and female from each community.
3. Community approach – help bring more areas under aquaculture like in community fish culture. Also, it is a tool to create community harmony.
4. Farmer leaders – choose farmer leaders acceptable to community and help them establish access to information on a sustainable basis.
5. Aquaculture education to children – incorporate lessons in aquaculture in schools and help children to learn about aquaculture through practice. Children are powerful vehicles for information dissemination.
6. Farmer participatory research – encourage farmers to conduct research using their own resources to develop technologies appropriate to each area. Help farmers to analyze and disseminate the information .
7. Participatory monitoring, evaluation and planning – use tools and development indicators acceptable to farmers to measure progress.
8. Opportunities for discussion where farmers learn from each other.
9. Mass communication approaches – newsletters, posters, radio, TV programs, billboards in local languages are good ways to create awareness. But to ensure action, support is required and this should be planned.
10. Cross visits – a most effective strategy: farmers can communicate in their own language.
11. Farmers science meet – apart from field days (which give an opportunity for the farmers to see): organize village fora to discuss the results obtained.

## **Increasing secondary adoption rates**

Farmers are encouraged to teach other farmers. Although successful activities are adopted easily by other farmers in the village, conscious efforts are necessary to increase adoption rates.

### **Consider these processes in scaling up aquaculture**

- Farmers are viewed as development partners and not beneficiaries.
- Staff are viewed as knowledge and learning catalysts and not information givers.
- Projects are viewed as educational programs not a technical intervention.
- Focus on learning skills and mechanisms for learning and not on giving information.

## **Vertical scaling up**

### **Partnership with NGOs**

To reach larger areas and more people, partnerships with other NGOs and CBOs, youth organizations, etc., are useful.

While fostering partnership, remember:

1. Partners should have shared vision and values.
2. Adequate time is necessary in the selection of partner NGOs.
3. Capacity building of NGOs/CBOs should be a priority. Long term strategies and building collegiate types of relationship should receive priority.
4. All transactions should be transparent. Adequate support should be provided to improve program and financial management of the organizations.
5. Inclusion of local farmers in various trainings would be useful.
6. Partnership should focus on long-term institutional linkages.

### **Why rice-fish has been spreading widely in CARE project areas**

The success of rice-fish has been attributed to the promotion of cultivation of both rice as well fish by the same extension agent. When these two components are promoted by two different extension agents, the result is poor.

Rice-fish culture is generally sustained by the farmers. In areas, where the activity was not sustained, poor participation of women was a major factor. Involvement of both male and female farmers from the same family assures sustainability.

### **Partnership with government agencies**

Working with the Department of Agricultural Extension/Department of Fisheries achieves wider coverage. As there are many differences in the working environment and approaches used, strengthening of these partnerships require an understanding of each other. Some of the challenges encountered are: bureaucratic systems, hierarchical attitudes, non-acceptance of NGOs as equal partners, poor pay structure in the public sector and lack of pro-poor policies.

### **Partnership with research and development**

Partnership with the universities and research organizations has helped in addressing many issues and in stimulating research for farmers. Many of the findings of these research institutes are transferred to farmers for further testing and adaptation. On the other hand, practical problems encountered by the farmers are fed back to researchers.

### **Consider these criteria in scaling-up aquaculture**

1. Aquaculture should be a felt need of farmers
2. Inputs should be easily and locally available
3. Activity should not add undue risks to farmers
4. Socially and culturally acceptable
5. Environmentally-sound
6. Economic benefit derived should be high
7. Market opportunity
8. Technology should be gender sensitive
9. Favorable policy environments
10. Appropriate institutional structures

## **Conclusion**

Aquaculture can make a significant impact on people. To achieve such an impact, changes are necessary in the extension processes. Following are the major lessons learned from the scaling up processes.

1. Scaling up is sustainable when education processes are adopted and participatory approaches are employed at all levels.
2. Scaling up should not be mistaken for replication. Every farmer should be encouraged to investigate and adapt the new information to suit his farming system.
3. Scaling up can have maximum impact on people with good policy environment. Hence, partnerships with government agencies, that can influence policy changes, would be useful.
4. Scaling up is faster and sustainable when holistic and integrated approaches are used. Treat aquaculture as a component of the farming system.
5. Scaling up quality entirely depends on the staff and, hence, staff development should be given the highest priority.
6. Scaling up requires an assurance of male and female participation.
7. Scaling up success and sustainability also largely depend on community participation in the activity and, hence, the use of community approaches as appropriate.
8. Scaling up can be enhanced and sustained by using participatory planning, monitoring and evaluation.

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Prepared by:

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# Scaling Up the Impact of Aquaculture: AquaOutreach at Asian Institute of Technology



## Horizontal scaling up through distance extension

The Asian Institute of Technology AquaOutreach Program's (AOP) approach to horizontal scaling up is based upon careful on-farm testing of technologies with representative farmers, i.e., trial and not demonstration. The approach, however, has been at individual farm level, rather than in a group, although several farm trials may have been conducted in a particular village. Technology is modified according to farmers' needs and verified with a larger group of farmers before it is considered ready for dissemination.

However, with a limited budget and a small staff, based in a regional university, the Program has not been able to operate as a separate development project, at least since the beginning of 1993 when it expanded its scope beyond Northeast Thailand. Partly by default, partly by choice, it has had to work through government institutions, which also had very few, if any, extension workers.

In its initial work in Northeast Thailand, therefore, AOP analyzed the extension options available and concluded that for wider dissemination of information, a distance extension approach had to be adopted, with heavy emphasis on the use of mass media. It was important, however, that the medium of dissemination, just like the technology (the message of extension), was carefully designed and tested with farmers. For example, the AOP:

- Tested various forms of mass media in its experimental extension trials,

including television and radio, as well as posters and leaflets.

- Examined which radio channels farmers listened to and when they were most likely to watch TV, to create awareness of the new technical options available.
- Tested draft posters and leaflets both with trial farmers and those who have not been exposed to the project to ensure understanding of the language and pictures used.
- Used the feedback received to make several drafts of the materials before they were declared ready for publication.
- Disseminated the printed materials through non-specialist channels like local schools, health centers and agricultural extension offices (AOP, 1994; Demaine et al, 1994; Demaine and Turongruang, 1996; Turongruang and Demaine, 1997).

The AOP tested this approach in several contexts where it did not have any direct contact with farmers. Results appeared to be remarkably consistent. Follow-up by the staff showed as many as 40% of farmers who received the leaflets followed at least one of the technical recommendations, although many followed the principle, rather than the exact practice. Around 70% were still following the recommendations several years later. Similar results were achieved where extension materials were handed out during training. Of course, such an approach could not specifically target poor people. The assumption is that if a technology has been tested successfully by the poor, having been applied for a number of years, then it should also be accessible to other poor people with the same level of resources. Evaluation, which looked into indicators of socio-economic status, suggested that those adopting aquaculture through this system were no better off than the regional average. Given the amount of materials distributed, AOP estimates that use of carefully developed and tested extension materials, which were based on equally carefully tested technical recommendations, has spread to well over 10,000 households in the region.

## **Vertical scaling-up: Capacity building and provincial networks**

A capacity building approach has been at the heart of the AOP. The program has worked through national government research and development institutions, primarily at the provincial level, to introduce new approaches to small-scale aquaculture research and development and new management systems.

- In Thailand, for example, the AOP acted as the catalyst to draw together the staffs of research stations and provincial fisheries officers into a single system focused on rural aquaculture. Provincial officers do research through on-farm trials while research stations collect data on the social and economic conditions of farmers to establish the focus of their activities.

AIT's Outreach Program's approach has evolved over time through the following phases:

1. Campus-based scientists working individually
2. Teams of natural and social scientists doing field research and working on development problems
3. Teams of natural and social scientists assisting national institutions in capacity-building for institutional development
4. National governments adopt policy changes based on results of field-based research and improved curricula.

By improving and adapting what already exists, the AOP enables systems to be transferred within and between provinces. This is like translating the farmer-to-farmer extension mode described above into aquaculture support services.

- In the Lao People's Democratic Republic, systems were developed in Savannakhet province, which then became the model for Khammouan and Champassak in the north and south. Now a network of six provinces in south central and southern Laos works together in planning, implementing and reviewing activities. A training unit in Savannakhet has developed skills which can serve all six provinces.
- A slightly different mode has developed in southern Vietnam, where AOP's initial phase of operations concentrated on building capacity at the Faculty of Fisheries in the University of Agriculture and Forestry (UAF) in Ho Chi Minh City. The UAF group slowly expanded project activities to several provinces in southeast Vietnam, which now constitute a network that develops and sets the annual work program, with technical backstopping from the university. With limited resources, the provinces are now seeking ways to expand the initial experience to wider groups of farmers.

The next step is the adoption of the approach as national policy. In the case of the AIT Aqua Outreach Program, the evidence that the technical recommendations can have a positive impact on the livelihood of small farmers and that the approach is appropriate given the resources available to local administrations led to a growing acceptance by policy makers that the model can be adopted as national policy. (Demaine and Edwards, 1998)

- In the Lao PDR, the Regional Development Committee has been designated as the organization responsible for developing a strategy for the livestock and fisheries sector in southern Laos.
- In Cambodia, evidence offered by AOP and similar projects have persuaded the Department of Fisheries to establish a separate Aquaculture Office to consolidate efforts in the sector.
- In Vietnam, the work of Aqua Outreach and the United Nations Development Program (UNDP) has led to the formulation of a strategy for Sustainable Aquaculture for Poverty Alleviation in the Ministry of Fisheries.

The acceptance of this approach as policy has been based on a clear demonstration of impact and relevance through pilot projects, not through advocacy of such approaches at national level.

## Conclusion

The two dimensions of scaling-up – horizontal and vertical – involve the testing of possible technologies with the participation of farmers to make sure the innovations are acceptable to clients before they are disseminated through farmer-to-farmer interaction.

In AOP, the trial has been on an individual farm basis. Extension materials were later produced using the results from the trial and with farmer participation. Like the CARE project described in another paper, the extension effort involves non-specialists in the on-farm research dissemination process. Both projects recognize the need to develop networks for vertical spread. In AOP's case, the project works within the government system, emphasizing capacity building at provincial and district levels to reach small-scale farmers on a country or region-wide basis.



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Prepared by:  
**Harvey Demaine**

# Participatory Approach to Extension and Training in Aquaculture



The fundamental objective of extension is development which is not limited to physical and economic aspects alone. Extension emphasizes development of peoples' overall capacity to help themselves. One such successful extension approach is known as the **trickle down system** (TDS) of aquaculture.

## Genesis and concept

Experience gained from extension services of the food farming sector indicated that, in addition to a dedicated and efficient extension services network, an appropriate extension approach is also needed to provide a definite direction to the program operation and to amplify its impact.

The approach was designed based on two core principles:

1. Get closer to the client groups and get a firsthand insight of their socio-economic settings, farming practices, level of knowledge and skills, needs, opportunities and constraints.
2. Foster participation of the client groups in planning and implementation of the

agreed program.

### **Trickle down system (TDS)**

This approach was developed and successfully demonstrated on a limited scale in Bangladesh through the FAO/UNDP project "Institutional Strengthening in the Fisheries Sector" in 1990-1993. The approach was piloted in 52 (out of 64) districts of the country in 1994-1996 through the FAO project "Strengthening Pond Fish Culture Extension". The pilot project helped to fine tune the approach. Subsequently TDS was applied on a national scale by the Department of Fisheries (DoF) in Bangladesh, Northern Vietnam and some parts of Sri Lanka.

The TDS approach is a participatory, farmer-to-farmer extension approach, which involves bottom-up participatory planning and implementation of the extension program. This results in the "trickling down" of knowledge and skills of improved technology from result demonstration farmers (RDFs) to fellow fish farmers (FFs).

## **Clientele**

Families with their own pond or any other type of aquaculture facility or have access to such a resource.

## **Functional design**

- Once a site is identified, village communities and opinion leaders/social workers, including progressive farmers, are approached and a local level assembly is organized in the form of a field level training session. This method was subsequently replaced by a combination of rapid rural appraisal (RRA) and field training. Finally it was found that the participatory assessment, planning and action (PAPA) approach at individual and community levels was more effective.
- By using the PAPA, a broad participatory assessment is made of the size and type of aquaculture resources, local availability of essential inputs, range of farming practices, local farming skills, ability to mobilize the extraneous inputs, constraints, etc. With this information and giving due consideration to the existing socio-economic environment, a plan is prepared for development through aquaculture. Measures are discussed to improve existing practices. In addition, the appropriateness of certain alternative technology packages is assessed.
- Before a planning workshop or training is organized, it is made clear that no form of monetary incentive can be expected.

- Once the plan is prepared, one or two RDFs are selected by the group to undertake an improved/appropriate culture technology trial. The rest of the participants are designated as fellow farmers (FFs). They watch and wait for the outcome of the trial. Again, before the RDFs are chosen, it is made clear that, except for on-site training and technical advice, no material or financial support will be given to those selected. This is meant to avert future complications and ensure sustainability of the activity.

- Adequate extension support is given to the RDFs through repeated short-term instructional training and periodic home/site visits to demonstrate the improved aquaculture technologies in their ponds. RDFs get on-site practical training using method



demonstrations at least two to three times in the course of a complete cropping cycle. Home/site visits are made once or twice a month depending on the specific need and nature of the culture practice. Participation of both men and women family members is ensured.

- Emphasis is also given to developing leadership qualities as well as technical and extension skills.
- Once the crop attains a presentable stage, RDFs are encouraged and assisted in organizing practical trainings for the FFs by demonstrating the various steps of culture technology. The role of the RDFs is constantly highlighted and appreciated, enhancing his/her status in the community. This was a valuable incentive for them. RDFs were, thus, groomed as voluntary extension workers of the Department of Fisheries (DoF). This inspired the RDFs to take more interest in propagating the aquaculture technology in their area.
- In subsequent cropping cycles, some FFs came forward to take up the culture practice and act as demonstration farmers, thereby becoming RDFs, with their own FFs. This process continues in the locality with little support from the extension services system.
- Extension training tools and materials were specially designed to make the training more participatory, effective and useful.
- Certain incentives were given to RDFs in the form of medals, public felicitations, etc., in recognition of their services to the farming community. This encourages them to take up extension work as a social responsibility.

- The process emphasizes the facilitation of the learning process. Instead of using the conventional technology transfer method, extension volunteers are encouraged to "walk the learning path," think and try new ideas for improving their farming practices and facilitating collective development actions. When farmers and communities are involved from the very beginning, they become active partners in the implementation of programs. This approach prevents the entry of vested interest groups that would mislead and exploit the farmers.



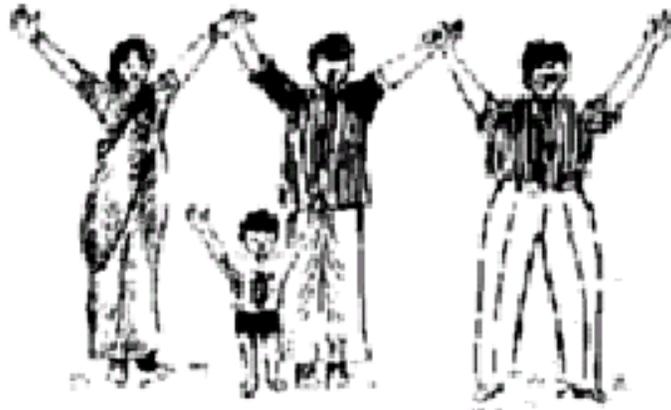
The approach helped inculcate an "extension" culture among the senior and field-level staff of the DoF and institutionalized the department's aquaculture extension services system. It is worth mentioning that unlike the agriculture sector, where the primary activity is extension, the fisheries sector has multi-faceted responsibilities ranging from management of fisheries and aquaculture resources under state/public ownership such as rivers, lakes, reservoirs, flood plains, etc.; enforcement of fisheries acts and regulations; and providing extension services to farmers and fishers. Most of these resources are in remote places, not easily accessible to the public transport system. With RDFs serving as local extension volunteers, the pressure on government extension personnel is reduced. This approach, based on "farmer to farmer" principles, was used for the first time in Bangladesh and was received positively by government and non-government organizations (NGOs).

## **Local variation in**

### **Vietnam**

The approach takes advantage of the strength of existing local level community

institutions by involving them in participatory extension activities. Various organizations such as Women's Union, Youth Union, Farmers' Association, and People's Committee are strong and active even at the local level (commune). A commune action group (CAG) is organized to develop aquaculture in the community. It is composed of one member from each of the existing local organizations, including one local aquaculture farmer. CAG members are trained in participatory resource and constraints assessment, planning and action for individual and cooperative level initiatives to develop aquaculture. After training, CAG members take the lead in organizing a commune level participatory planning exercise and select Demonstration Farmers. This approach is being used in the "Aquaculture Development in Northern Uplands" project in Vietnam of the Food and Agriculture Organization and United Nations Development Program (FAO/UNDP).



The impact of this extension approach was demonstrated by the FAO-TCP project prompting the Government of Bangladesh to launch a five-year nationwide project exclusively through national funding. An inter-ministerial evaluation was conducted during the last phase of the project. The group was highly satisfied with the program and its impact on the development of pond aquaculture in the country. Based on the body's recommendations, another five-year phase is now being implemented and will be integrated into the Department of Fisheries as a regular activity.

## **Local level variation in Sri Lanka**

In Sri Lanka where seasonal tanks hold vast potential for the development of inland aquaculture, TDS is largely a group-to-group approach. Local communities involved with any specific seasonal tanks are organized for planning and development of aquaculture through collective actions. Other groups associated with nearby seasonal tanks are invited to observe the development process and plan their development program in the subsequent season.

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Prepared by:

**A. K. M. Reshad Alam and Kevin Kamp**

# A "Farmer Field School" for Aquaculture



Many extension strategies are limited to demonstration of technologies or providing advice via workshops and individual farm visits. Often the fundamental issue is a technology that has been packaged for farmers. Farmers are required to remember and replicate these systems on their farms. This may be one of the primary reasons why aquaculture successes have spread more slowly than expected.

It is about time that an alternative model of extension is considered, one which encourages a holistic understanding of aquatic ecosystems, and embraces farmers as partners in technology development. The alternative approach should address livelihoods and empower farmers with greater planning, monitoring and decision-making abilities. This can be achieved through a "farmer field school" approach to aquaculture.

## **Production technologies: refocusing on the basics**

Many aquaculture technologies in Bangladesh are promoted in a conventional manner, focusing on how to increase yields. The approaches do not consider the current level of knowledge, capabilities and opportunities of small-scale farmers. Too often, the technology focuses specifically on systems that require high levels of external and internal inputs (piscicides, supplementary feeds, inorganic fertilizers, etc.) applied in a very specific manner.

Extensionists will do well to contextualize the content of their demonstrations and the methodology they use to ensure their relevance to the situation of farmers they work with.

By listening and learning from the farmers, extensionists can recommend those techniques and technologies most suited to the farmers' situations.

Rather than introducing a predetermined technology and its accompanying practices, providing farmers an array of practices to choose from generally results in greater adoption rates. Farmers can select and adapt those practices that suit their own unique needs. They are actually involved in the development not only of the technology system, but of the practices that define it.

Alternative approaches help the farmers gain a fundamental understanding of aquatic ecology. They can then work with the extension professionals to design, implement and evaluate the impact of potential new practices and to develop appropriate, farmer-specific technologies. Learning approaches should be experiential, discovery-based and need-driven as well as tailored to the goal of transforming farmers into experts of their own aquatic systems. The first step in this transformation is to help farmers understand the aquatic system.

## Farmers as experts

Farmers can be experts of their own ponds. What would it take to make them experts?

- 1. Extensionists must believe that farmers can be experts.** Without this fundamental belief in the capabilities of farmers, it is unlikely that a program to enhance their abilities will succeed.
- 2. Rethink technologies and practices.** Focus learning efforts on understanding the basics of aquatic ecosystems.
- 3. Make the invisible visible.** Develop methods that will allow farmers to actually see, feel and hear what is going on under the surface of the water.
- 4. Provide opportunities for farmers to put concepts together.** Develop possible practices and technologies and test them with the farmers as a group . Encourage farmers to set the research agenda. This may mean ensuring a number of small pits, ditches or ponds are available. Planning, implementing, monitoring and evaluating together can be a powerful experience for farmers and can provide them with valuable skills. Group work also acts as an information, education and communication tool. More people will be reached by this method and will want to take part in the learning process.

**5. Develop strong management tools that farmers know how to use.** Farmers need tools to quickly and easily monitor the "health" of the pond, the results of which will encourage and support management decisions.

**6. Enhance farmers' expertise to ensure the sustainability of aquaculture and institute a process by which farmers take the lead in innovation and development of new technologies.** The role of the extension worker will be to support the farmers' learning opportunities on a regular basis.

Extensionists have to learn how to communicate more effectively to enable farmers to easily grasp the alternative practices (and hence learn what is best for them).

By demonstrating and asking the farmers to carry out simple practical "experiments" and by giving concrete visible examples, farmers can quickly grasp the philosophy behind a new technology/technique being introduced.



By listening to and learning from the farmers, the introduction of new technologies would be much simpler and enjoyable. Both extensionists and farmers will easily notice that the new technologies do result in higher levels of yield and profit and actually match the goals and specific resources of individual farmers.

## **Discovery-based, experiential learning**

1. Farmers learn the effect of fertilizers on phytoplankton

Farmers easily discover this when asked to do the following.

- Put some water in a number of plastic jars.
- Add different types of fertilizers and manure to each plastic jar.
- Experiment with different amounts of fertilizer and manure in each jar.
- No fertilizer or manure should be put in some of the jars, which will serve as

control jars.

- Expose the mixtures to sunlight for four to six days. By carrying out this simple experiment on his own, a farmer will learn about the impact of organic and inorganic fertilizers on phytoplankton growth. He may even go so far as to test the nutrient levels in his pond's water by adding various doses of different nutrients to see which has the most impact on phytoplankton growth. He can document for himself if indeed nitrogen is not limiting and phosphorus is.

2. But so what if he can produce more phytoplankton?

The farmer now needs to understand how phytoplankton is consumed by the fish or how it increases the production of zooplankton (next organisms up in the fish food chain). To test this: Ask the farmer to put zooplankton in plastic jars with the fish and to observe closely to be sure that the fish are actually eating the organisms.



3. Farmers learn the benefits/effect of using lime over water

Apply small amounts of diluted lime in plastic bottles containing different types of water generally found in the village (e.g., turbid water, polluted water, water with a high organic level, etc.) After applying the lime into the bottles, the farmers should be able to observe how, in 10 minutes, different types of water become clear. This exercise should strengthen their belief that lime can purify water.

4. Farmers become empowered to make the best decision on managing predators and small fish

Help farmers learn about the range of predatory fishes that exist in ponds by sampling small pits in rice fields. Farmers will be able to learn about the diversity of species found in small water bodies. They will find not only fish species, but various snakes, insects, and other benthos organisms in such dynamic water bodies. By draining a small pit and removing the fish, they will understand the impact of drying such an aquatic ecosystem and how quickly it is reestablished with invertebrate and vertebrate organisms. By netting the pits before they are drained and dried, farmers will also learn the efficiency of netting to remove predatory and small fishes, and how many times it had to be done.

5. Farmers will only be able to decide on the best supplementary feed to use if they

are provided with pits and small ditches where they can experiment

The recommended supplementary feed items in Bangladesh usually involve rice bran and oil cake. Both can be expensive and might not actually be needed. How does a farmer decide?

The use of small ditches where groups of farmers can plan, implement, monitor and evaluate their own experiments is important, not only for learning specific concepts, but for putting together practices based on these concepts, trying them out in the real world, and continuing the learning process long after the extensionist has moved to another district. Design and observation skills are critical for this process.

### **Remember!**

It is important to use methods and examples relevant to the farmers' situation that they can relate to. This will increase their self-confidence to make observations and decisions based on the observations. Their observations and experiences will enable them to calculate doses and to learn about the appropriate types/levels of fertilizers to use in ponds.

Farmers, who want to evaluate the effectiveness of rice bran and oilcake compared to pond fertilization food production strategies, would need a place to do it. They can discover the real answer for themselves depending on the quality of the pond.

### **Conclusion**

A "Farmer Field School" approach is an empowering process to enhance the decision-making capabilities of farmers. Through the process, farmers can relate to the technology that the extension worker is trying to introduce. This approach requires that farmers be recognized as experts in their own ponds.

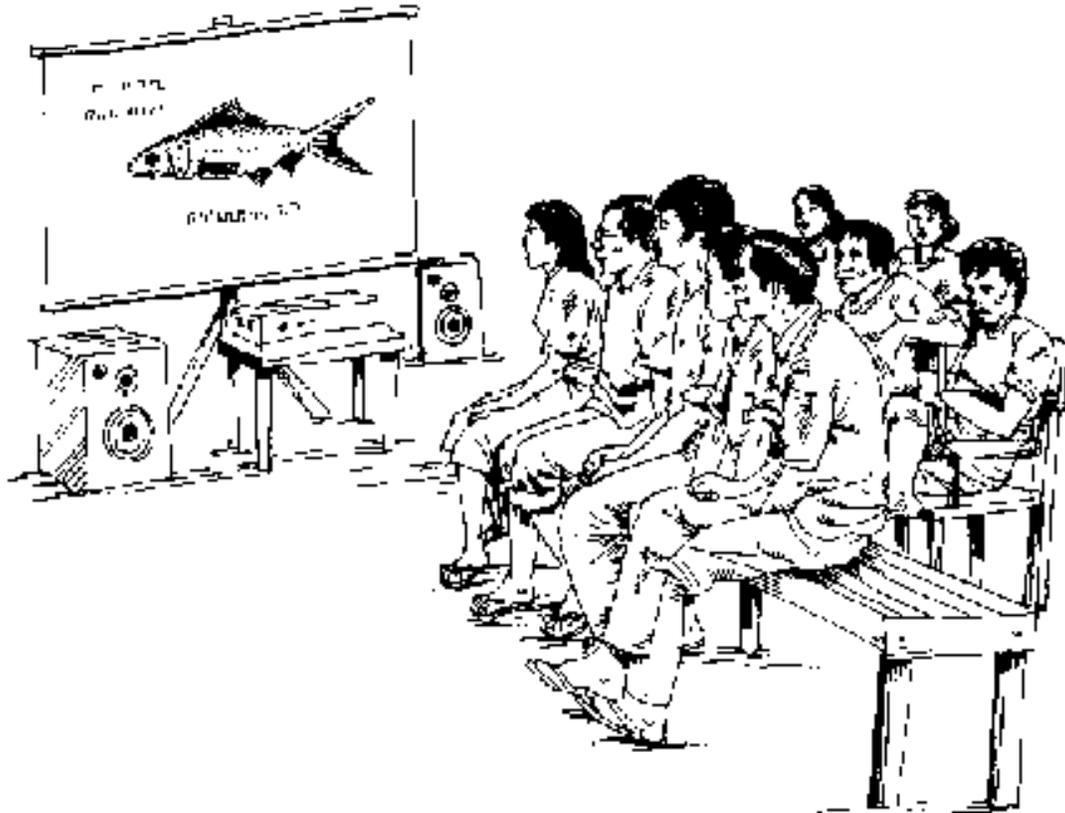


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# Aquaculture Development and Information Processes



The challenge in aquacultural development is to assure and be able to verify that target populations have actually benefited from such efforts. Even successful programs have had to face these challenges. Enough poor results exist to justify a brief examination of the previous and current models and processes for aquaculture development.

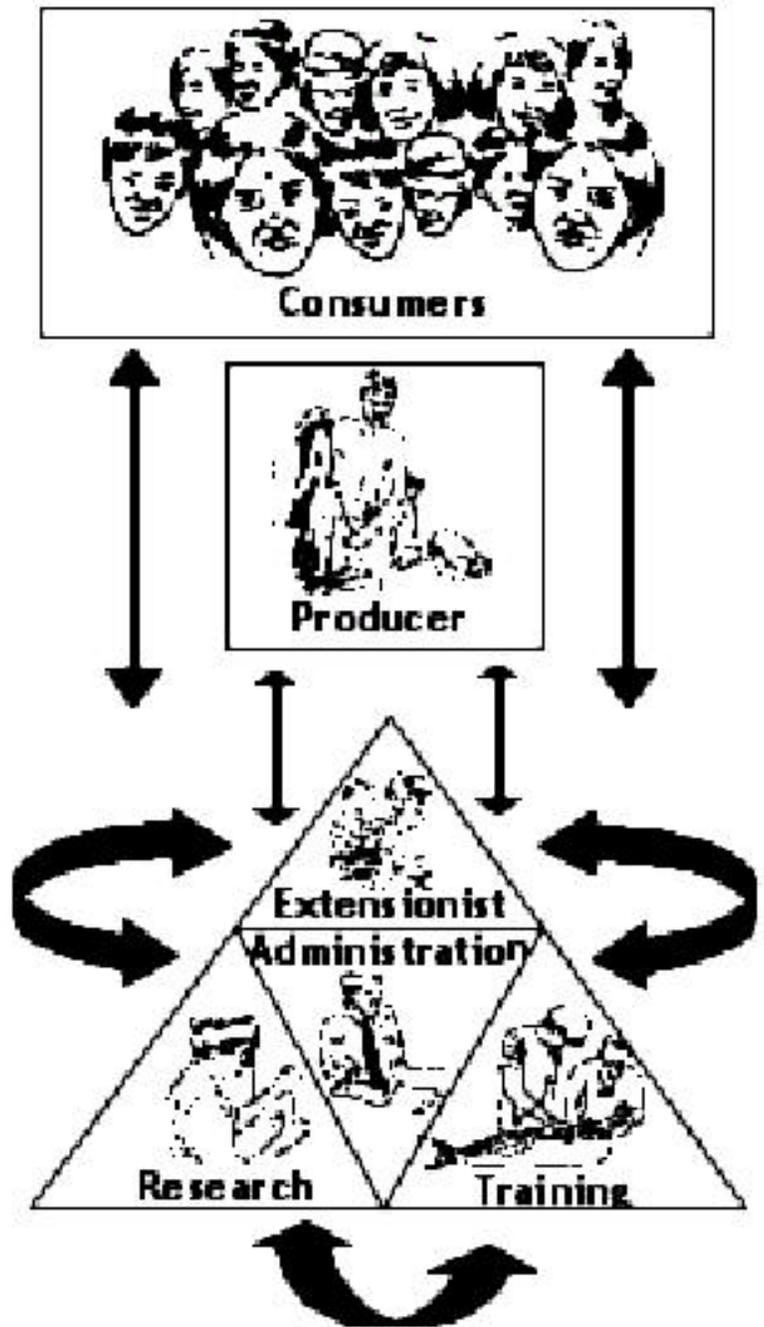
## **Causes of failure**

There are plenty of examples of the failure of aquaculture development efforts to live up to expectations in spite of the good intentions of those who designed and implemented the projects. In some cases failure resulted from inappropriate technology (e.g., trout facilities in the tropics) or lack of appreciation of the complexity of farming systems in which aquaculture is to be introduced (e.g., assuming labor or animal wastes do not have competing opportunities). More often, however, failures are linked to external forces (e.g., breakdown in law and order) or the inability to cut through ineffective and under-funded governmental systems (e.g., failure to release budget support on time).

Another problem is failure to build a comprehensive system needed for aquacultural development. The following diagram is a conceptual model of a holistic system that highlights the interconnectivity of different elements and functions. Any specific development effort might address part of the model but ultimately, all the supporting functions must be addressed for an aquaculture industry to be sustainable.

An extension system can be temporarily enhanced but without an effective training mechanism to bring new people into the system and a research source to infuse new and proven technology, it will eventually collapse. Similarly, research needs new scientists from training programs and, in turn, should provide updated information to keep education relevant. Research-based aquaculture technology is vital to guide extension, education and development efforts. It is also essential to have an administration system that provides an environment that allows the different functions to operate, including the legal framework and public infrastructure.

The model should make it clear that the support systems have to be sustainable. All too often a program that is introduced, often with foreign assistance, runs for a few years then fades at the end of the project. Program planners are generally aware of



the problem but political urgency and unrealistic expectations about the pace of development and institutional capabilities undermine the sustainability of support functions.

Another problem is where and how support assistance is spent. Salaries, allowances, and overhead charges for specialists from the more developed countries can eat up a good portion of foreign development support. The program processes imposed by donor agencies can also be formidable and costly. Off-shore training of local scholars can be very expensive, time consuming, and may contribute more to the brain drain than to home country development. Many host country governments are notorious for their cumbersome bureaucracies (a feature also of some donor organizations) and sometimes outright graft. The net result is that little of the support actually trickles down to the truly needy.

## **Paradigm shifts**

Past efforts to develop small-scale aquaculture have generally focused on helping rural poor and landless people, with particular emphasis on production and nutrition. Although these are important considerations, development planners are now thinking more in terms of profits and enhanced business success. An aquaculture product may be too valuable for a farmer to eat, but the income from its sale may enable the farmer to purchase other items such as health services, education for children or less expensive alternative food items, and to enhance their livelihood and help them overcome poverty.

## **Information**

**delivery**

The question really is what does it take for a resource-limited person to take advantage of the inherent opportunities of small scale aquaculture and how can the information be delivered efficiently? This assumes that small-scale aquaculture is economically viable in that particular setting, that soil, water and climatic conditions are not limiting, the technology is within the grasp of the adopter, there are markets, credit, seed stock, feeds or fertilizers, etc. All these factors, along with social considerations like water use rights, poaching risks, labor demands and so forth, should be considered before pushing for aquaculture development.



One problem in development work is defining who should convey new information to farmers. In America, the land-grant university system has this responsibility and most countries, to some extent, charge their agricultural universities with some rural extension work. In the less developed world, typically this responsibility is given to some ministry or ministries like the Ministry of Agriculture. The agencies are often under-funded and ineffective in actually getting out and among the rural constituency. Official development assistance is often restricted to government channels. This is where external money goes (and sometimes siphoned off). A thriving NGO system has developed in some countries to help facilitate rural development through outreach and credit activities, particularly where public programs have left a void.



A participatory approach, now considered essential, suggests asking the potential adapters how they would like to learn about and assess the opportunities for them in small-scale aquaculture. Establishing a continuing presence and an effective feedback mechanism can also lead to building information transfer processes. Working with groups such as a village women's organization may help facilitate the processes.

The classical "extension method" suggests that the first step is to create an awareness that such possibilities exist. Traditional approaches include mass meetings, information leaflets, media programs, on-farm demonstrations and gatherings, etc. Working with groups may be the only approach that is practical and efficient .

There is a whole discipline dealing with extension education and lessons learned from that discipline should be understood and incorporated into rural development planning.

It is one thing to work with college-educated farmers and another to work with landless peasants. In many places, the latter have low literacy rates, little formal education and limited exposure to mass media. The resources they bring to the tasks of aquaculture are basically their hands and perhaps some traditional knowledge picked up from their rural upbringing. Obviously, strategies to



create awareness have to be tailored to the prevailing conditions in the target area.

The time honored approach of guiding an "opinion leader" type person, perhaps one selected by a community through a participatory process, to adopt a given practice and share his experience with neighbors is still regarded as a good method for creating an awareness in a community. Sign boards, portable loud speakers, radio and television programs and curriculum models for schools have also been employed.

A recent study in Bangladesh (FEED), for example, asked fish farmers where they got their best advice. The most credible source identified was government personnel but it turned out that actual contact with government agents was minimal because they were few and were being diverted to functions other than extension outreach. Another project in the same country involves small fry/fingerling dealers in the belief that virtually every fish farmer comes in contact with them as they procure fish stocking material.

In more industrial societies the private sector may also get involved both through vertical integration and market development. Thus, a fish feed manufacturer may have his own pond production facilities and also guide other farmers to assure their success and to expand his market for the feed.

Where many interests promote aquaculture, there might be some contradictions on recommendations about how the farming should be done. Unscrupulous and ill-informed promoters are all too common in the aquaculture world. Poor peasant farmers are generally ill-equipped to sort through conflicting claims and tend to take the conservative approach of not changing their practices when their tolerance for failure is very low.

Subtle cultural features may help or destroy the effectiveness of the information transfer process. In the design of one project, for example, the purchase of bicycles for extension agents was discouraged because the mode of transport lowered the agents' social status and credibility in the rural communities. It was better to have the money for public transportation and to walk than to ride a bicycle in this particular setting.

The type of person charged with extension responsibilities is also very important. Some personalities are just better at some tasks than others. Technical knowledge and experience are desirable but these must be coupled with personal characteristics suited to the tasks of information transfer. Local individuals historically have had the most success as "farm agents" assisting with the adoption of new farming practices.

Although there is some appreciation of information transfer processes, they are often poorly implemented, partly because the resources just do not trickle down adequately to support farmer-level operations. Outreach efforts have to assess where resources are spent and to ensure that field people and their operational needs are given priority.

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Prepared by:  
**John Grover**

# Rural Aquaculture Development and Mangrove Conservation Projects (Initiated by Fishers in Collaboration with Various Institutions in Sri Lanka)



This is a story on the positive impact of a unique and successful partnership between local communities, NGO's and government institutions that launched recently a major program for the development of the aquaculture industry in Sri Lanka. The uniqueness of the approach lies in its eco-friendly rural aquaculture development projects aimed at the rural poor.

The present per capita consumption of fish in Sri Lanka is estimated at 18 kg per year as against a required average of 21 kg per year. Faced with communal disharmony in the North and East of the country, fish flows and transportation to the cities and other parts of the island have decreased. As many villagers do not have easy access to the high seas, the only fish available for the rural poor is, decidedly, freshwater fish.

Linkages have been established among the following organizations in an effort to boost the local production of fish: the Small Fishers Federation (SFF), a non-government organization (NGO); the National Aquaculture Development Authority of Sri Lanka (NAQDA), a statutory body under the Ministry of Fisheries and Aquatic Resource Development (MFARD); and the Food and Agricultural Organization of the United Nations (FAO).

The SFF grew from a development network set up in 1984 called "Fisher Folk-Based NGOs". The federation, funded by NORAD (a Norwegian government agency), played a pivotal role in the national food production program in the country and achieved optimum results through a community-based participatory approach. It effectively expanded and grew, becoming a Federation, through active participation. It has launched many beneficial programs such as crab culture and mangrove conservation projects in the northwestern province of Sri Lanka. Thus, SFF is rich in experience that can be shared with grassroot level organizations worldwide.

### **Reasons for success**

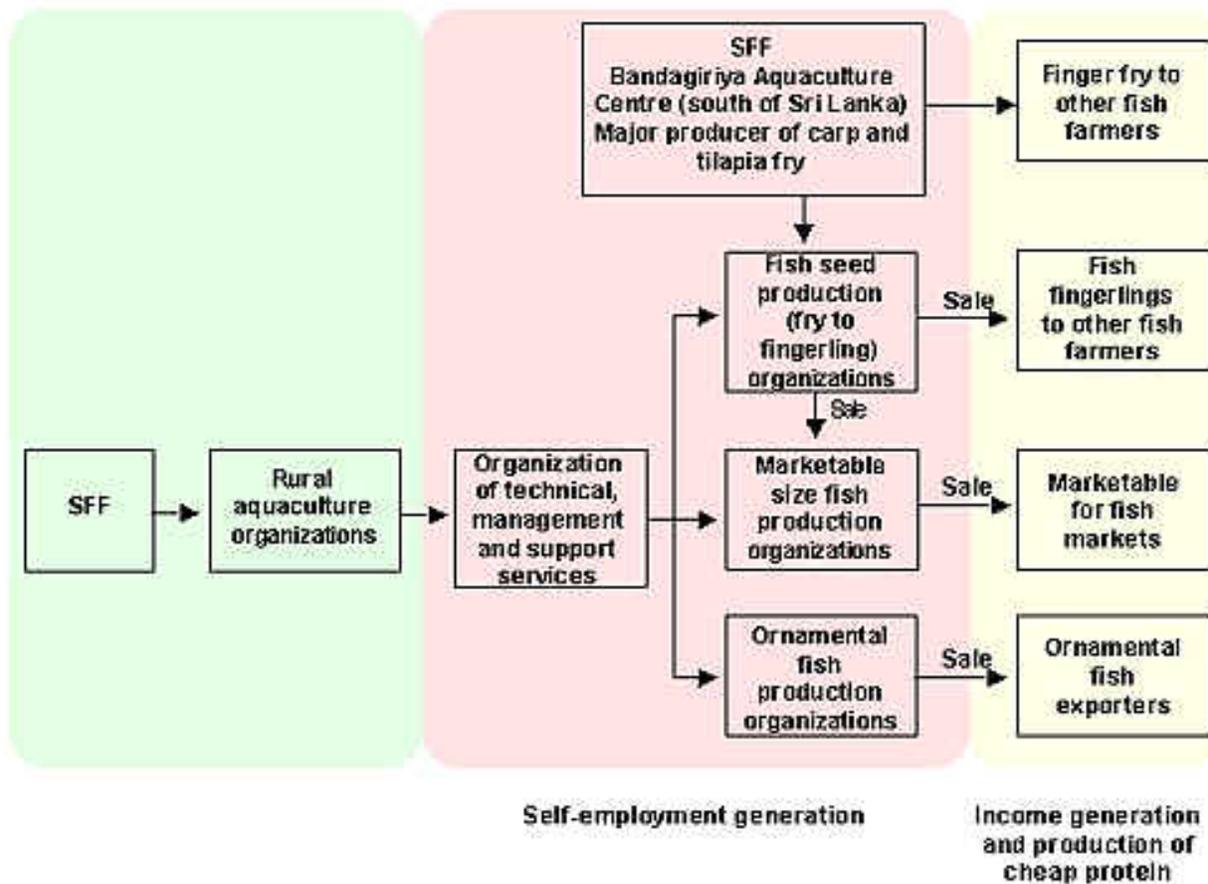
- Honesty and good leadership qualities demonstrated by SFF members
- Wise use of credit funds
- Proper site selection
- Application of appropriate (farmer-friendly) training methodologies

At present, the SFF, together with government institutions, actively seeks community participation and extends assistance in solving individual and communal issues in the field of fisheries through the development and conservation of aquatic resources in island waters, coastal wetlands, offshore areas and the lagoons.

SFF's success stems from the strong institutional links it has formed with government and semi government institutions. The first step in this strong partnership was MFARD's waking up to the reality of the severely limited and rapidly declining fisheries resources. It decided to collaborate with SFF. MFARD, finding that the SFF had a wide fishing community network on the island, formally invited the Federation to participate in the national endeavor to improve aquaculture fisheries. This was indeed a giant step. Before 1994, NGOs and communities working with government departments was unheard of in Sri Lanka .



Another milestone was a comprehensive legislation, the amended Fisheries and Aquatic Resources Act of 1996, which contained measures for "protection of fish and other aquatic resources" and raised concerns about the "sustainable use of aquatic biodiversity" in the fishery sector.



However, the rural poor were not actively involved until 1999 when NAQDA was established. NAQDA invited NGOs and the private sector to participate in its aquaculture projects. Although NAQDA works with many NGOs, such as Seva Lanka (Service to Lanka), Sri Lanka-Canada Development Fund and SFF, it is their partnership with the latter that proved to be the most successful.

Of the many functions of NAQDA, the following are important for rural poor communities with access to communal waterways:

1. Promotion of the optimum utilization of aquatic resources through environmentally-friendly aquaculture programs.
2. Conservation of biodiversity.
3. Promotion and development of small, medium and large-scale private sector investment in aquaculture.

By actively seeking and inviting NGOs and rural communities to take part in small-scale aquaculture projects, an immediate sense of ownership was fostered. Projects started with a transfer of skills and technologies. Training kits were provided to participants. Technical support was extended to this government/NGO partnership with the implementation of the FAO/TCP/SRL/6712(A) – Aquaculture Development Project. The Inland Aquaculture Consultant of this project assisted the rural development program by training trainers, providing on-the-spot technical advice, helping in the design of mini-hatchery projects, and promoting innovative strategies.

One of these strategies was the promotion of low-cost carp production in undrainable ponds enabling the rural poor to gain additional income by selling carp fingerlings. (For additional information on this project refer to the paper on *Low-Cost Aquaculture in Undrainable Homestead Ponds*). Small-scale aquaculture in mangroves is now being promoted by providing support to poor coastal communities to start small-scale coastal aquaculture technologies.



The Small Fisheries Federation (SFF) recognized that mangrove reserves were strategically important for many species including various types of fish, aquatic birds, shrimp, crab, mollusks and worms. The destruction of mangroves had adversely affected the local resident fishermen in these areas, with their daily hauls of fish in the Pambala lagoon in the north east coast drastically dropping on an average from 4 kg to 1½ per day in the past three years. Also, the proliferation of unauthorized shrimp farms in the area posed a major threat to indigenous fishery in the Puttalam district (It was said that one third of all shrimp ponds were located on former mangrove land resulting in the loss of about 600 hectares of mangrove forest).

Responding to a request to form a working-alliance by actively networking, building links and seeking support, the Small Fishers Federation, Mangrove Conservation Center, Pambala, Chilaw formally affiliated with the Mangrove Action Project (MAP) based in Seattle, Washington. The center was designated as the MAP-South Asian Resource Center Facility in Sri Lanka.

With assistance from the FAO and extensive pilot tests, NAQDA was able to effect the technology transfer of three successful small-scale aquaculture projects in mangrove ecosystems:

- mud crab fattening in wooden cages with PVC netting and culture in ponds;
- sea bass/grouper culture in cages; and
- mollusk culture

The future is looking very bright indeed for this unique collaboration. Right now there are only three NAQDA-owned fish breeding centers and demand is much higher than supply. The project cannot supply the requirements of the entire island. Aquaculture projects of the rural poor have a huge untapped potential market.

## The Mangrove Conservation Center



- SFF Staff and members of a nearby local fishing community collaborate in running this Center. Community members actively participate in mangrove reforestation projects and small-scale silvi-culture including crab and oyster culture.

- A graphic description of the Mangrove Conservation Center's activities in the past two years (1998-1999) is displayed on a large board. It proudly announces the planting of 144,000 mangrove saplings at the Pambala lagoon area.

- The Center has become an active educational/training facility and a meeting place where fisher groups and academics often gather.

- A total of 186 seminars and conferences have been conducted with the participation of 9,000 school children, 860 government officials, 900 fisherfolk leaders and 500 mangrove lovers.

- Cooperatives formed by widows manage small revolving bank loans. Local school children learn coastal ecology and acquire natural resource management skills.

- The center has mounted 15 exhibitions depicting mangroves, with a total of 27,000 students attending, together with some government officials and mangrove specialists. Some 2,500 fisherfolks participated at the exhibitions.

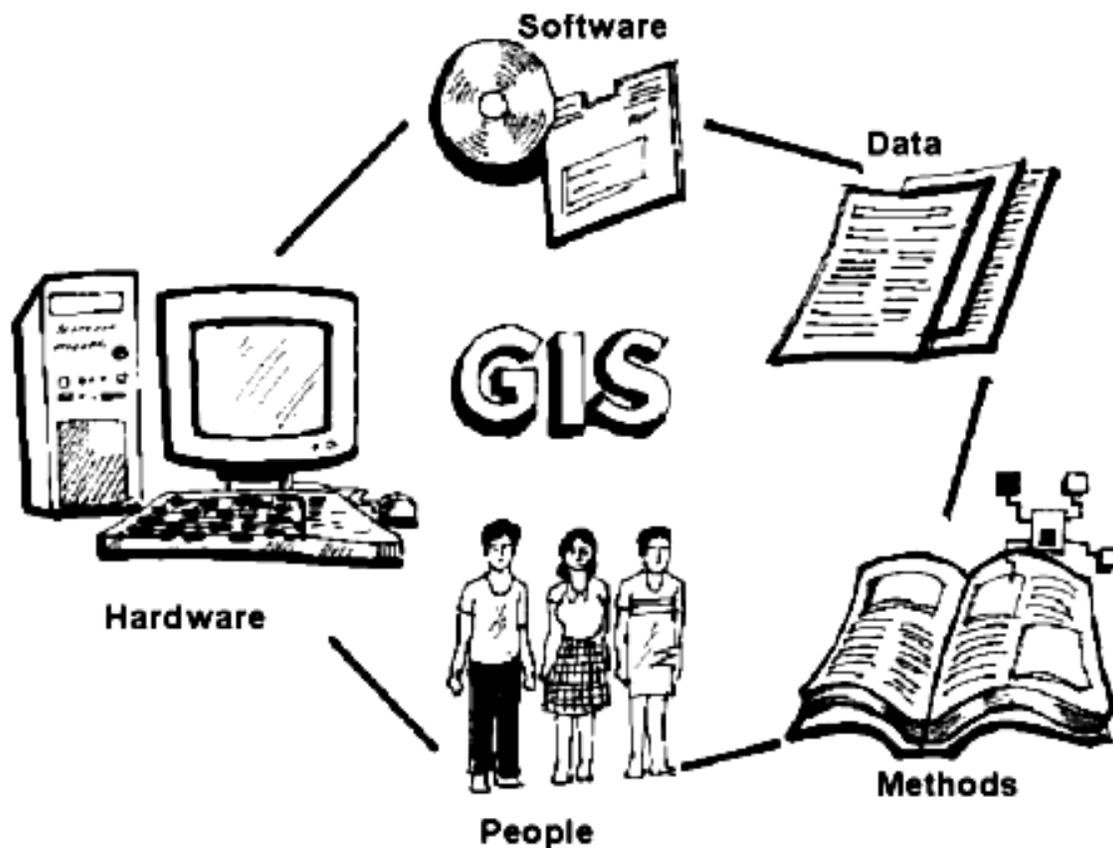
- Seven research projects have been carried out to date.

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Prepared by:

**Christie Fernando and R. K. U. D. Pushpakumara**

# Use of Geographic Information Systems (GIS) for Planning and Management of Aquaculture



Maps have been in existence for thousands of years. However, in their traditional form, they suffer from a number of problems. First, maps are static and therefore difficult and expensive to update. To cite an example, maps exist as single sheets. In most cases, an area of interest lies on the corner of four adjacent sheets. In addition, maps are often very complex and an expert may be required to extract a particular data.

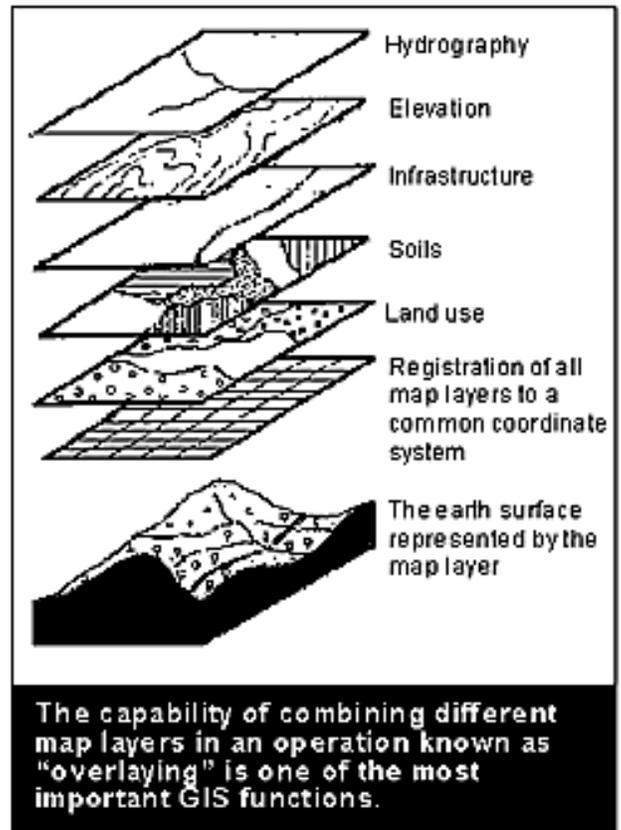
Geographic Information Systems (GIS) can be regarded as the high-tech equivalent of a map. GIS provide the facility to extract different sets of information from a map (vegetation, soils, lakes, roads, settlements, etc.) and to use these as required. This provides great flexibility, allowing a paper map to be quickly produced.

Geographic Information Systems (GIS) portray the real world. A view of the world as represented on a paper map reveals that the surface consists of points, lines or polygons. Thus, cities are usually represented by points, roads by lines and lakes or fields by polygons.

The difference between a paper map and a GIS map is that in the latter information

comes from a database (i.e., set of data stored in a given file) and it is shown only if the user wants to see it. The database stores information like where a point is located, how long a road is, and even how many square kilometers a lake occupies.

Each piece of information on a GIS map sits on a layer, and the users turn the layers on or off according to their needs. One layer could be made up of all the roads in an area. Another could represent all the lakes in the same area, yet another could represent all the cities. More importantly, a GIS combines layers of information about a place for a better understanding of that area. Determining how the layers of information combine depends on the user's needs. For example, to find areas with potential for fish farming, it would be necessary to combine data like water, soil, land use, markets, cities, roads and population density.

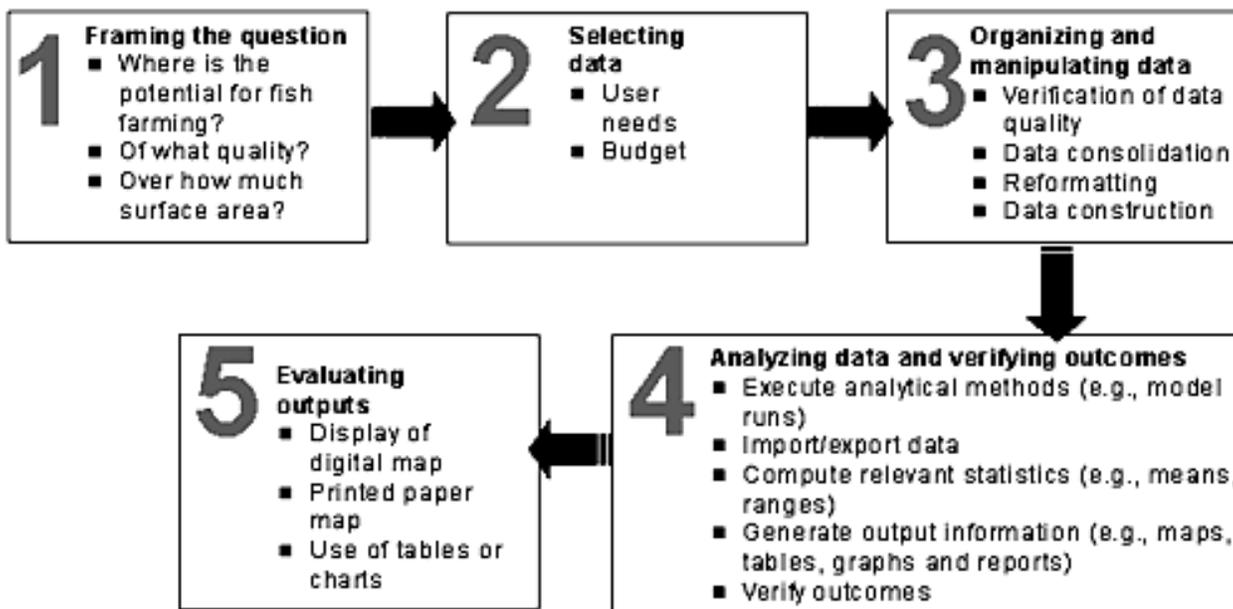


In both vector and raster systems, a geographic coordinate system is used to represent space. Many coordinate systems have been defined, ranging from simple Cartesian X-Y grids to spatial representations that correspond to the real world as latitude/longitude pairings.

GIS has the potential for an enormous range of applications (e.g., business, defense, education, engineering, government, health, food security, transportation, natural resources, fisheries and aquaculture).

## Analysis methods

Basically, any GIS study consists of five phases.



## Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. It ranges from low-end software for simple map display to high-end software capable of handling sophisticated models, Internet mapping and 3D visualization.

### Factors in selecting GIS software

- Intended use of the chosen application
- Software and maintenance cost
- Software "learning curve"
- Current technical expertise of agency personnel

### Software availability in Asia

GIS have developed rapidly in recent years. This development has been paralleled by a massive increase in low-cost computing power. As a result, very comprehensive tools for handling GIS data are now available to a wide range of users.

A large number of GIS software are available ranging from free easy-to-use software to highly sophisticated and expensive packages. Countrywise, GIS activities and major GIS software vendors in the Asia-Pacific region can be located at: <http://www.gisdevelopment.net/regional/>. Available on the Internet at present are some free and easy-to-use GIS software such as Arc/Explorer (<http://www.esri.com/software/arcexplorer/>), and Windisp4 (<http://www.fao.org/giews/english/windisp/windisp.htm>).

An important consideration is that if an expensive GIS software is chosen, its cost

declines substantially as the tools and techniques are used for additional projects and data are shared among different departments (e.g., fisheries, agriculture, forestry, etc.).

## Hardware

Hardware selection must relate to personal preferences, software, functional requirements, capital available, number of users, and the degree of interaction with other computer systems.

The hardware components of a GIS include units that are common to any general purpose.

- Computer such as several disk drives for storing data and programs
- Tape drives for back up copies of data
- Color graphic display units
- Other general purpose computer peripherals

In addition, GIS have several specialized hardware components. These include: digitizer or scanner used to convert the geographical information from maps into digital form to be sent to the computer; a plotter, which prints out the maps and other graphic outputs of the system; and a visual color graphics workstation on which spatial data editing and display can be performed.

## Sources of data

- **Primary data** gathered in the field, such as direct mapping and field sketching, photography, interviews, questionnaires and measurements.
- **Secondary data** are primary data that have been converted into a more accessible form (e.g., database within an organization, the Internet, mapping data providers, government organizations).
- **Proxy data** refer to information derived from another data source, with which relationships have been established. Examples include estimation of water temperature from air temperature or extraction of semi-quantitative texture from FAO soil distribution maps.
- **Satellite data** are in digital form and provide a rich source of information in a form suitable for use in GIS.

## Cost effectiveness

The access to free or low cost GIS data is rapidly expanding, mainly via the Internet. Hardware and software are also developing rapidly and are becoming more powerful and affordable.

## Evaluating outputs

The final step is to look at the results of the analysis and take action based on those results.

Results can be displayed as a digital map, printed as a paper map, combined with tables or charts or displayed as such.

## Trained users

Whether the use of GIS is for casual or professional purposes, some form of education or technical training is highly recommended. Good training will equip people to better understand the process of GIS to apply it properly.

### Four main methods of learning GIS

- Formal GIS degree or certificate programs
- Instructor-led training
- Internet learning
- Self-study

## Main benefits derived from the use of GIS

### ● Improved planning and management

A GIS can link sets together by common data, such as locations, helping departments and agencies share information. By creating a shared database, one department can benefit from the work of another. That is, data can be collected once and used many times.

### ● Make better decisions

A GIS is not just an automated decision-making system but a tool to query, analyze, and map data in support of the decision-making process.

### ● Making maps

Making maps with GIS is much more flexible than traditional manual or automated

cartography approaches. A GIS creates maps from data pulled from database and existing paper maps can be translated into the GIS as well.

GIS can be used to help reach a decision about the location of a new fish farm in a suitable environment (e.g., good climate and soils). The information can be presented clearly in the form of a map and accompanying report, allowing decision-makers to focus on the real issues rather than trying to understand the data. Moreover, because GIS products can be produced quickly, multiple scenarios can be evaluated efficiently and effectively. Managers can test the consequences of various actions before mistakes are made in the landscape itself.

## Who uses GIS?

GIS can be used by Fisheries Departments, applied research institutes, banks and private individuals to better plan their own aquaculture development or investment activities. On the commercial side, GIS can be used to reduce risks and for site selection. On the government side, GIS will be used increasingly for administration and regulation to promote the development of aquaculture.

## GIS use in aquaculture

Aquaculture is a notably diverse activity, which requires secure access and rights to large areas of terrestrial and aquatic "space". Planning activities to promote and monitor the growth of aquaculture in individual countries (or larger regions) inherently take into account the differences among biophysical and socio-economic characteristics from location to location.

### Biophysical characteristics

- Water quality (temperature, dissolved oxygen, alkalinity, salinity, turbidity and pollution)
- Water quantity (volume and seasonal profiles of availability)
- Soil type (slope, structural suitability, water retention, capacity and chemical nature)
- Climate (rainfall distribution, air temperature, wind speed and relative humidity)

### Socio-economic characteristics

- Administrative regulations
- Competing resource users
- Market conditions (demand for fishing products, accessibility to markets)
- Infrastructure support

- Availability of technical expertise

GIS have been applied in aquaculture for the last 13 years. The scale of investigation varied greatly and GIS have been used at different planning levels with appropriately different spatial resolutions, depending on the intended purposes. GIS use in aquaculture has also varied significantly with regard to the complexity of the analytical methods used (i.e. ranging from simple map displays, simple and weighted combinations, to use of relatively sophisticated models).

Continental studies of aquaculture potential have been made for Africa and Latin America. Likewise, several national or state-level studies have been conducted successfully. These studies are particularly useful for decisions related to:

- environmental protection and sustainable resource use;
- national planning activities;
- assessing food security issues; and
- investigating trade-offs pertaining to land allocation among different economic activities.

GIS have also been used for site-level investigations after a preliminary choice of a site has been made. In conjunction with remote sensing and direct data collection, GIS can form the basis for continued monitoring of a site.

## **Case study**

Following is a case study to illustrate basic GIS methodology applied for aquaculture in Asia.

### **Microcomputer spreadsheets for the implementation of geographic information systems in aquaculture: A case study of carp in Pakistan**

This study was chosen because it shows a method of attaining limited GIS functionality through the use of a more readily obtainable, and usually more familiar, spreadsheet package. Spreadsheets are simply a two-dimensional array of cells, they can serve as an x and y coordinate system of geographical references, so they can be very suitable for simple GIS work, provided that the source data can be arranged in raster format.

A 1:2 000 000 scale topographic map of Pakistan was used to trace an overlay which divided the country into 172 cells each representing a 75 km x 75 km area. The following factors were chosen as selection criteria relevant to the development and location of carp culture:

- Air temperature
- Surface water availability
- Soil type
- Precipitation
- Availability of underground water
- Slope
- Availability of fish seed
- Distance from wholesale markets
- Access to road transportation

### Data sources

Most data for each of these factors were obtained from a series of maps published by the Pakistan government, though in some cases additional data were obtained from specific government ministries.

Data for each factor, in each cell, were scored on a scale of 1 to 5, with 5 representing the highest suitability of the parameter and 1 the lowest. The scored data were then entered into a spreadsheet package in a layout that spatially represented the country. After scoring the cells, a value was given to each factor according to how important it was seen to be compared to other factors. Values varied between 0 and 1. Scores were then multiplied by their relevant values and aggregated. The overall score represented the rating of the suitability of each cell for carp culture.

Figure 1 shows the calculated sheet and Figure 2 is the graphic representation of Figure 1 using shaded blocks. It appears that the most suitable areas for carp culture are in central-eastern Pakistan where many tributaries of the River Indus converge across a wide flood plain.

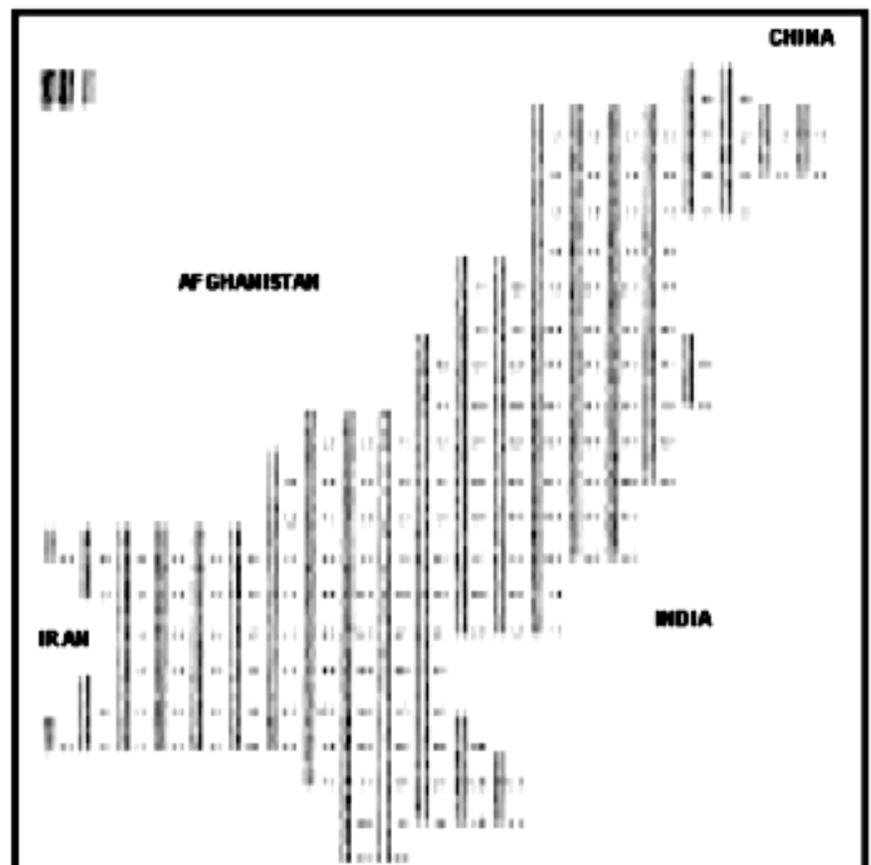


Figure 1. Scored cells showing suitability for carp culture in Pakistan

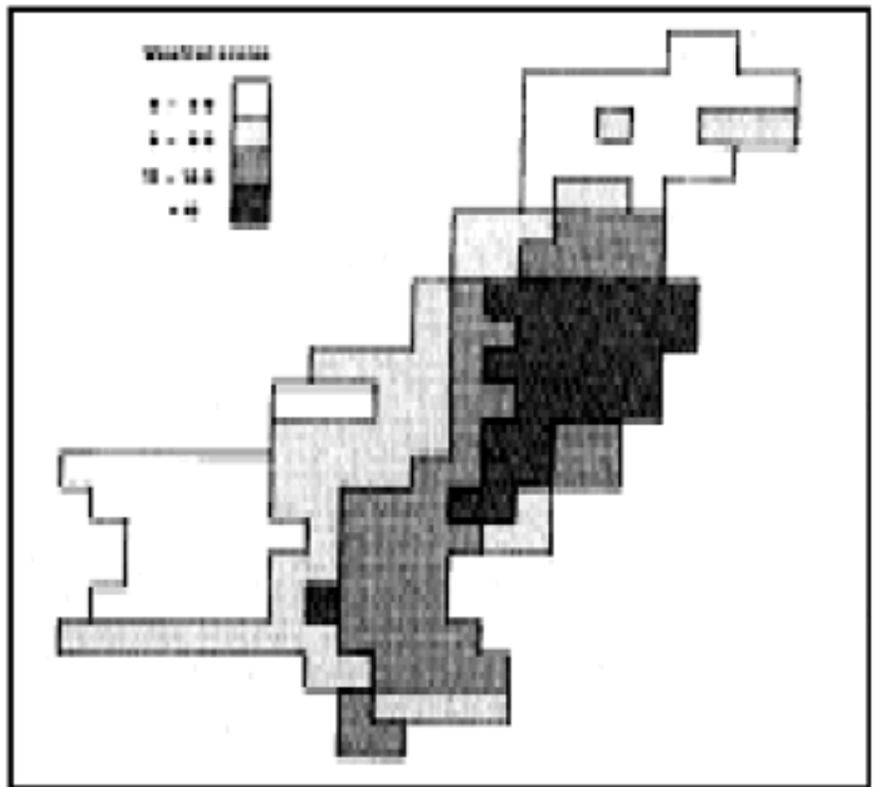


Figure 1. Scored cells showing suitability for carp culture in Pakistan

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## Community-Managed Aquatic Resources

[Aquatic Resources as Common Property](#)

[Community-Based Fisheries Management: An Approach to Sustainable Common Property Resource Management](#)

[Economic Considerations for Community-Based Small-Scale Aquaculture in Oxbow Lakes](#)

[Considerations in Co-Management of Capture Inland Fisheries and Aquaculture in Laos](#)

[Culture-Based Fisheries in Reservoirs and Lakes in India](#)

[Community Rice-Fish Farming in Bangladesh](#)

[Marine Reserves and the Role of Local Government in Units in the Philippines](#)

[Local Knowledge and the Conservation and Use of Aquatic Biodiversity](#)

## Community-Managed Aquatic Resources



# Aquatic Resources as Common Property



A common property resource (CPR) is broadly defined as a natural resource in which a group of people has common user rights (not necessarily ownership rights). It is common for the resources of lakes, rivers, estuaries and marine areas to be considered as CPRs.

Traditionally, CPRs are not open-access, that is available to anyone, but are subject to rules and conventions, often unwritten, of local communities. Particularly after colonization, such CPRs have come under State control, indigenous institutions have been marginalized and people's participation in management of CPRs has frequently decreased.

CPRs form an integral part of the survival mechanisms for the poor and landless. Accessibility should, thus, be ensured and the resources protected. This usually requires community management.

### Why participatory management?

- CPRs are community life-lines and almost all people have a stake in their well-being.
- CPRs that could once sustain local communities may no longer be able to do so because they are over-stressed and mismanaged.
- It is not desirable that an external agency takes control of resources that essentially belong to the community.

Public awareness has to be raised and local people have to be involved in CPR management.

#### **Oxbow lakes: a CPR**

In Bangladesh, oxbow lakes have been managed by Local Management Groups to maintain equitable access to resources and to sustain the lakes.

#### **People-managed fish stocks**

In Southern Laos, local communities are now managing fish stocks in the Mekong River based on Conservation Zones and other management regulations.

### Why is CPR management difficult?

- Conflict between different resource users, both within and outside the community.
- Difficulty in excluding outsiders from resource use.
- Uses of common resources are continually changing due to new opportunities and constraints.
- Lack of appropriate knowledge or skills to manage resources effectively.
- Livelihood constraints – even if local people know what they need to do to protect common resources, they are often dependent on these for income and have few livelihood alternatives.
- Individuals are reluctant to curtail destructive activities if other people do them. The benefits of individual conservation actions are shared by the entire community, while the costs are incurred by the individual.
- Management of common resources often occurs at different "scales" (local, municipal, national and regional) and the regulations at these different levels are sometimes conflicting.
- Government responsibility for managing parts of the ecosystem often falls

under several different government sectors (e.g., mangroves may fall under forestry and fisheries) and policies and mandates of the different sectors may be conflicting.

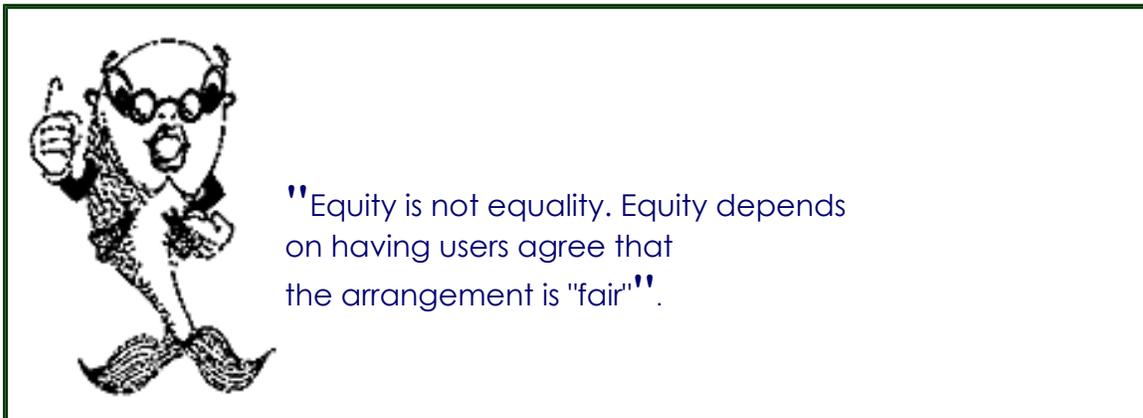
- Inequitable use and allocation of resources.

### **Scale is important!**

The larger the resource and the more people are involved, the more difficult it is to have consensus. Larger systems may need to be managed in creative, possibly hierarchical ways to keep all users committed.

### **Strategies for effective management**

- Institutionalize people centered management programs.
- Ensure equitable distribution of benefits among all users.



### **How do you make CPR management effective?**

- Help people to organize themselves for collective action.
- Involve the community in planning and development as they are the stakeholders.
- Develop clear guidelines on user rights and responsibilities of each person in maintaining and managing the CPR.
- Develop supportive policy and governmental regulatory mechanisms.
- Help minimize conflicts between and within communities and with government.
- Define boundaries around the area for local management, and legitimize community control through legislation.
- Follow an interdisciplinary and systems approach to addressing management issues.

If resource users are not part of the "solution", they will be part of the problem. Ensure that "marginalized" users have a part to play, otherwise they may continue to exploit the resources without regard to the sustainable practices of the larger group.

## Guidelines for equity in resource use

- People should have a share in the benefits from aquatic resources.
- Duties and responsibilities must be clearly stated.
- The role and responsibility of government must be clear and accepted by the stakeholders.
- Means for enforcing regulations must be clear.
- Unambiguous guidelines should define:

- who may fish or undertake aquaculture activities,
- where it can be done and
- what methods are acceptable.



## Protected areas and CPRs

Protected areas, marine protected areas and fish conservation zones establish CPRs but they are often associated with restricted use. The immediate benefits are in the "spill-over" to other areas. It may be necessary to designate other areas as being protected or regulated for communal use with sets of guidelines and enforcement measures. These efforts should be made in addition to other resource management schemes.

## Gender issues

In places where women have limited rights to property or control of resources, CPRs

are often important sources of the resources they use. However, representation of women in local institutions and their training in the use of CPRs is disproportionately low compared to their use of CPRs. If the CPR is close to the households, women are more likely to participate.

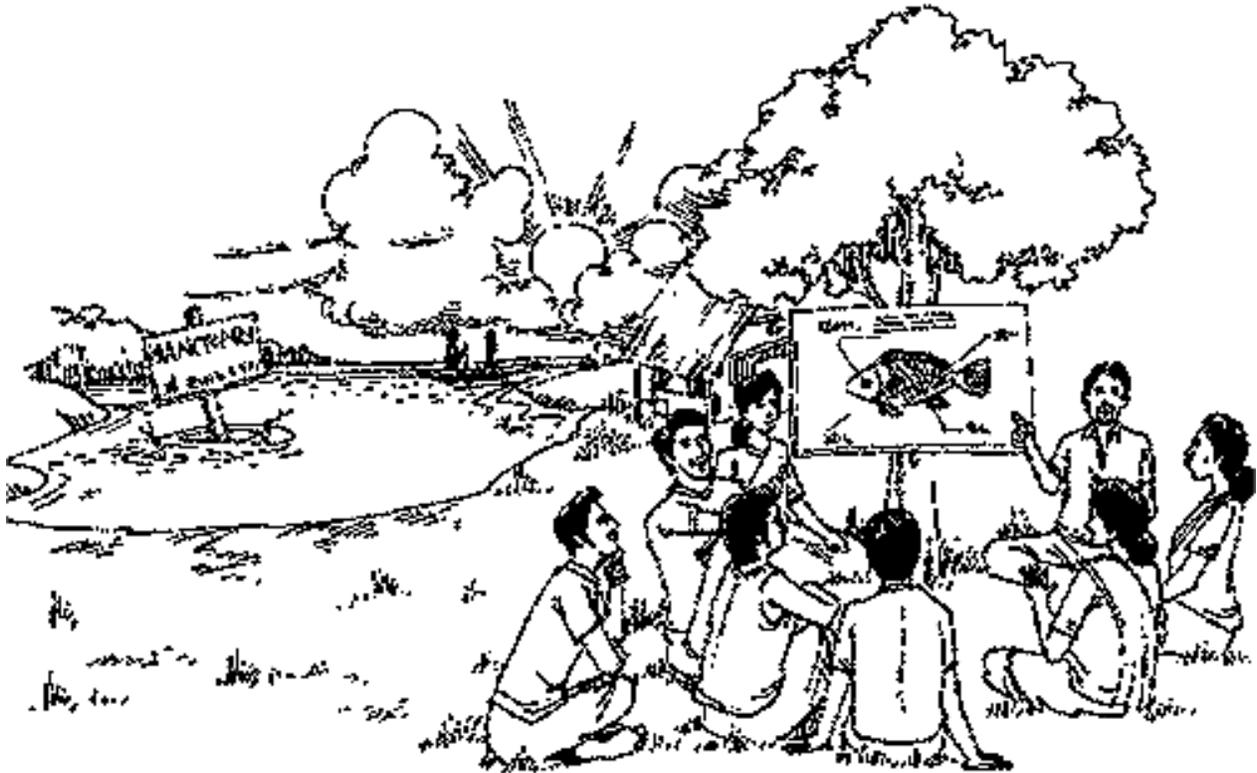
CPRs are often important sources of food for household consumption but the fish caught by men are usually destined for the market. Management of CPRs for aquaculture must be sensitive to how the resources are used. Men do not always recognize or identify such use.

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**Gary Newkirk, Ian Baird and Karen McAllister**

# Community-based Fisheries Management: An Approach to Sustainable Common Property Resource Management



Community-based fisheries management (CBFM) is recognized as a management approach for semi-closed lakes, known as **beels**. Beels are saucer shaped depressions representing perennial or seasonal water bodies. These common property resources are of relevance to aquaculture development efforts in Bangladesh.

## **Four main methods of learning GIS**

- Formal GIS degree or certificate programs
- Instructor-led training
- Internet learning
- Self-study

Previously, only the influential and rich derived benefits from these semi-closed beels, because of the nature of the leasing system and the cost of lease. Resource poor

communities living around the beel were used as laborers (for cleaning, netting, guarding, etc.) but had no opportunity to derive benefits from this production system. They have never been involved in the management and development programs of the beels.

### **Necessary initiatives to ensure community involvement**

- Identify the direct beneficiaries using various information sources and hold consultations with all stakeholders in the community
- Organize them into groups (15-30 members in each group)
- Hold regular meetings
- Initiate savings (weekly/fortnightly)
- Trainings (discussions)
- Participatory resource-use analysis
- Participatory planning for collective actions
- Activities:
  - Fisheries (stocking, nursery, hatchery)  
and
  - Non-fisheries income generating activities (IGAs)  
for individuals and groups
- Equitable distribution of benefits
- Institutionalization

A community-based fisheries management approach, by its objectives, emphasizes establishing fishing rights for the resource poor community. After accessing these fishing rights, the community develops a sense of ownership helps them improve their livelihood.

## Case Study

Under the community-based fisheries management (CBFM) program, CARITAS-Bangladesh organized eight fisher groups (189 members) among the resource poor surrounding the Rajdlhala Beel in Purbadhala Thana, Netrokana district.

Activities of CARITAS included adult literacy, trainings, financial support for lease money (interest free) and credit for income generating activities. Prior to the CBFM initiative, an influential person living far away from the beel acquired lease rights to the resource and local community fishers worked as laborers.

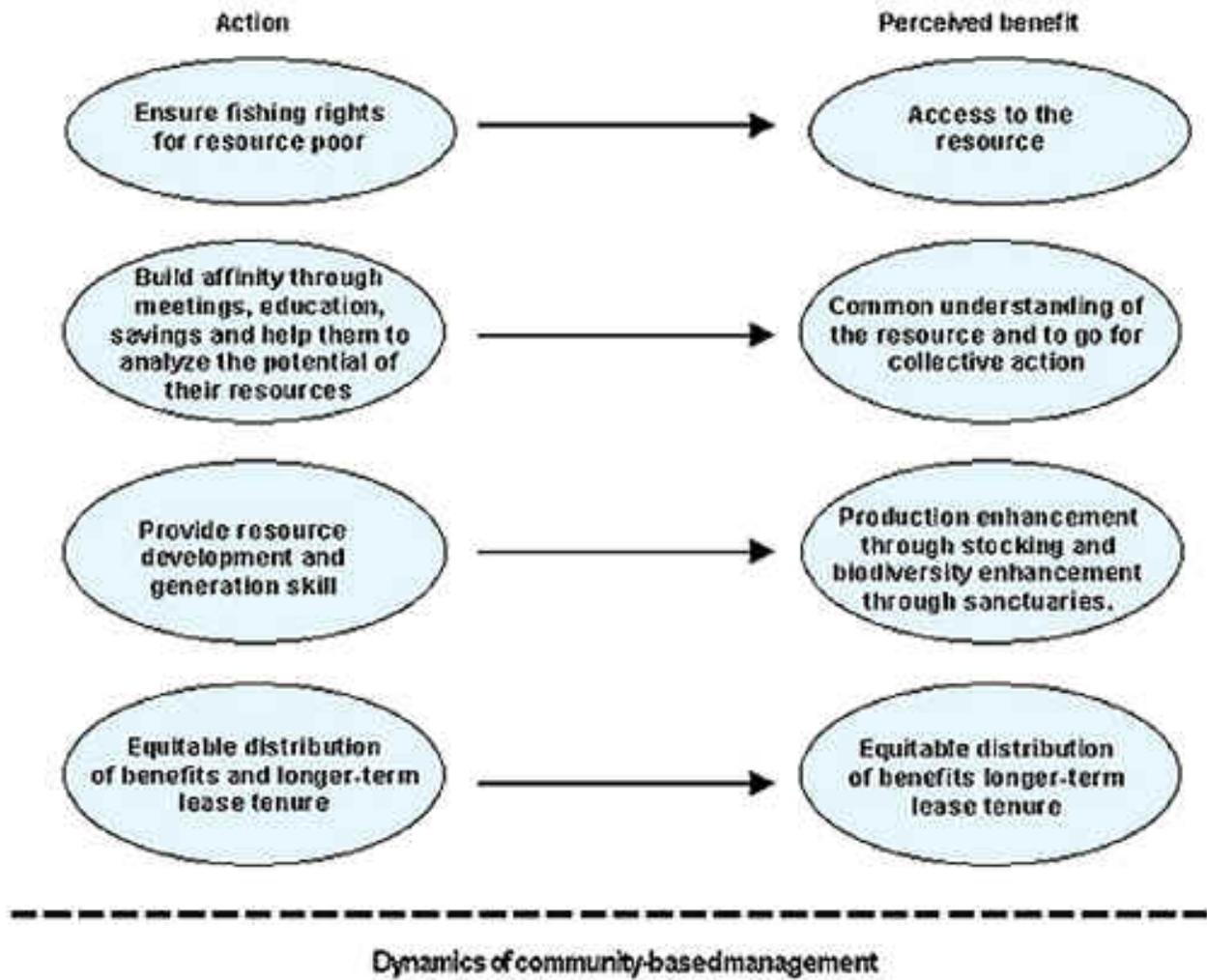
Now the farmer laborers have been able to establish their fishing rights through a three-year lease under CBFM. The community became skilled in planning, beel management, small indigenous species (SIS) conservation and other income generating activities through the different trainings of CARITAS. They organized a beel management committee (BMC) by themselves, with members from each group. The community constructed a facility or center for meetings, trainings, guarding and fish landing. They re-excavated two ponds near the beel which they use as nursery ponds. They accumulated savings valued at US\$2,500 used as counterpart for various fisheries and non-fisheries activities. CBFM presented opportunities to the community by providing nutritional support, economic benefit and a feeling of unity and ownership of a resource. The community has also taken responsibility for biodiversity conservation.

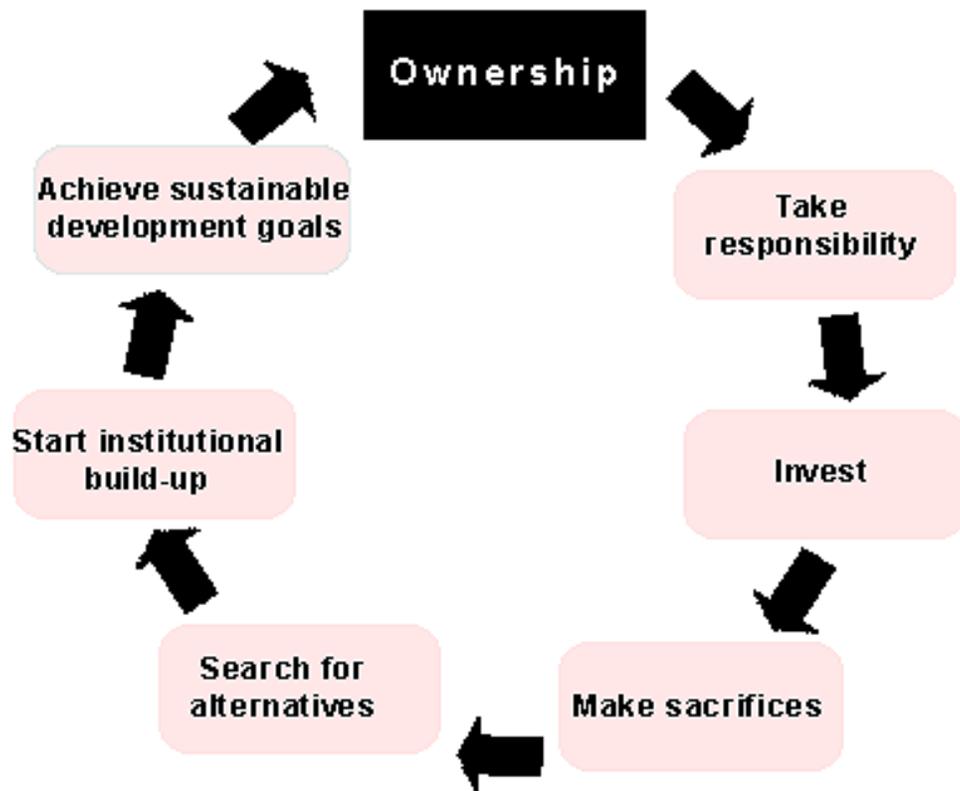
Now that the three years are over, the community has taken another lease for three years and is negotiating for longer lease periods. Since they invested money for the development of the resources, CARITAS is giving them priority hoping that this community will act as a model and a source of inspiration for other communities in managing their own beels in a sustainable manner.

## Training areas

- Value added awareness
- Potentials of the resource
- Biodiversity of the resource
- Resource use analysis
- Participatory planning
- Distribution of responsibilities
- Social awareness
- Adult literacy
- Simple accounting
- Group management
- Gender
- Equity

## Actions and resulting benefits to communities





## Constraints

- **High lease value**

The normal system is to lease out the beel for three years with a 25% increase in cost for the first year and a 10% increase for years two and three. CARITAS is assisting the communities bargain for a longer lease period.

- **Lack of demarcation**

Water resources are becoming scarce with time (siltation, drought, etc.) but government records are not updated to this effect. Leasing out dry areas to agricultural farmers, who continue their activities during the fishing season, threatens the breeding of small indigenous species (SIS). Fishers giving lease money for agricultural land, ultimately create social conflicts.

- **Tenurial issue**

Resource development, especially resource generation, demands some sort of investment (dike, nursery, hatchery, landing place, etc.) and sacrifice (sanctuary, fishing ban). As the maximum tenure for more than 10,000 khas plots (government owned land/water) is only three years, it appears difficult to initiate resource generation or resource development.

## Strategies to overcome constraints

- **Community responsibility**

A democratic process of voting to organize a management committee is necessary to manage activities like general meetings and deal with bank accounts, leasing authorities and other stakeholders, etc. A new committee might take some time to work out a system that works best.



Community responsibility is among the most important issues for the khas plots management -- from planning to distribution of benefits. Communities must have specific livelihood development projects as well as a resource development plan. One will not work without the other.

- **Conflicts**

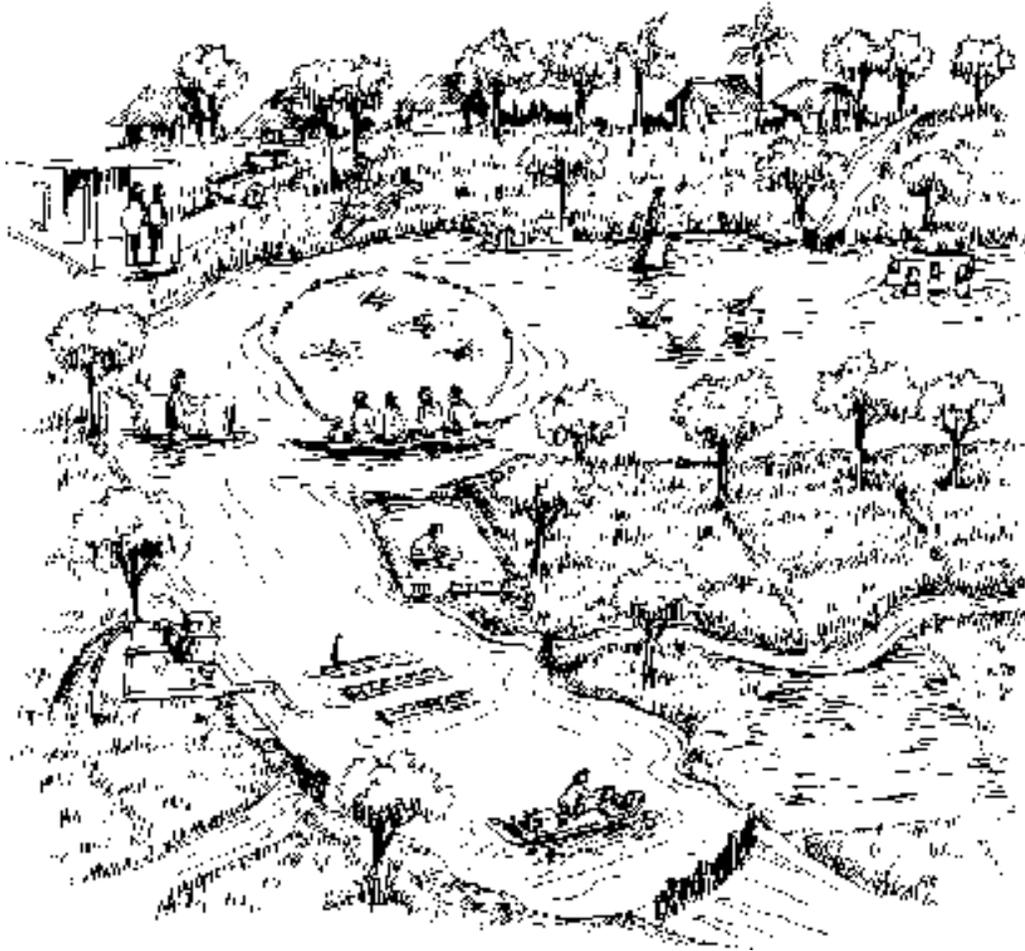
- Influential rich vs. resource poor
- Various water-users (aquaculture, agriculture, etc.)
- Inter-sectoral
- Outsider vs. community

### **Replication of the approach**

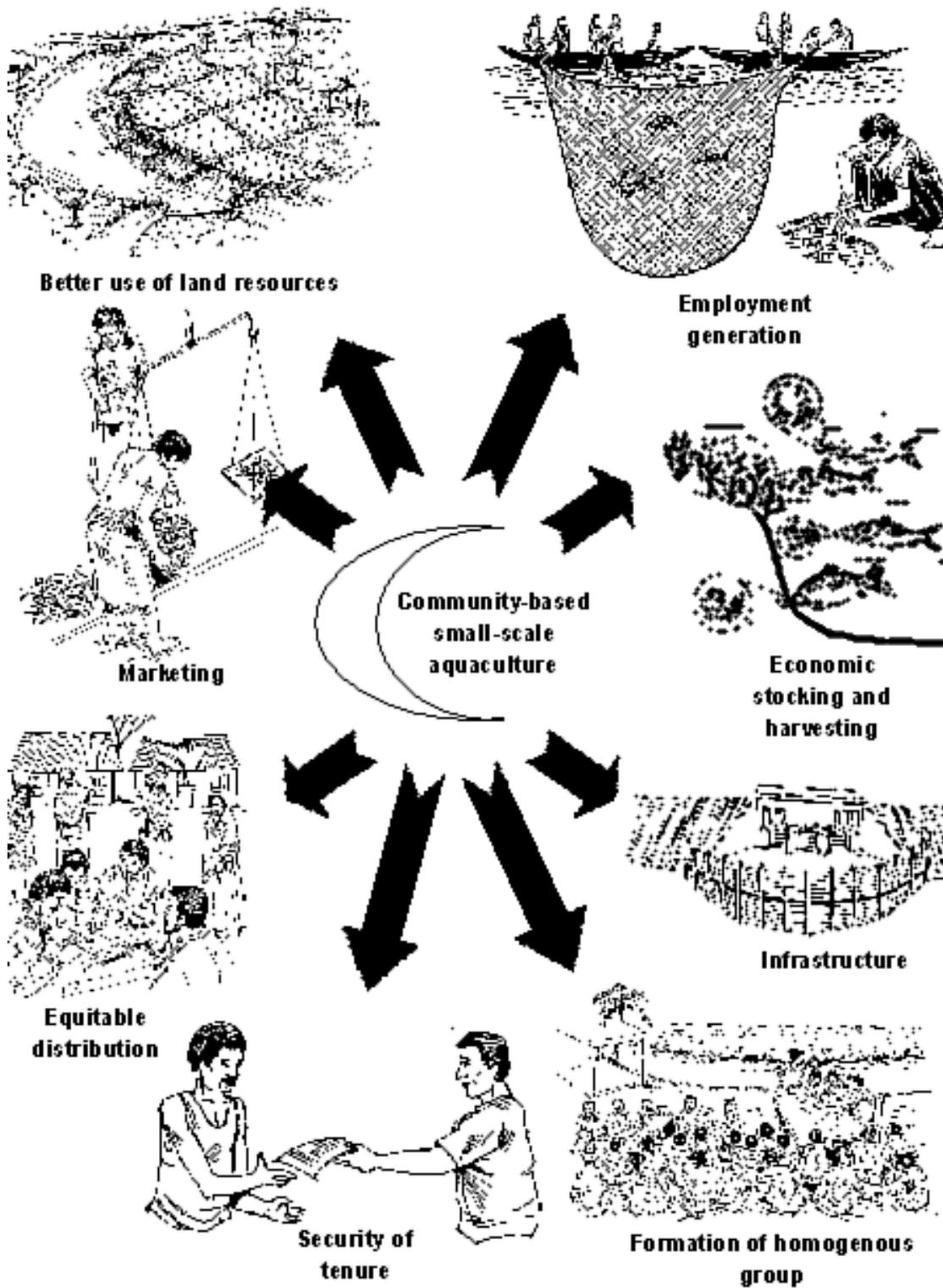
Hopes for the future appear to be bright, however. CARITAS-Bangladesh has initiated two projects, with the implementation strategy being based on the experience of the CBFM, community-based fisheries management project. The projects are: Management of Aquatic Ecosystem through Community Husbandry (MACH) and Sustainable Aquatic Resources Management (SARM).

CBFM has proven to be a successful strategy and is becoming popular. Even the country's two significant development projects – Sustainable Environment Management Project (SEMP) under the Ministry of Environment and Forest and the Fourth Fisheries Project under the Ministry of Fisheries and Livestock – have been launched based on the same strategy.

# Economic Considerations for Community-Based Small-Scale Aquaculture in Oxbow Lakes



Oxbow lakes, including the fish and the water forming part of it, are common properties. With its bountiful resources, proper management of these lakes would yield greater benefits to the surrounding poor communities. In managing Oxbow Lakes, the dynamic partnership between the fishers and government should be nurtured. Non-government organizations (NGOs) can play a catalytic role by building up the capacities and interests of local communities.



## Security of tenure

- To establish a community-based fisheries management institution, fishers should be granted "secured use right" to oxbow lake management on a long-term lease.
- Standardized annual lease fees should be imposed on members of the Lake Management Group (LMG) to avoid an open-access type of fishery.

Initially, the Oxbow Lakes were leased to the community for seven years. The successful management of the Oxbow Lakes led to a 50-year guaranteed lease by the government to community institutions.

## **Infrastructure**

- Fishers need government/donor assistance for the enormous initial investment.
- Infrastructure development such as screen installation, water control structures, community meeting shade and roads, among others, has to be done.
- Annual repair and replacement by the fishers of screen are necessary.

## **Institutional credit**

- Poor fishers should have access to credit facilities to cover the cost of inputs and maintenance.

## **Employment generation**

- One to three fishers per hectare could be involved in fishery management.
- Continuous stocking, harvesting and other fishery-related activities can generate employment and increase production.

## **Marketing**

- Fish marketing costs range from 3-10% depending on the mechanism and distance of markets.
- Marketing network information is necessary to get competitive prices.
- Timing of fishing is important in relation to local and wholesale markets.

Marketing costs were low in Oxbow Lakes where the fishers used a rotation in involving fishers groups to market harvest. (Rahman, M.M., 1996.)

## **Better use of land resources**

- Construction of small ponds could increase production and generate employment during dry season when the Oxbow Lake catchment area becomes dry.
- Dikes can be used for vegetable cultivation.
- Afforestation program can be undertaken with high-value timber tree.
- Pipe culverts should be installed to allow the nutrient and washings to go into the lake.

The OLP II constructed a series of ponds with the help of the World Food Program. Women were involved in the fish culture. Six women assigned per hectare. Some ponds were allocated to LMGs for fingerling nursery.

### **Formation of homogeneous group**

- Government and NGOs must facilitate the formation of a wider community-based, fishery management forum.
- The user community should form a cohesive and homogeneous group based on social and economic criteria.

LMCs are authorized to spend US\$10 without prior permission of the general membership. In the monthly general meeting, the LMC has to propose a planned expenditure and get approval from 75% of the LMG members. It also has to present detailed expenditure for the previous month and current cash status. The bank account is managed by three co-signees of the LMC. In spite of that, a participatory audit team was constituted with representatives from the LMC, NGO (BRAC) and DoF. This participatory method helped reduce unseen expenditure and increased confidence.

### **Income and expenditure**

Transparent record keeping on an annual basis is essential to establish mutual trust among the fishers if community institutions are to remain sustainable.

### **Annual physical and financial planning**

An annual physical and financial plan is important in community-based Oxbow Lakes fishery management. Planning includes issues such as fingerling stocking, harvesting, money flow, credit repayment, and income distribution and saving.

### **Introduction of continuous stocking and harvesting**

- Continuous stocking and harvesting generate employment and increase production.
- Fishing is prohibited during the rainy season, i.e., July to September, to allow fish to grow.
- Annual planning and related activities can be undertaken during lean periods.
- The stocking size is 30-40 g each, i.e., 25-35 fingerlings/kg. 3-4.5 thousand/ha.
- Harvesting size (within 12 months of stocking) is 30-40 cm in length (400-700 g). Yields could be 2 t/ha.

Several Oxbow Lake community group annual planning discussions resulted in very innovative and fruitful ideas for disseminating a new culture practice of the Oxbow Lakes fishery (Rahman, 1995). Annual plans are prepared at the beginning of each financial year that starts in July.

## **Selection of species**

Species selection is important if local demands are to be met to facilitate marketing.

In OLP II, small lakes (<80 ha) had an average net income of US\$462 per ha while the average net income of larger lakes (>80 ha) was US\$302.

## **Economic size of Oxbow Lakes**

Larger Oxbow Lakes tend to have lower fishery related net income per hectare compared to smaller lakes.

## **Equitable distribution**

Equitable distribution and cost sharing are fundamental in sustaining community-based aquaculture.

## **Entrepreneurship**

An entrepreneurship attitude is necessary for taking the initiative in adopting and innovating new practice, thus creating responsible aquaculture.

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Prepared by:  
**Mokhlesur Rahman**

# Considerations in Co-Management of Capture Inland Fisheries and Aquaculture in Laos



**Basket-bundle fish trap** – one of the many varieties of traditional fishing gears used in Laos

Freshwater fish and other inland aquatic animals are important sources of food and income for rural people living adjacent to the Mekong River and its tributaries, including those in the Lao People's Democratic Republic (Lao PDR or Laos). The Mekong River, which runs through Laos, supports a diverse and productive aquatic system. Nowhere in Laos are wild capture fisheries more important than in Khong District, Champasak Province, where most of the over 65,000 residents are semi-subsistence rice farmers and small-scale fishers living on numerous islands in the middle of the Mekong River or along its banks.

Inland water bodies are important to small-scale fisheries in Khong. The vast majority of the aquatic animals consumed and traded by Lao people are caught in the wild. Aquaculture is virtually absent in the district. It is not commonly or traditionally practiced in Laos, although a few ethnic groups have historically engaged in a limited traditional rice-fish culture using wild species. The Mekong River Basin in Laos has a very high aquatic biodiversity and its conservation, as well as sustainable management, is important to the livelihoods of local people.

The majority of rural people in remote areas still rely more on capture fisheries than on aquaculture.

However, the importance of wild capture fisheries in increasing the amount of fish available to the local population has often been overlooked by development agencies both within and outside Laos. It has sometimes been assumed that wild capture fisheries are declining and that it is not feasible to restore natural stocks of aquatic animals. It has also been argued that an increasing population is likely to make it impossible for wild capture fisheries to meet local demand for fish products. Aquaculture has been assumed to be the only realistic and viable way to increase fish availability in rural areas. As a result, aquaculture has received most of the funding and only a few agencies have supported the management and improvement of wild capture fisheries in Laos and other countries in the Mekong Basin. The situation appears to be changing, however, as developers begin to realize the importance of wild capture fisheries.



Adopting natural aquatic co-management regimes is a cost-effective way of improving natural resource management, increasing fish productivity, human nutrition, increasing community solidarity and reducing rural poverty.

### **Natural aquatic resource co-management in Khong District, Champasak Province**

In 1993, the Lao Community Fisheries and Dolphin Protection Project (LCFDPP) was established to promote the conservation and sustainable use of aquatic resources in the mainstream Mekong River along with adjacent seasonal streams, rice fields, and natural depressions. The LCFDPP attempted to help locals improve their quality of life while also improving environmental conditions, the basis for aquatic productivity. This led to the establishment of a natural aquatic resource co-management program in cooperation with the local government. Communities were given the authority to pursue their own unique sets of co-management regulations through a participatory and voluntary process.

Co-management is the collaborative and participatory process of regulatory decision-making among representatives of user-groups, governments and research institutes.

The direct stakeholders involved in the co-management system in Khong district are:

1. the villages and all its members (i.e., both men and women);
2. the government, including line agencies responsible for aquatic resources; and
3. NGOs with projects supporting co-management in Khong district.

Communities in Khong District are relatively homogeneous and economically unstratified, leading to a relatively small number of stakeholders compared to many places.

Between 1993 and 1999, 63 villages in Khong District established co-management regulations for managing aquatic resources that were recognized by the Government in the vicinities of their communities. This enabled individual communities to establish 68 separate Fish Conservation Zones (FCZs), or fishery "no-take zones" in the mainstream Mekong River.



Results from a rapid survey in 14 randomly selected villages in Khong District in 1997 showed that 94% of the families in the district took part in subsistence fisheries; an average person in Khong caught 62 kg of fish over a 12-month period in 1996 - 1997. Fish products were the most important source of animal protein consumed in about 80% of the meals in Khong and the total annual fish catch estimate for the district was 4,000 metric tons. Over US\$ 1 million of fish products originating from Khong were sold to local and distant markets; the average family generated the equivalent of US\$ 100 per annum from selling fish caught by using small-scale fishing gears such as gill nets, longlines, castnets and various kinds of traps.

The FCZs are among the most important elements of the co-management system, although other regulations have also been adopted, such as:

1. Banning the use of fish traps in streams at the beginning of the rainy season when some fish species migrate up to rainfed rice fields, natural depressions and other wetlands.
2. Prohibiting the capture of snakehead fish (*Channa striata* or *pa kho*, in Lao) fry with scoop nets.
3. Restricting the harvesting of frogs (*Rana* spp. or *kop*, in Lao), especially during the spawning season.
4. Restricting a number of fishing gears and methods, including spearing fish at night and water banging fishing.
5. Protecting wetland habitat.

The aquatic resource co-management program in Khong has been very successful. Local people believe that fish stocks and catches have increased due to the co-management regulations, including the establishment of FCZs. Village solidarity has also improved. This has all been done at a very low cost to donors and the Government, since villagers do most of the work themselves. Although technical and biological answers to how the various management strategies, including the establishment of FCZs, led to increased fish stocks, villagers are already convinced that the systems work and they intend to continue implementing them indefinitely. Several reviewers have also concluded that the program has been successful and appropriate (see Meusch, 1997; Hogan, 1997; Cunningham, 1998; Baird and Flaherty, 1999; Chomchanta et al., 2000).



Fish spearing with lights at night has been banned in many communities in Khong

Some key elements of the established systems include:

1. Each village has its own unique set of regulations based on local social and environmental conditions.
2. The local government fully supports the co-management process and has helped promote it.
3. The regulations created can be amended according to changing social and environmental circumstances. Flexible management regimes can keep the systems relevant.
4. The local Government carefully ensured that resource-poor communities were not excluded from fishing in richer areas, where co-management regulations apply, to reduce conflict between communities. However, resource-poor communities must follow the same regulations that the host communities have imposed on themselves.

The poor often do not hold tenure to land and water resources that is generally required before aquaculture can be developed.

Special efforts should, therefore, be made to ensure that poor and disadvantaged groups are not denied access to natural aquatic resources or that the natural resources they depend on is not degraded due to the development of aquaculture.

## Environmental health concerns regarding aquaculture development

Aquaculture provides a wide-range of benefits to people and the environment, but it can also cause ecological problems. We now know that some types of aquaculture (e.g., large-scale commercial shrimp farming) are unsustainable and destructive. Inland shrimp farming has become a threat to the environment in Thailand, as they added large amounts of salt to ponds in inland areas. However, over the past decade, shifts in research priorities from intensive to extensive and semi-intensive culture have resulted in breakthroughs in small-scale inland aquaculture.

Small-scale extensive and semi-intensive inland aquaculture needs to be carefully managed and regulated in order to ensure that it does not cause environmental and social problems.



Aquaculture and wild fish stocks often compete for the same limited resources (e.g., land, water and nutrients). Aquaculture has to be developed without jeopardizing the natural resources that support important capture fisheries.

The introduction of exotic aquatic animals into the wild through aquaculture has sometimes resulted in socio-economic benefits to rural people, especially over the short run. However, it could also pose serious

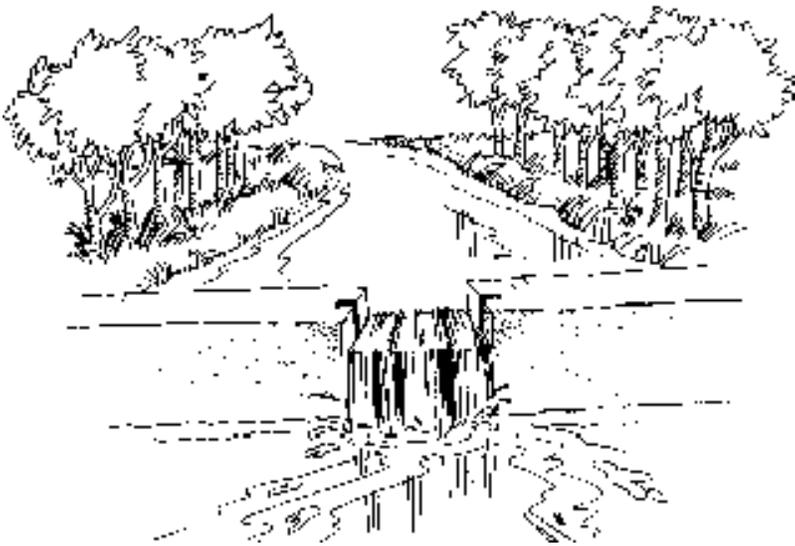
problems, especially over the long term. For example, the golden apple snail, introduced for aquaculture, has become one of Laos' most serious rice pests, especially in the Vientiane area. This is also true for other countries including the Philippines. At present, the common carp (*Cyprinus carpio*) and tilapia (*Oreochromis* spp.) are two of the most commonly farmed fish species in Laos and other countries in the Mekong Basin. Both species, which are not native to the Mekong, are suspected of causing serious ecological damage to native fish species and aquatic

communities in other parts of the world.

Genetically modified organisms (GMOs) have the potential to damage the environment and biodiversity. It seems logical to expect that introducing GMOs and non-native species into natural waterways will eventually lead to ecological changes that might adversely affect native strains and species. History indicates that it is reasonable to expect that fish farmed over many years will eventually escape or be released into the wild. Therefore, precautionary measures should be taken in introducing exotic species for aquaculture.

There are probably more than 1000 indigenous fish species in the Mekong River Basin. This means some species might be suitable for aquaculture. The effort has to be made to investigate and develop their potential.

More research should focus on identifying and promoting native fish species for aquaculture. For example, the silver barb (*Barbodes gonionotus*) is a native species bred artificially in Laos and found to be extremely suitable for pond culture in the country (FAO, 1999). The giant carp (*Catlocarpio siamensis*) has shown promise as an aquaculture species in Cambodia.



Freshwater fish aquaculture can adversely affect the environment by causing the alteration and degradation of natural habitats. For example, streams have sometimes been dammed to create small reservoirs where fish can be raised. While the impact of blocking a small stream is not likely to be as severe as that of damming a large river, fish migrations and habitat usage can still be affected.

Many freshwater ecosystems such as lakes, rivers and wetlands are some of the most endangered in the world. Wetlands have sometimes been converted into aquaculture ponds, causing the loss of valuable wild fish habitat. Habitat conversion may involve the dredging of wetlands, removal of surrounding vegetation, fragmentation of water bodies, or diversion of water from other wetlands. More care must be taken to internalize costs associated with aquaculture development and reduce the impact on the environment.

Another potential problem with aquaculture relates to the quality of water released into the natural environment from ponds and cages. Although there are not yet many examples from Laos, chemicals and antibiotics used in aquaculture can contribute to high levels of pollution. Intensive aquaculture generally uses the least

amount of land and water, but has the most potential to cause serious pollution problems due to high inputs and high waste output. Pollution caused by aquaculture, as well as by other industries, often contributes to various animal health problems such as the spread of viruses that threaten both wild and cultured animals.

Epizootic Ulcerative Syndrome (EUS) is one of the most serious diseases affecting both cultured and wild fish in inland areas in Asia. Native fish species inhabiting rice field and small wetland have been especially devastated by EUS for over 20 years in mainland Southeast Asia, including Laos, leading to massive protein and income losses for local people. While more research on EUS is needed, some researchers believe that its spread was facilitated by the transfer of aquaculture fish species into the region.

The ecological footprint concept, developed to determine the area necessary to sustain current levels of resource consumption and waste discharge, is useful when considering the ecological impact of aquaculture development. Some forms of aquaculture have a large ecological footprint while others have much smaller ones. For example, carnivorous species like shrimps and catfish have a large ecological footprint because they rely heavily on external food sources, such as fish meal obtained from capture fisheries. Therefore, it generally takes much more weight in fish to raise carnivorous aquatic animals compared to the final harvest weight. This leads to an overall reduction in animal protein available to an increasingly populous world.

### **Ecological footprint**

As an example of how the ecological footprint concept works, Folke et al. (1998) estimated that carnivorous fish farming in cages is sometimes dependent on marine ecosystem areas 10,000-50,000 times the size of the cages used for producing the fish. Additional area is also required to absorb wastes from the cages. However, herbivorous species, like the silver barb, are much less dependent on external sources of food and, therefore, have a smaller ecological footprint. In addition, aquaculture that combines species from different trophic levels, applies ecocyclic production, and generates multiple services and outputs can reduce the ecological footprint substantially.

Rice-fish culture can result in significant environmental benefits resulting from the ability of fish to help reduce agricultural pests and vectors that affect human health. However, when high dikes are built to keep the fish stocked into rice fields from escaping, an important habitat previously available to wild fish is lost. Measures should be taken to allow wild fish to enter rice fields. Denying them access can lead to declines in fish stocks outside the fields, affecting poor people who rely on the harvest of the wild fish that need the rice field habitat for part of their life cycle.

Aquaculture can have a negative impact on natural aquatic communities through the collection of seed from the wild, especially when intensive collection is done, and when aquatic animals are collected from the wild to supply feed for carnivorous and

omnivorous cultured species.



## Social and equity considerations

It seems likely that there have been occasions when development agencies have inadvertently helped better-off farmers adopt and benefit from aquaculture while poor fishers who relied on the natural resources degraded by aquaculture, registered a net loss due to aquaculture development. Some commercial aquaculture programs have negative impacts on the rural poor in terms of resource competition, altered familial work patterns, increased unemployment and the degradation of nutrition.

In Laos, it has been found that aquaculture often leads to the privatization of common property resources by the relatively powerful and influential. A good example is found in the Oupaxa Village in Khong District. There, a natural depression previously fished by everyone in the community became privatized a few years ago after one of the more powerful members of the community decided he wanted to try farming fish in the natural pond. Essentially, a resource that used to benefit the whole community, including the poor, was taken and given over to a single well-off family. The privatization of common property in the name of promoting aquaculture is one of the most serious problems aquaculture advocates must address.

Sadly, aquaculture has sometimes been used to justify either degrading wild fish stocks or not putting sufficient resources into the sustainable management or restoration of naturally occurring aquatic communities. For example, advocates of large-scale hydroelectric dams often claim that the damage the infrastructure does to natural aquatic communities, including productive wild-capture fisheries, can be justified, since aquaculture can be introduced to mitigate losses of fish protein and income to local people.

The capital-intensiveness of certain aquaculture practices can force small farmers to go into debt for inputs. A debt cycle is likely to develop in aquaculture if the technology packages for the rural poor include too many inputs like feeds and fertilizers. Aquaculture may indeed lead to increased production but malnutrition

might persist. Moreover, aquaculture often requires a sustained investment in terms of seed, feed and other inputs, while wild fish are natural capital that farmers and fishers can benefit from at a low cost and risk, and sometimes without any investment.

Aquaculture can benefit wild capture fisheries by providing fishers with an alternative source of protein and income, which may help reduce overfishing and restore depleted stocks. But using aquaculture as an excuse for neglecting natural fish stocks is a problem that needs to be seriously addressed.

## Conclusion

Aquaculture is an important means for producing increased amounts of affordable aquatic protein, especially when herbivorous and omnivorous species are cultured on a small-scale and as a part of integrated farming systems. While there is no space here to review the benefits of aquaculture, it is acknowledged that it has the potential to benefit society and the environment. This paper does not claim that natural aquatic co-management will be the most appropriate form of intervention in particular areas. Many social and environmental factors need to be considered, and individual circumstances are generally complex. Aquaculture can benefit local people in rural areas, but we need to be cautious and careful in promoting it. While aquaculture activities are often essentially environmentally and socially benign, they can sometimes cause or increase various kinds of environmental and social problems, especially when precautions are not taken. We need to be especially alert to problems and address them at an early stage, or even prevent their happening.

.Aquaculture will continue to be developed in Southern countries like Laos. Therefore, it is necessary to push for the adoption of more sustainable forms of aquaculture, rather than deny its role in rural development. Essentially, precautionary measures should be taken in developing aquaculture, although such measures will certainly slow the growth of aquaculture over the short term. However, careful promotion should benefit aquaculture in the long term by silencing its critics through improved practices.

Aquaculture in Laos and other countries in the region should not be regarded as the only means for increasing fish production. Governments must also allocate resources to the management of wild fisheries. The promotion, conservation and sustainable management of naturally occurring aquatic resources are important as many rural people still rely primarily on nature for their subsistence and welfare. Well-managed fish stocks can help to take up the slack when famines, flooding and drought cause land-based crops to fail. They are especially important for the poorest of the poor and subsistence-oriented people living in rural areas. Many types of aquaculture are useful in improving the livelihoods of local people but, as development advocates, we need to remain critical regarding their benefits. Aquaculture is not a panacea for the wild capture fisheries problems that we are facing worldwide. It cannot and should not be seen as a substitute for sound fisheries management allowing the full participation of all stakeholders. Aquaculture is but a part of the equation. How it is extended and promoted will indicate whether it is helpful to the rural poor and the environment or not.



While it is admirable that efforts have been made to integrate small-scale aquaculture with other agricultural activities, we now need to advance further by considering aquaculture in the broader overall context of natural aquatic resource management and livelihood opportunities, including non-farm options.

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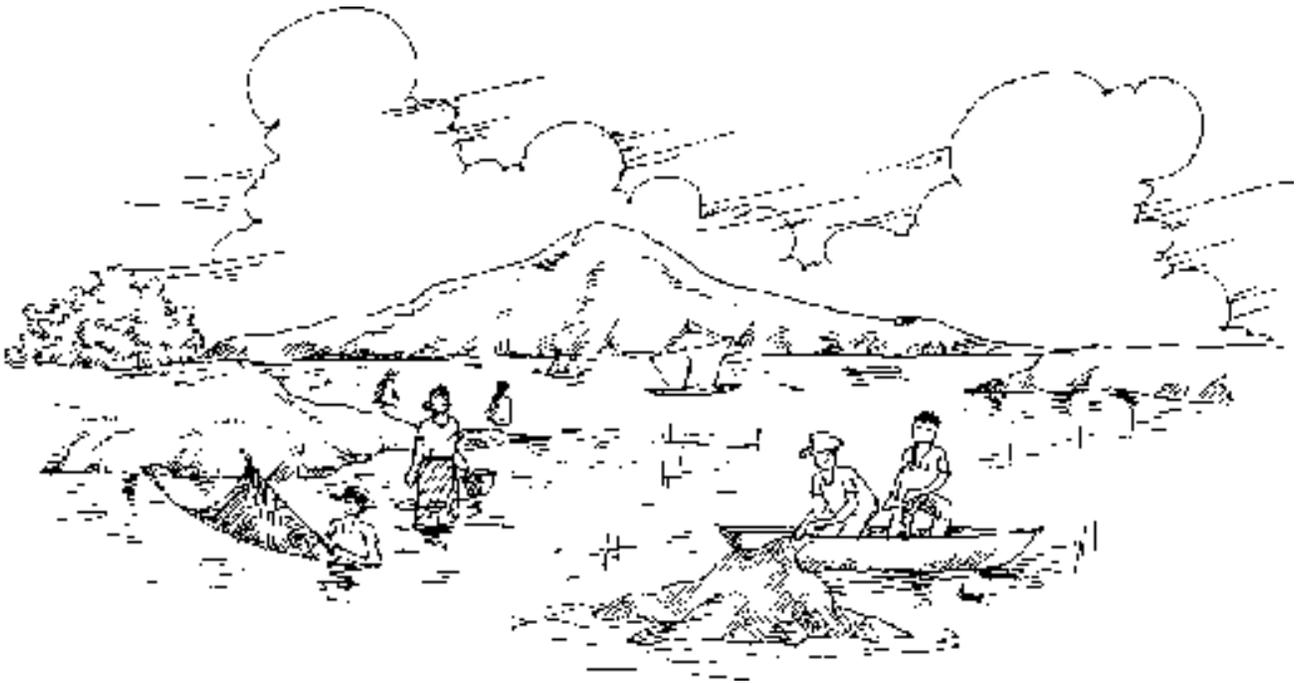
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# Culture-Based Fisheries in Reservoirs and Lakes in India



In many developing countries, aquaculture has been given a high priority, either to improve the availability of protective food or to cater to overseas trade. However, the unchecked growth of aquaculture ventures that violate environmental norms can open the floodgate to new concerns, as evident in the recent Asian prawn culture experience. Living aquatic resources, although renewable, are not infinite. They need to be managed in a sustainable manner. In this context, enhancements, especially culture-based fisheries, assume significance. Welcomme (1996) considers enhancements as the fastest expanding sectors of freshwater fish production, which currently contributes about 20% to the inland fish production in the world (Lorenzen, 2000).

Most nations are reported to be exploring the possibilities of utilizing inland lakes and reservoirs to improve or commence culture-based fisheries. This should be attractive to most environmental groups as it entails little or no manipulation of the environment (De Silva, 2000). The social relevance of culture-based fisheries is equally important. Unlike intensive aquaculture systems, culture-based fishery is practiced in community or common property regimes, where the benefit accrued from the increased productivity is more equitably distributed.

Growth in the marine sub-sector in India has slowed down considerably over the years while the share of inland fisheries has increased. Nearly one million tons of inland fish production in India is attributed to culture-based fishery and other forms of enhancement practiced in reservoirs, small irrigation impoundments and floodplain

wetlands.

## Reservoirs

In broad terms, the small reservoirs are managed as culture-based fisheries, while medium and large reservoirs can be considered as more akin to stock and species enhancement. However, there cannot be a thumb rule to differentiate the two systems on the basis of reservoir area alone. Fishing conditions, shallowness of the reservoir and natural recruitment are major factors that determine whether capture or culture-based fishery is followed.

<b>Reservoir resources in India</b>		
<b>Category</b>	<b>Number</b>	<b>Area (ha)</b>
Small (<1000 ha)	19,134	1,485,557
Medium (100-5000 ha)	180	527,541
Large (>5000 ha)	56	1,140,268
Total	19,370	3,153,366

### Culture-based fisheries of small reservoirs

More than 70% of the small reservoirs in India are small irrigation impoundments created to store stream water for irrigation. They either dry up completely or retain very little water during summer, thus ruling out the possibility of retaining brood stock for recruitment. Culture-based fishery is the most appropriate management option for small reservoirs in India.

### Species selection

Culture-based fisheries of small reservoirs in India largely center around the three species of Indian major carps -- *Catla catla*, *Cirrhinus mrigala* and *Labeo rohita* -- because many Indian States have the technical capability to produce carp seed. The Indian major carps have impressive growth rates and their feeding habits are suitable for utilization of various food niches. Stocking of Indian major carps has always been very effective in small reservoirs.

### Stocking rate

A large country like India, with many water bodies to stock, has an inadequate state machinery to meet the stocking requirements of all its reservoirs. The main considerations in determining the stocking rate are growth rate of individual species, mortality rate, size at stocking and the growing time. As a result of the National Consultation on Reservoir Fisheries, the Government of India adopted recently Welcomme's (1976) formula in calculating the stocking rate for small reservoirs.

## **Management of medium and large reservoirs**

Since large and medium reservoirs are managed on the principles of enhancement of capture fisheries, the main focus of management is on conservation of habitat to allow the natural recruitment and growth of the target species. Stock monitoring is achieved through the maneuvering of fishing effort and following mesh size regulations. Introduction is undertaken to correct imbalances in the species spectrum, while stocking is done as a temporary measure to compensate for recruitment failure.

## **Stock enhancement**

Stocking attempts made in medium and large reservoirs were successful when the stocked fishes bred and propagated themselves (Sreenivasan, 1984). In a number of reservoirs, even repeated stocking for more than 10 years did not make any impact because the fish did not breed. The increase in fish production due to recapture was not enough to recover the expenditure involved in stocking. Thus, the main aim of stocking efforts in medium and large reservoirs should be stock enhancement rather than recapture (unlike the culture-based fisheries).



## **Species enhancement**

Species enhancement aims to augment the species range by adding fish species from outside. These introductions colonize all the diverse niches of the biotope. The three Indian major carps, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*, were

being stocked in the peninsular reservoirs for the last five decades. This was done despite the fact that the peninsular rivers have habitats distinctly different from those of Ganga and Brahmaputra where fishes are indigenous. In some of the south Indian reservoirs, they have established breeding populations. The hallmark of the Indian policy on stocking (introductions in the case of peninsular reservoirs) is heavy dependence on Indian major carps.

### **Introduction of exotic species**

The government policy clearly disallows stocking of exotic fish in reservoirs to prevent any adverse impact on the biodiversity. However, tilapia (*Oreochromis mossambicus*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), and three varieties of common carp (scale carp *Cyprinus carpio communis*, mirror carp *C. carpio specularis*, and leather carp *C. carpio nudus*) have gained entry into Indian reservoirs either by accident or deliberate stocking. A spectacular performance of silver carp is recorded in the Gobindsagar reservoir (Himachal Pradesh) where, after an accidental introduction, the fish formed a breeding population and brought about a phenomenal increase in fish yield. Silver carp was instrumental in enhancing production of Gobindsagar from 160 t in 1970-71 to more than 1,000 t at present. However, this high yield was at the cost of *Catla catla*. Moreover, as the people did not accept the exotic fish, this resulted in social and economic problems.



### **Fish production**

The average national yield from culture-based fisheries of small reservoirs in India is nearly 50 kg/ha (Sugunan and Sinha, 2000), which is low (Sugunan, 1997) compared to other countries in Asia and Latin America such as China (743 kg/ha), Sri Lanka (300 kg/ha) and Cuba (100 kg/ha). Even a modest increase in yield can push up the production of small reservoirs to at least 0.15 million t, against the present level of less than 0.07 million t. Similarly, the medium and large reservoirs can add another

0.13 million t. Producing 0.2 million t of fish from aquaculture would entail creation of 100,000 ha of new ponds at a cost of 20 billion INR (US\$ 440 million). Considering that this yield enhancement can be achieved at a much lower cost, on sustainable and eco-friendly terms, reservoirs should receive adequate priority in future plans for inland fishery development in India.

One of the reasons for the low yield is under-stocking. There are 900 hatcheries across the country producing more than 18,000 million fry of Indian major carps annually. However, most of the fry produced in the hatcheries go to aquaculture managed by the private sector. The government and cooperative societies, which manage the reservoir fisheries, do not have enough infrastructure to produce the required number of fingerlings.

## Recent trends

Efforts made by the Central Inland Capture Fisheries Research Institute (CIFRI) in many small reservoirs across the country have demonstrated the efficacy of culture-based fisheries. For instance, in Aliyar reservoir (Tamil Nadu) fish yield increased from 35 kg/ha to 194 kg/ha. Successful stocking has also been reported from a number of small reservoirs in India.

A recent World Bank-assisted reservoir fisheries development project in India confirmed the validity of using Indian major carps in the culture-based fisheries of small reservoirs. The project, covering 78 reservoirs (24,613 ha) in three states, involved erection of pen nurseries in the reservoirs to ensure that the fish seed was reared to at least 100 mm in size before stocking. Loan was provided to cooperative societies to buy boats and nets. A perceptible relation between stocking and yield was obtained.



## Floodplain wetlands

Wetlands located at the floodplains of major rivers form an important fishery resource in the northern and northeastern states of the country. Known as beels, boars, pats, and chaur, they spread over more than 200,000 ha of surface area in the eastern and northeastern regions of the country. Studies conducted by the CIFRI in the past 15 years have shown that fish yields from the floodplain wetlands of West Bengal can be raised to 1,000-1500 kg/ha/yr from its present level of only 100-150 kg/ha/yr by adopting culture-based fisheries (CIFRI, 2000).

There are two kinds of floodplain wetlands, namely, *open and closed*, depending on their connection with the parent river. They have different patterns of community metabolism.

## Fisheries of the open lakes

The open type of floodplain wetlands is a typical continuum of rivers, where the management strategy is essentially akin to riverine fisheries. In capture fishery management, the basic approach is to allow recruitment by conserving and protecting the brooders and juveniles. Therefore, an insight into population dynamics including recruitment, growth and mortality is very much essential. Identification and protection of breeding grounds, free migration of brooders and juveniles, and protection of brood stock and juveniles through conservation measures are important. Common strategies followed are summarized as:

- Increase the minimum mesh size to catch fish at the size of at least 500 g
- Increase or decrease the fishing effort to maintain maximum sustainable yield
- Observe the close season (usually during the southwest monsoon) to protect the brood stock
- Maintain the diversity of the gear that comprise a number of indigenous designs (fish aggregating devices, traps, lift nets, dip nets, cast nets, etc.)
- Selective augmentation of stock, only if unavoidable

### **Culture-based fisheries of the closed lakes**

Culture-based fishery is most suitable for closed lakes. In culture-based fishery, growth depends on stocking density and survival depends on the size of the stocked fish. The growth varies from one water body to another depending on the water quality and food availability.

The management parameters are:

- Stocking density
- Size at stocking
  - Fishing effort
  - Size at capture
  - Species management
  - Selection of species

Closed lakes are ideal for practicing culture-based fisheries for the following reasons: First, they are very rich in nutrients and fish food organisms, enabling the stocked fishes to grow faster to support a fishery. Growth is achieved at a faster rate than in reservoirs. Second, the floodplain wetlands allow higher stocking density because of better growth performance and high yield. Third, there are no irrigation canals and spillways unlike in small reservoirs, which cause stock loss. Also, the lack of effective river connection prevents entry of unwanted stock. Stocking of detritivores is allowed as the energy transfer takes place through the detritus chain.

### **Culture and culture-based systems**

There are systems that can combine the norms of culture and culture-based fisheries. The marginal areas of the lakes are cordoned off for culture systems either as ponds or as pens and the central portion is left for culture-based (or capture) fisheries. Floodplain wetlands also can be part of an integrated system.

## Conclusion

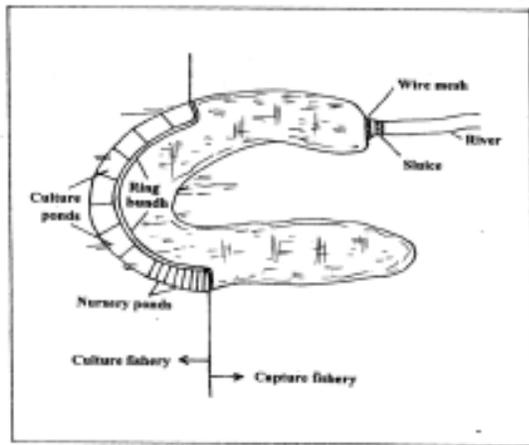
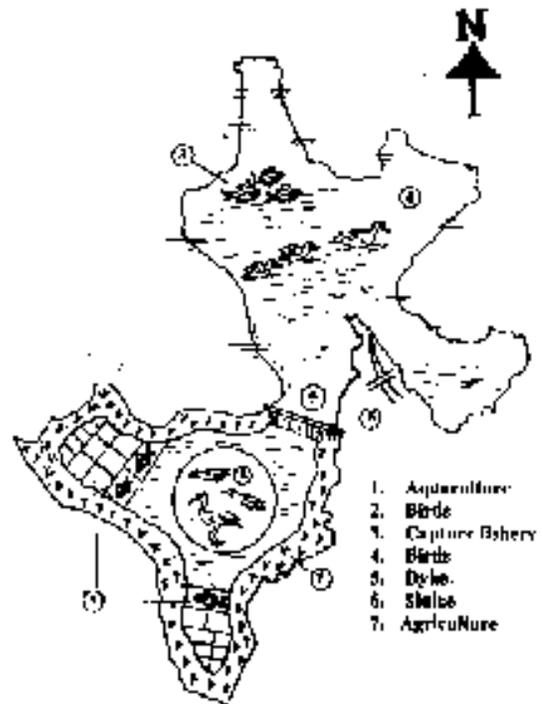


Figure 5 Diagrammatic representation of culture-cum-capture fisheries

Diagrammatic representation of culture-cum capture fisheries



Integrated Development of Belom Beel

Rivers, estuaries and lagoons, being threatened with environmental degradation, are not expected to play a major role in meeting the additional requirements of inland fish production. Intensive aquaculture entails high cost and its unchecked growth may lead to many new environmental, social and legal issues. Therefore, any substantial increases in inland fish production may have to come from the development of culture-based fisheries in small reservoirs and lakes. Various kinds of enhancements in medium and large reservoirs need to be given priority.

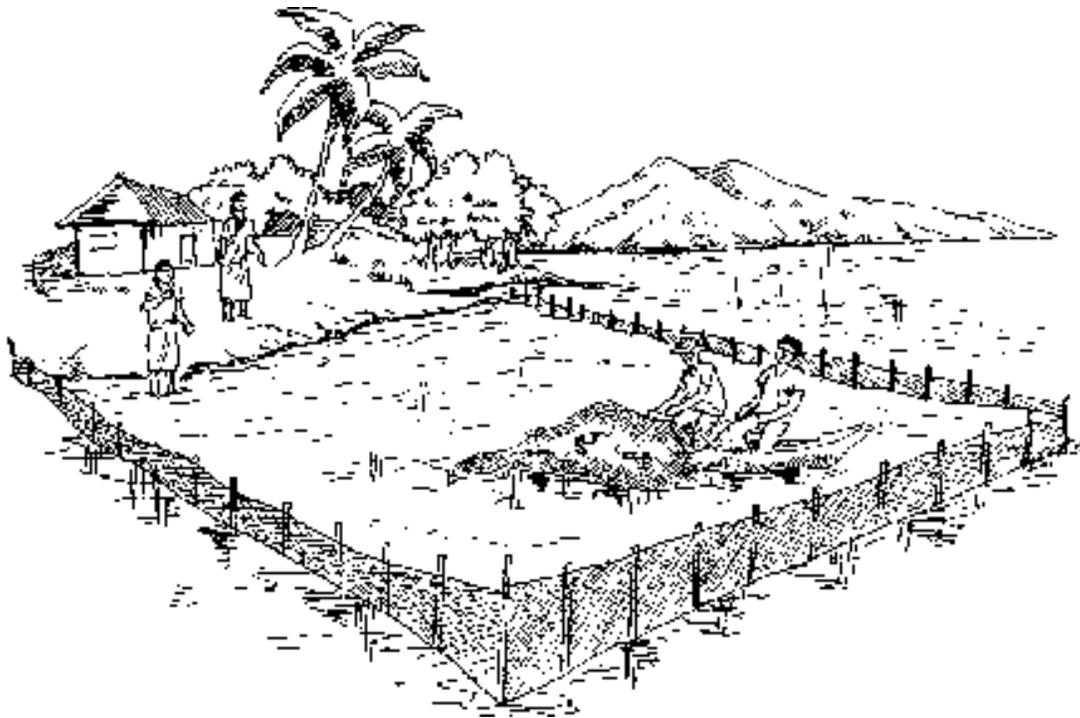
## Pen culture in floodplain wetlands

Culture of fishes and prawns in pen enclosures is a very useful option for yield enhancement in floodplain wetlands, especially those infested with weeds and harvesting is a problem. Pens are barricades erected on the periphery of lakes to cordon off a portion of the water body to keep captive stock of fish and prawn. They can be constructed in any shape and size using a variety of locally available material.



CIFRI has standardized the methods for culture of freshwater prawn (*Macrobrachium rosenbergii*) in pens. Pens made of bamboo are stocked with juvenile prawns at the rate of 40,000/m<sup>2</sup>, which are given locally made feed with 38% crude protein. The required feeding rate in the pens was very low (as low as 1-2% body weight) due to the rich natural fish food resources in the lake. The rate varies according to the scale of operation and availability of natural food. At the end of a 90-day growth period, prawns grew from 4 to 65 g (average) with a survival rate of 60%, resulting in a yield of 1,560 kg/ha of pen area.

These are recognized as eco-friendly and socially relevant means of fishery development all over the world. Reservoirs and floodplain wetlands in India can make substantial contributions to fish harvests through the adoption of culture-based fisheries.



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# Community Rice-Fish Farming in Bangladesh



Rice paddies in the medium and lowland areas are also suitable for fish cultivation. In Bangladesh alone, there are more than 1.46 million hectares of lowland rice areas that provide scope for fish cultivation. These areas are currently exploited for wild fish capture, but productivity is now declining.

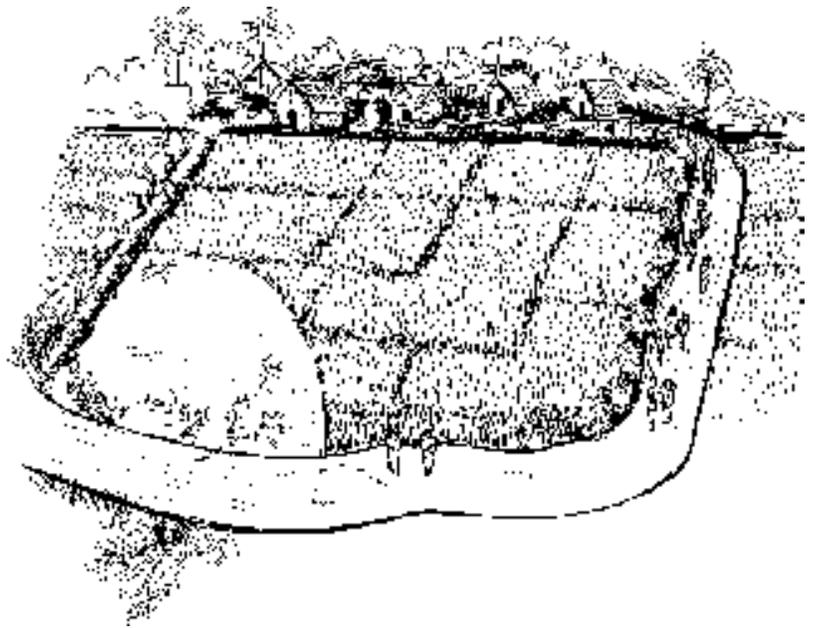
In medium land areas, farmers build dikes about two feet high and fish are grown in such rice fields. However, increasing population pressure is resulting in increasing fragmentation of land and rice-fish cultivation. These smaller areas are becoming less attractive economically. Isolated rice-fish farming poses problems for the maintenance of water levels suitable for rice-fish cultivation.

In addition, dikes are too low to prevent flooding. However, one high dike around a number of fields is enough to solve many of these problems. Community fish-farming technology provides a strategy for implementing and managing this collective area.

To overcome the above problems in low and medium land areas, particularly during the monsoon season, community fish farming technology has been developed in Bangladesh. Since Asia abounds with these low and medium land areas, there is opportunity to explore the adaptation of this technique to other areas in the region.



Community rice-fish farming unit in lowland area



Community rice-fish farming unit in medium lowland area

## What is community rice-fish farming?

It is a collective effort of people living largely in low and medium level land areas undertaking rice-fish cultivation by artificial stocking of fish into the environment. Wild fish trapping and cultivation is promoted with cultured fish. There is no limit for the number of people involved. In medium land, small groups are generally formed, while a bigger group size is common in lowland areas since large areas remain flooded and the land is owned by many people. However, from the management point of view, if the group is less than 30, community rice-fish farming is more effective.

Community fish culture in lowland areas provide opportunities as well as challenges to bring together different sectors of society. Strategies have to be devised to bring these diverse groups of people to work together. Exclusion of any single group could pose a threat to long- or even medium-term sustainability of the activity.



The landless form an important group since these people have generally been using such areas either for fishing or other activities to derive their livelihood. The inclusion of these people to meet the labor requirements of the activity like guarding, harvesting, etc. have helped them in getting a share of the profit. In some instances, small fish are given to these people to sell and make a living.

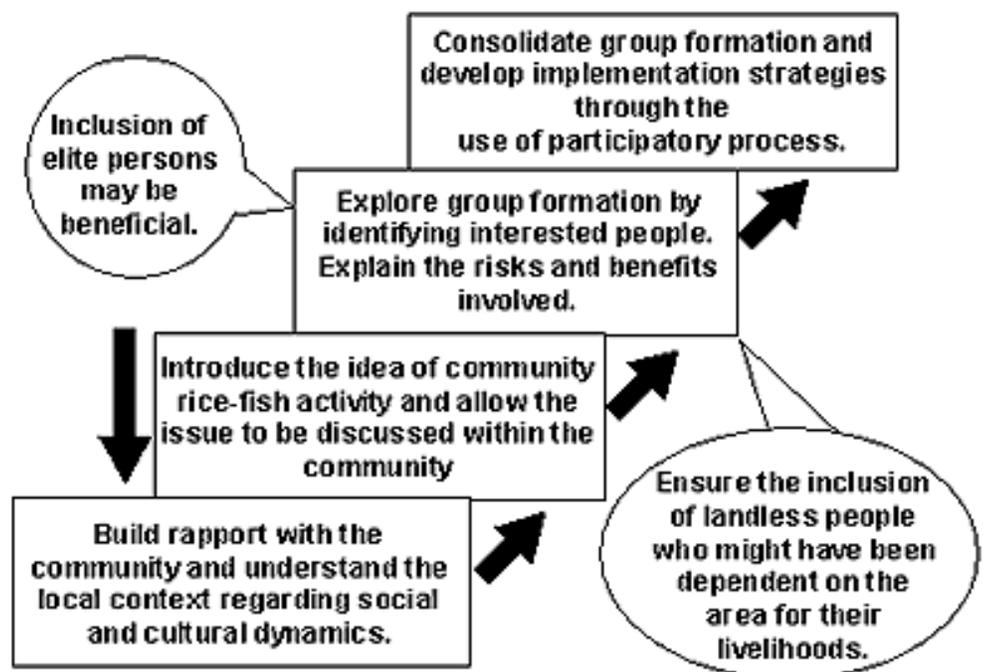
One benefit from the inclusion of such people is the elimination of poaching and group conflict. Likewise, it increased community bondage.

## Identification of suitable area

Adequate steps should be taken to identify the suitable area and examine the history of the area with regard to drought and flood over time. This will help in deciding the level of investment that has to be made, particularly with regard to raising dikes, construction of *bana* (bamboo net), etc. This is particularly important in low-lying areas, where heavy floods are more common. Suitable low and medium ricefields are those which are surrounded by elevated areas like roads, homesteads, and where it is easy to install inlets and outlets.

## Formation of groups

Although the landless have no land in the cultivation unit, they share equal contributions with the other members of the group. Their involvement in the group provides them priority in selling their labor whenever necessary.



## Organizational framework

The early development of an organizational framework helps to maintain group cohesiveness and to avoid conflicts. The framework should be developed with the participation of all the stakeholders and

should cover a range of issues and aspects.

### **Tips for developing an organizational framework**

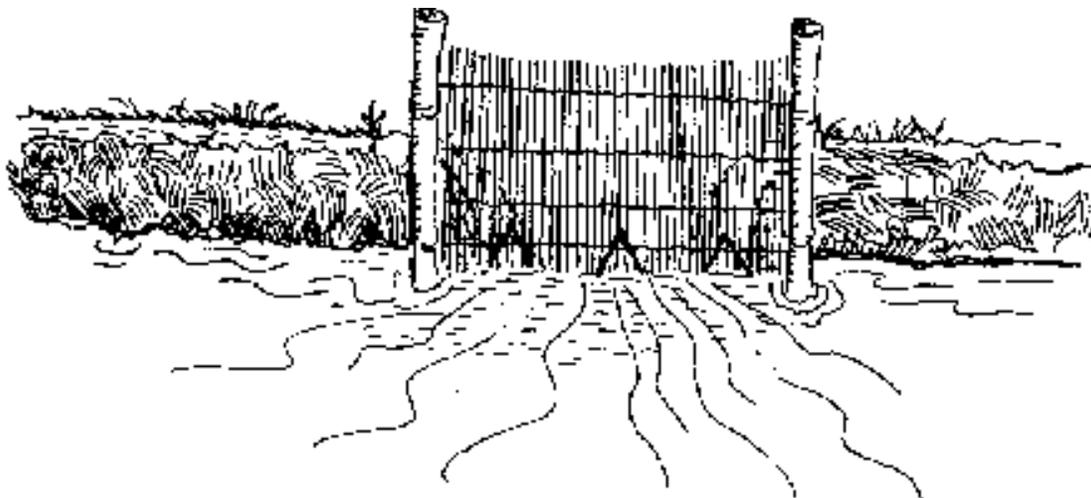
- Ensure group cohesiveness and resolve conflicts. Encourage farmers to elect a leader of their choice.
- Increase the facilitation skills and leadership qualities, provide special training to the elected leader/s.
- Assist the group to develop their rules and regulations for the group activity, which should include sharing of costs, risks and benefits.
- Help the group to develop their own financial management system.



### **Resource management aspects**

The organizational framework should help in the efficient management of the resources to get the best output. The following are some key points to be considered in resource management:

- The building of dikes to protect the area from floods is a major activity and should be done early in the season.



- Wild fish constitute a good source of income in low-lying areas. Special nets can allow wild fish to enter (but not return) and help to increase yields.

- Focus learning sessions on the symbiotic relationship between different species living in the aquatic environment.

- Encourage farmers to efficiently use peripheral dikes for vegetable cultivation.

- Learning sessions focused on the integrated pest management (IPM) approaches with emphasis on

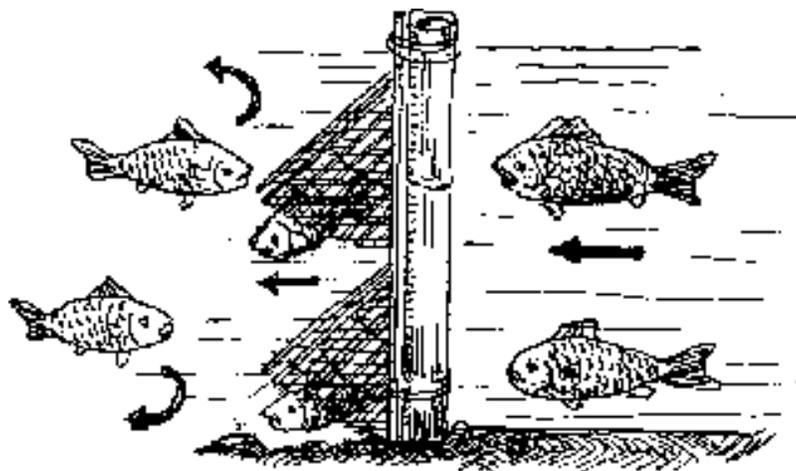
the natural management of insect pests would be helpful to ensure that people will not resort to pesticide use.

- It is necessary to guard the resources from theft, poisoning, etc.

- Feeding and fertilization are generally avoided to reduce costs and risks, particularly in the formative years.

- Help farmers to understand the principles of the activity and encourage them to develop technologies appropriate to the local environment.

- Use participatory monitoring and evaluation tools to ensure community participation in the management of the activity.



IPM is the economical, ecological, environmental and social strategy that focuses on long-term prevention of pest problems. This is done through a combination of techniques such as encouraging biological control of pests and ecologically sound agricultural practices.

## Training course for group organizers

Group organizers are provided with training to help them organize the groups better. The training is composed of four modules.

### Objectives

- Build better understanding on resource management.
- Increase leadership qualities of the elected leaders.
- Strengthen organizing skills of group leaders.
- Build understanding on resource management.



### Module 1

What is community rice-fish culture, why is it required – costs and benefits, opportunities and constraints for community rice-fish.

### Module 2

Role of group organizers, organizing groups, solving conflicts in groups and team building.

### Module 3

Organization, meeting, agenda setting, facilitation and documentation of meetings.

### Module 4

Participatory decision making process, role of members in guarding, marketing and harvesting, accounts maintenance and planning for the coming season.

### Problems encountered

- Internal group conflict affects group integrity
- Weak leadership of the group organizers
- Lack of interest of the participants in the early stage of the process
- Less coordination among the group members
- Lack of proper size fingerlings
- Less access to fish market to sell the fishes
- Jealousy among members of the community
- Poisoning
- Poaching



### Lessons learned

- Unity among the group is a key to success. Conflicts, if any should be resolved early through community participation.
- Community approach is a good tool to promote IPM and eliminate pesticide usage.
- The productivity of the community fish culture units is generally high as compared to general rice-fish system owing to better growth of fish and

contribution from wild fish.

- Avoid overstocking of fish to manage disease in winter and promote good growth of fish.
- If there are rice plots in the area, avoid stocking grass carp.
- Development of fish seed bank will be helpful to overcome the problem related to scarcity of fingerling.

## Conclusion

Community fish culture provides an opportunity for better use of resources, which at present is not exploited. Due to lack of leadership and direction, these resources are often either unused or become the subject of conflict. Hence, facilitation by outsiders to help the community in realizing the potential would help in better use of the resources.

### **Community rice-fish farming in Jamalpur, Bangladesh**

Farmers, in low-lying areas of Bewra Plash Tala of Jamalpur District of Bangladesh, decided to experiment on community fish culture activity. 54 farmers of the village joined together using a total area of about 8 ha. While there were some farmers who were the members of farmer field school, majority of them were non-members. The group elected a group leader for the management of the activities. The chairperson and the secretary were given training on group organization skills in a special training conducted by New Options for Pest Management (NOPEST) project of CARE.



26,000 fingerlings of different fish species (rohu, mrigal, catla, carpio and silver barb) were stocked in the area. These were grown with natural food available in the fields. To meet expenses incurred, each member contributed 200 Taka (54 Taka = US\$1).

To counteract flash floods resulting from heavy rains, the group members made bana (nets) using available resources. These stretched over 600 m. In addition, the fish are also protected by placing banana trees, nets, tree branches, etc.

Even with the loss of some fish during floods, the community was still able to harvest 2.2 tons of fish during the six months culture period. The earnings reached a total of 66,000 Taka and each member got a share of 1,222 Taka. The group is now in its third year of operation and functioning on its own. With the success of the group, several communities in the area have initiated similar activities in other project areas of CARE. The community fish culture activity has helped bring large areas under rice-fish cultivation. The impact of the activity is seen in:

- increased community cooperation;
- better use of the resources;
- increased fish availability in the area; and
- increased income.



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# Marine Reserves and the Role of Local Government Units in the Philippines



Overfishing, destruction of marine habitats and the resulting decline in fish catches affect small-scale fishermen throughout the Philippines. The establishment of marine protected areas is a recognized and proven strategy for resource conservation and management. The protection and management of marine areas can result in marked increases in fish growth and yields. Marine reserves protect breeding populations of corals, mollusks, fishes, shrimps, mangroves and seagrass from which neighboring depleted areas can be recolonized. Local government units (LGUs) play a critical role in establishing and managing marine reserves and protected areas.

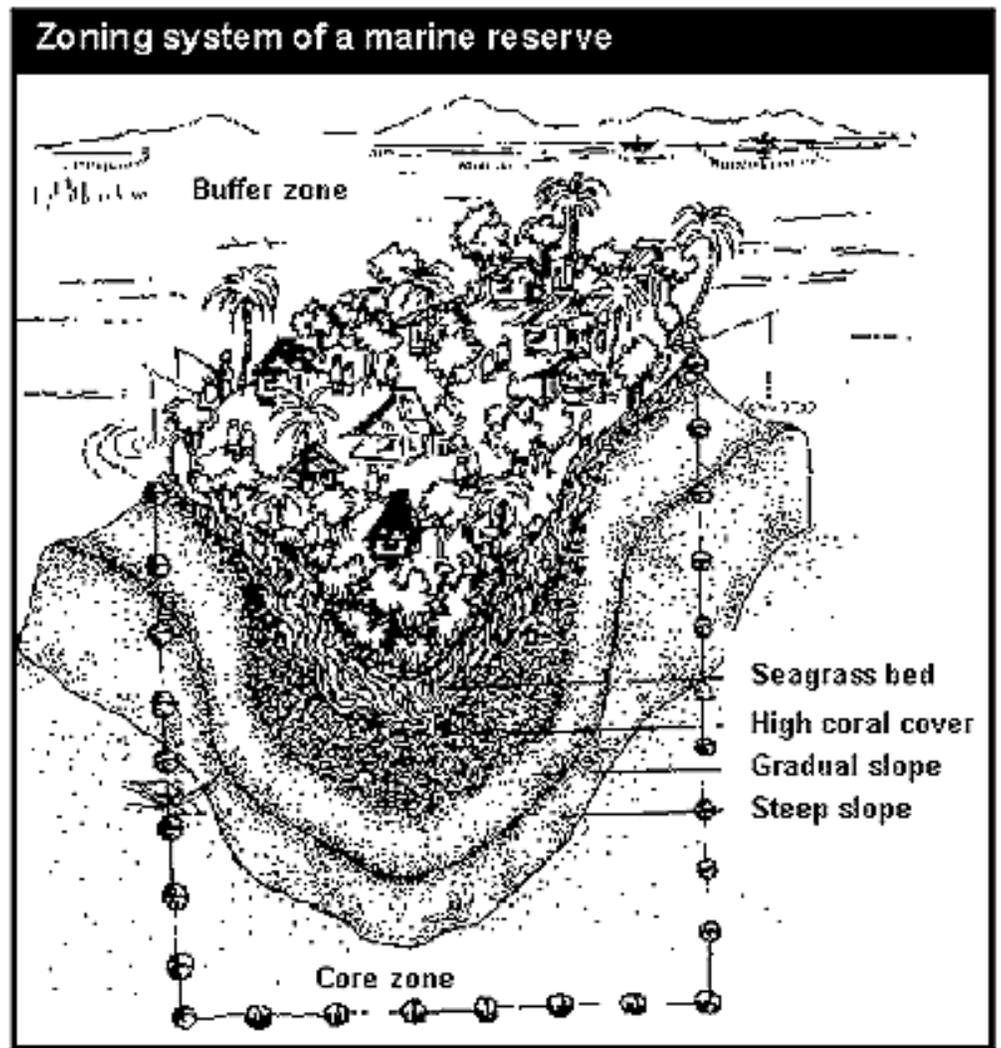
**What is a marine reserve?**

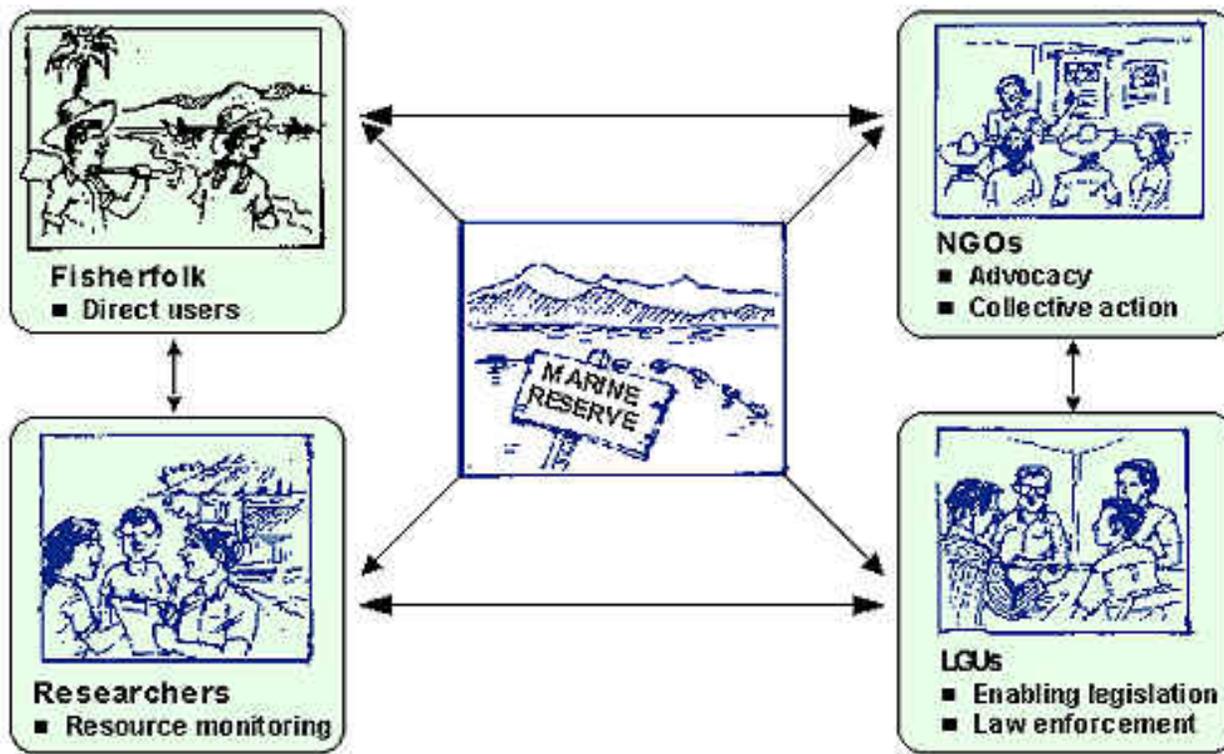
A marine reserve is an area within a coastal zone where resource extraction is either banned or highly regulated. It may be a part of a single or a combination of any of the major coastal ecosystems (coral reefs, mangroves, seagrasses, soft-bottom communities). Resource utilization in these areas is strictly managed, hence, resources are protected.

Also, marine reserves conserve biodiversity to support local fisheries. They are venues for education, research, and habitat restoration. These areas provide an environment for low-impact aquaculture managed and organized by coastal communities.

Resources in marine reserves may be viewed as "common property" for the exclusive use by a community. Various sectors of the community therefore "own" or have an interest in the use, management, and protection of marine reserves.

## Stakeholders





## Legislative and legal support

The protection and allocation of marine and inland aquatic resources is enshrined in the laws of different states. In the Philippines, this is amply stated in the 1987 Philippine Constitution, which gives preference to subsistence fisherfolk.

### Stakeholders

**Fisherfolk** who depend on the sea for their livelihood and benefit from the improved fishery as a consequence of establishing a marine reserve.

**Researchers** who conduct studies to monitor the status of resources in marine reserves as an input to management decisions.

**Non-government organizations (NGOs)** guide collective action and advocacy among resource-users.

**Local government units (LGUs)** provide the institutional framework and legal basis for any individual or collective management actions.



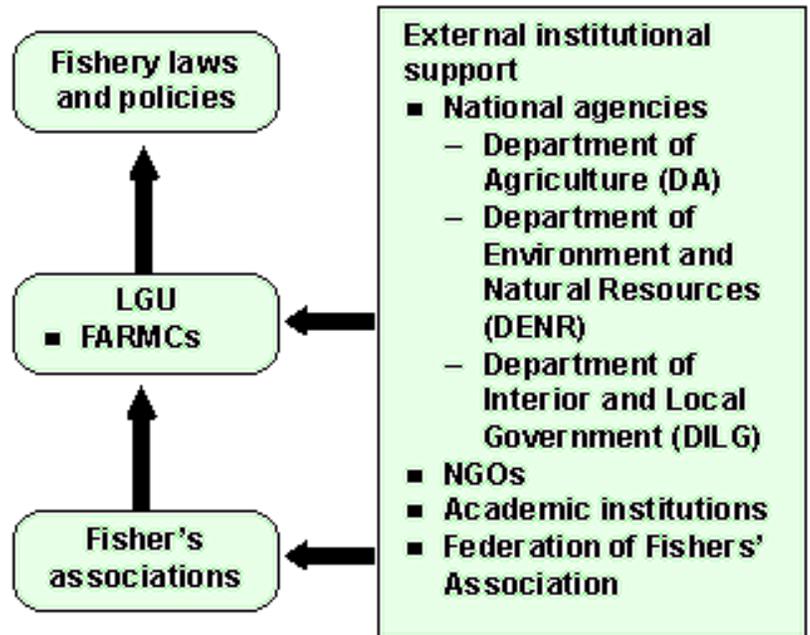
Being direct-users, fisherfolk are day-to-day managers in the use of marine resources. This requires collaboration with LGUs, which provide the enabling legislation to make protective management actions binding to all stakeholders.

Key legislations in recent years have empowered and given both the LGUs and fisherfolk greater control over their resources in municipal waters.

## Co-management of marine reserves

Enabling national legislation allowed the evolution of co-management schemes involving the participation of all stakeholders in the decision-making process, which is a requirement to sustain management intervention strategies such as marine reserves.

Administered by the LGU, the Fisheries and Aquatic Resource Management Council (FARMC) is a multi-sectoral body of fishers' organizations, NGOs, the LGU and government agencies that regulate resource use by all stakeholders. FARMCs provide a legitimate forum to raise fishery-related issues and problems. The LGU and the fishers' organization, often assisted by an NGO, national agencies and a federation of fishers' organizations, conduct general assemblies and consensus-building activities to draw up solutions suitable to the community. The LGU enacts fishery-related laws and policies recommended by the FARMC, thus, minimizing conflicts in resource use. The municipal and *barangay* (villages) councils and deputized fisher-wardens enforce the regulations and monitor compliance.



### Caution

Marine reserves have proliferated in many coastal municipalities in the Philippines and elsewhere as a result, in part, of the global conservation movement in recent years. Indeed, this has been a welcome and innovative move, especially in coastal communities where overfishing has been rampant. However, in the rush to adopt a novel strategy, the basic norms of establishing and managing marine reserves have been overlooked, resulting in the non-sustainability of management measures. Physico-biological factors and, most importantly, sociopolitical considerations are often ignored. Marine reserves can be an effective resource management tool when concerns of all stakeholders have been and will be considered. Sadly, many marine reserves in the country are "paper" reserves, with no credible conservation measures being applied.

## LGU support of marine reserves: Two examples

## 1. Malalison Island, Culasi, Antique

The island community of more than 100 households consists of subsistence fishers, having monthly incomes below the national poverty level. Before 1990, the island's reef fishery was typically open-access, with island and other fishers from neighboring coastal barangays engaged in illegal and destructive fishing. Conflicting national fishery laws encouraged the encroachment of commercial fisheries in municipal waters (including the island), which became a source of dispute. Coastal resource conservation among island fishers was practically non-existent.

This scenario changed in 1990. An exclusive fishery-use zone of one square kilometer was initially set by a Culasi municipal ordinance. This was followed by another ordinance in 1991, which permitted the deployment of artificial concrete habitats in the protected zone. Organized fisherfolk succeeded in getting the Culasi municipal council to declare the entire waters of Malalison Island for the island fishers' exclusive use. A ban on commercial fishing and destructive gears was imposed. In 1995, acting again on the petition of the organized fisherfolk and the barangay FARMC, the Culasi municipal council declared one of the island's reef fishing grounds a marine sanctuary closed to any form of fishing. No serious violation of the sanctuary has yet occurred. To date, resource monitoring of the island's marine resources by the organized fisherfolk, together with SEAFDEC researchers, provides advice on management decisions. Since co-management arrangements have been in place, performance indicators (equity, efficiency and sustainability) have improved, particularly in the perceived control over fishery resources, fair allocation of access rights, and participation and influence in fishery management.

### **Related Philippine Laws**

- The Local Government Code of 1991 (Republic Act 7160) provides LGUs greater and exclusive access to their coastal resources. LGUs are authorized to issue licences for and collect fees from several fishery activities in municipal waters without prior approval from the national government. Municipal waters extend 15 km from the shoreline. The Code does not explicitly stipulate the establishment nor governance of marine protected areas in municipal waters.
- The Fisheries Code of 1998 (Republic Act 8550) allows LGUs and municipal Fishery and Aquatic Resource Management Councils (FARMCs) to recommend to the national government the declaration of closed seasons for the fishery and the establishment of at least 15% of the total coastal area in municipalities as fishery reserves and sanctuaries. Local representation is emphasized in municipal FARMCs. Together with barangay (village) FARMCs created in 1995 by Executive Order 240, municipal FARMCs may recommend the enactment of relevant fishery legislations to the municipal council.
- The National Integrated Protected Areas System (NIPAS) Act of 1992

(Republic Act 7586) provides the legal mechanism for the establishment and management of protected areas to be directly managed by a Protected Area Management Board (PAMB). With assistance from the Department of Environment and Natural Resources (DENR), presidential decrees then national legislation set aside protected areas. Like the FARMC, local representation is strong in the PAMB. The board implements a general management strategy or plan, which is formulated in consultation with both national and local stakeholders.

## 2. Sablayan, Mindoro Occidental

Exploited by local municipal fishers and by commercial fishers from elsewhere, the reefs of Sablayan have become sources of conflicts among contending users, including sports diving enthusiasts who frequented Apo reef. In 1980, the national tourism agency declared Apo reef a marine park and in 1983, through a municipal ordinance, a tourist zone and marine reserve. Over the years, however, enforcement of protective management has failed to the detriment of reef resources, since local stakeholders were not fully consulted. Local fishers resisted the plan to protect Apo and neighboring reefs in the municipality. Clearly, the approach of establishing a marine reserve in the area had to change. With the assistance of university researchers, an NGO, and LGU extension workers, public consultations and dialogues were initiated with local fishers until, in 1995, Apo reef was declared a "natural park" under the NIPAS Act. Nearby reefs became municipal marine reserves. Municipal fishers were organized into a cooperative. Other livelihood options were extended to members of the cooperative to mitigate the impact of regulating fishing in their reefs. The LGU deputized fisher-wardens or Bantay Dagat to patrol Apo and neighboring reefs to ward off poachers. Fishery co-management of the marine reserves has continued to date. All stakeholders are being educated on the value of conservation of their coastal resources. Good rapport exists between fishers and the LGU. Fishers have reported an improvement in their daily catch from outside the marine reserves. In addition, several fish, sea turtles, and migratory birds have returned to the area.

## Lessons learned

- Consultations and dialogue among stakeholders are essential in ensuring the sustainability of marine reserve management.
- Empowered and enlightened fisherfolk can effectively take part in the management and use of marine reserves.
- Research-based information is important in arriving at decisions and in formulating policies.
- Management of marine reserves can be sustained by instituting an acceptable cost-sharing scheme which confers on the local fishing community some equity rights. This motivates them to continuously support the

project.

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# Local Knowledge and the Conservation and Use of Aquatic Biodiversity



It was only recently that people in international development circles began to recognize the importance of biodiversity for rural livelihoods. Traditional rural societies have long understood the importance of biodiversity and have, either intentionally or incidentally, developed practices to protect it. This is because rural people, with varied livelihood strategies, rely heavily on biodiversity for their livelihoods. For example, in Khong District, Champasak Province, in Southern Laos, local people living on islands in the middle of the Mekong River use different traditional and modern fishing methods to harvest about 200 fish species at different times of the year, of which approximately 150 are significant in terms of maintaining their livelihoods. The reliance of local people on biodiversity has provided them with a powerful incentive to ensure that it is maintained.

Local knowledge (LK) is the knowledge that people in a given community have developed over time and continue to develop. LK is dynamic and is based on the experiences of the holders of the knowledge. LK is sometimes referred to as indigenous knowledge (IIRR, 1996), or local indigenous knowledge. Many terms with similar meanings are used.

Biodiversity can be described as the variety of living organisms and is often considered at three levels: genetic, species and ecosystem (Koziell, 1998).



## Rural traditional biodiversity conservation



Often, biodiversity conservation occurred coincidentally through cultural beliefs and taboos, leading to practices that are essentially but not entirely biodiversity friendly. However, beliefs have sometimes been established by traditional societies to support practical concerns, including those related to natural resource management and biodiversity conservation. Nevertheless, it must also be understood that organized attempts to protect biodiversity in rural areas arise as a direct or indirect reaction to natural resource management and livelihood crisis. In many cases the most biodiversity friendly societies are notable not for their intricate conservation oriented regulations, but rather for the lack of them. Therefore,

there is a risk that outside influences might break down these traditional systems and local people may be unable to adapt, thus resulting in the community adopting new livelihood strategies that may not be ecologically sustainable or biodiversity friendly.

Rural people engaged in subsistence-oriented livelihoods are notable for their practical way of viewing the world. However, it would be incorrect to suggest that they care only about basic subsistence and improving their material wealth. For example, in Khong district local people often state that they want to see particular fish species and other aquatic organisms protected because they do not want their children and grandchildren to grow up not knowing what those species look like. When people have a long history of living in a particular area, their sense of history and belonging, aside from very practical reasons, often act as powerful incentives for protecting biodiversity.



Local people living in Khong District along the banks or on islands in the middle of the Mekong River rely heavily on the aquatic resources found near their communities. This heavy reliance on aquatic resources has resulted in the generation of LK regarding the management of resources that communities depend on. For example, their LK led them to conclude that deep-water pools in the middle of the Mekong River play a critical role in maintaining aquatic communities. They recognize that during the low water dry season, deep-water pools act as critical refuges for fish, including broodstock. Some governments in the Mekong Basin have adopted regulations designed to conserve fish species during their spawning season, which for most Mekong River fish species is during the wet season. LK suggests, however, that protecting fish during the dry season may be more important, since traditionally that is the time of greatest impact on Mekong fish through harvesting, as water levels are low, and the rice season is over, giving local people more time for fishing.

"Sea cucumbers are very important. They clean sea grasses. If your house is in a mess you do not like to live there and you move to another place. Fish are just like people." A fisher from Rizal, Misamis Occidental Province, Philippines states.

Fishers' local knowledge is used to promote the conservation of the sea cucumbers and other sea grass bed species, which are important parts of the aquatic ecosystem.

In the past, people in Khong District protected deep-water pools in the Mekong River through taboos based on a fear of dangerous spirits that were believed to inhabit the areas. Moreover, there was little need for locals to fish deep-water areas, since fish were plentiful throughout the river, including shallow areas.

## **The role of local knowledge in the monitoring and protection of aquatic biodiversity in a modern world**

With the relatively recent but rapid arrival of the market economy in Laos, the desire for material wealth has increased rapidly, as has been the case in many subsistence-oriented societies in various countries in Asia. Efficient fishing gears, such as nylon gill nets, have also been introduced, making it much easier for locals to exploit fisheries resources. New markets have, for the first time, given fish a value beyond simply food for the family. These changes led to the weakening of many of the traditional taboos and norms that once kept locals from fishing in deep-water pools in the Mekong River in Khong District, Southern Laos. When locals first began fishing the deep-water pools in the Mekong River over 20 years ago, fish were plentiful. Later, there has been a noticeable decline in fish catches due to overexploitation.

Local protection of aquatic biodiversity can be observed in many communities adjacent to limestone mountains in Khammouane Province, Central Laos. During the rainy season lowland areas are flooded. However, during the dry season most streams and natural small water bodies dry up. The fish are forced to seek refuge in the few places that retain enough water to sustain them, including caves situated at the base of the mountains. The fish that survive in these caves act as important broodstock. At the beginning of the rainy season, when the caves overflow, the fish re-enter streams and wetlands in surrounding areas to spawn, leading to high fisheries production in surrounding areas. While the conservation value of protecting these areas is generally recognized by local people due to their extensive LK, this conservation effort is not directly associated with this understanding. The impetus for conservation is the locals' fear of spirits that they believe protect the caves. For them, the spirits represent a powerful tool for protecting important aquatic resources to this day.

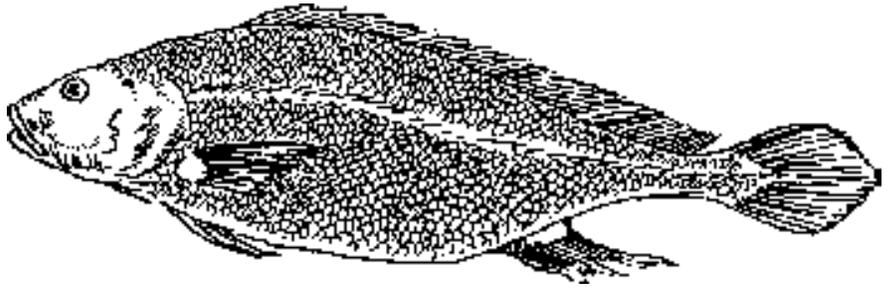


The LCFDPP (The Lao Community Fisheries and Dolphin Protection Project), established in 1993, contacted the local fishers who had witnessed these changes in fish stocks. The fishers were quick to utilize their LK to identify the deep-water pools that were potentially important keystone habitats. They also used their LK regarding fish ecology to indicate that it would be wise to protect the deep-water pools as Fish Conservation Zones (FCZs), or fishery "no-take zones". With the fear of "spirits" no longer enough to protect deep-water areas, the fishers recognized the need to implement a new system that would effectively lead to the protection of key deep-water pool habitat in the context of Government supported community-based co-management. Since then, a network of 68 mainstream Mekong River FCZs have been established in 63 villages in Khong District, and the number continues to grow.

**Keystone habitats** are critical habitats that are proportionally more important than others and are essential for the maintenance of ecological systems.

## Monitoring the impact of fish conservation zones (FCZ)

The extensive LK of local people in Khong indicated to them that deep-water pools do not constitute a single habitat type. Every area was ecologically unique and every deep-water pool supports a unique



assemblage of aquatic animals. Thus, the monitoring of FCZs requires a variety of methods that takes biodiversity into account and local understanding of the areas.

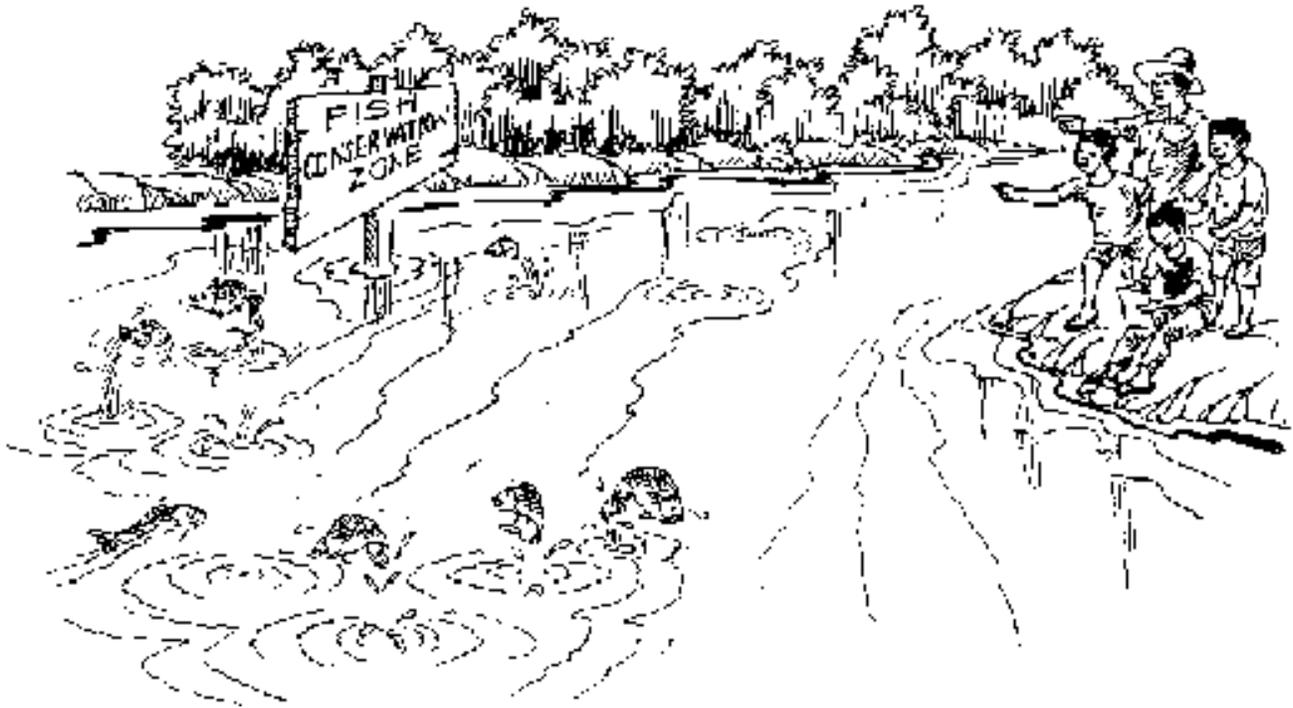
In Central Bangladesh, professional inland fishers release back into the wild, after capture with seine nets, the biggest fish. Their LK helps ensure that fish will be available during the next fishing season.

Local fishers in Khong have utilized and built on LK by developing unique methods for monitoring the success of FCZs that they have established in the mainstream Mekong River. Ban Tholathi, a village on a small island in the middle of the Mekong River near the border with Cambodia, is unique in that the large freshwater Smallscale croaker *Boesemania microlepis* (pa kouang in Lao) is known to be abundant in the area. Villagers have detailed LK regarding the biology and ecology of this and many other species, but are particularly interested in the Smallscale croaker, since the carnivorous species is high valued and a good tasting food fish that reaches at least 18 kg in weight. Moreover, this species is unique because of its habit of emitting loud and easily audible vocalizations during the height of the dry season, between March and May, its spawning season. LK also recognizes that the species only inhabits specific deep-water habitat over 20 m deep and with counter eddies in the dry season.

Along the Mekong River in Vietnam, Cambodia and Laos, local people have taboos that prevent them from harming or eating Irrawaddy dolphin (*Orcaella brevirostris*) meat. They believe that it is bad luck to kill dolphins and that dolphins can protect fishers from dangerous sting rays and crocodiles, or from drowning. In coastal areas of Southern Vietnam, fishers also culturally protect dolphins and whales, and erect small shrines where they deposit the bones of dead marine mammals. Since whales and dolphins have very low reproductive potentials, these taboos and beliefs have traditionally been important in protecting dolphins, which are now in serious decline due to various unintentional human-caused impacts, such as entanglement in gill nets.

Some 20 years ago, the Smallscale croaker was common around Ban Tholathi. During the dry season, its "croaking" was so loud that locals were afraid to paddle their canoes past the area where the croakers were concentrated. However, the introduction of nylon large-meshed gillnets and the deterioration of local taboos that prevented villagers from fishing the deep-water pools resulted in intensive harvesting

of the croaker. Within just a few years, the villagers noticed that the vocalizations had become faint and almost disappeared altogether. This indicated that stocks had been heavily overexploited.



Since protecting the area as an FCZ, locals have qualitatively monitored the Smallscale croaker population by listening to their vocalizations. Fishers were pleased to find that the vocalizations increased little by little over the years. Now, five years after the establishment of the FCZ, they believe that the level of vocalizations has returned to what it was prior to the beginning of gill net fishing in the area. In addition, they reported that Smallscale croaker populations have expanded to areas outside the FCZ, since fishers have both heard and caught them in surrounding areas. Other indicators include:

I The monitoring of rocks in the water close to the edge of relatively fast flowing areas. Fishers recognize that many of the most important fish species in their FCZs are herbivorous algae grazers. By observing rocks in shallow water at the edge of their FCZs, they get a feel for how many fish are in the area. If the rocks are relatively clean of algae, grazing is heavy, and fish are assumed to be plentiful. Moreover, different species have different mouth shapes and sizes, and fishers can recognize the grazing "tracks" that different species of fish make on rocks.

I The monitoring of the surfacing of different species of fish in FCZs. While scientists know virtually nothing about fish surfacing in the wild, villagers recognize that different species surface in different ways, and at different times of the day. They utilize this knowledge to determine what species are found in FCZs, and to estimate their numbers.

I The monitoring of levels of fish catches in areas adjacent to FCZs can provide an important indication of success

Villages in Khong with FCZs have been encouraged to establish village-based participatory monitoring programs with village fishers as researchers. Locals are initially asked to hypothesize about what fish species have benefited from FCZs. They then set the research agenda by determining how best to test their hypotheses. For example, increased catches of particular fish species in areas adjacent to FCZs are an important indicator of success. Villagers then decide what fishing methods should be monitored, and at what time of the year. They then choose the fishers in the village most suited to conduct the research, and are interested in doing so. Local researchers are trained in basic data collection methods. The research then begins, with researchers documenting their daily fish catches using notebooks and pens. The collection of data on a daily basis over months helps stimulate fishers to think about what is happening. Frequent meetings among the researchers and other community members are organized to review the research. Later the data are compiled and analyzed by the community and NGO. The villagers then consider the implications of the results and how they can contribute to improving the management of FCZs. This process helps build up LK, and also provides a certain level of quantitative data that may be useful for the government and development agencies, and which can be compared with data collected in the future.



## The role of indigenous knowledge with respect to local ecology

Local communities have a broad and holistic understanding of the linkage between natural resources. Understanding the linkages between different resources and habitats helps them appreciate the value of biodiversity, and the value of species and habitats that might not appear to be important if viewed from a narrower perspective. For example, fishers in Khong identified over 70 plant species that they believe fish are utilizing. Villagers also use a number of wild fruits, leaves and even flowers as baits for targeting particular species of fish.

### **Caution!**

LK is not always useful and can sometimes lead to the transfer of incorrect information. The community-based development of LK can help solve this problem. It should also be understood that LK is easily misunderstood and misinterpreted by outsiders.



People in Khong District do not see FCZs as isolated entities, but rather as a part of larger systems, albeit an important one. They consider FCZs to be only part of what is needed to ensure the

maintenance of biodiversity. Their LK indicates to them that many strategies, including measures related to habitat protection, will be necessary to effectively protect aquatic biodiversity. While there is no room here to elaborate on all the measures locals have adopted as part of their co-management systems, it is useful to provide one example of the linkages that locals have made.

Traditionally, farmers in Bangladesh involved in wild fish trapping systems in rivers, canals, rice fields, etc. use branches of the "shewra" tree to attract fish into an area. This practice has two purposes, which are based on farmer LK.

- Fish are attracted to the branches because the bark quickly decomposes in the water, helping provide food for many fish species. Moreover, periphyton grows quickly on the branches, and serves as food for fish.
- Tree branches placed in ditches act as anti-poaching devices, and as refuges for fish, until harvesting occurs.

Some Mekong river fish species migrate from deep-water areas, where they stay in the dry season, to streams, natural depressions and inundated rice fields, which they inhabit during the wet season. Many communities have developed specific co-management regulations designed to protect fish as they move from the mainstream Mekong River to these habitats. For example, villagers often prohibit trap fishing in streams during the beginning of the rainy season in May and June, when fish migrate upstream. This gives the fish a chance to migrate into wetlands unobstructed, so they can spawn. However, at the end of the rainy season, after juveniles have had a number of months to grow, locals allow trap fishing in the streams as the fish attempt to return from the drying out wetlands to the mainstream Mekong River. LK has, in this way, been utilized to ensure that indigenous fish stocks are protected, and that maximum benefit from the resource is gained.

## Supporting LK at the community level

The LK in Khong has helped determine what strategies are likely to be the most successful in protecting aquatic biodiversity. However, LK only remains relevant when it is dynamic (i.e., local people are constantly building on LK through direct experiences). Development agencies, including NGOs, can help promote LK in communities. The LCFDPP has tried to promote LK, not only by recognizing its importance, and promoting it within the local Government, but also by providing relevant information to local people. Even more critically, the LCFDPP has encouraged locals to be observant, learn from real experiences, and communicate those experiences to groups so everyone can learn.

It is important to recognize that the network of FCZs and other co-management regulations support and reinforce each other, since fish do not recognize village boundaries. The more villages establish co-management regulations, the greater the chances that individual communities' regulations will be successful, especially in terms of migratory species. Local people are aware of this, and are therefore keen to see the system expand throughout the Mekong Basin.

## Points to consider in developing LK in rural communities

- Extensionists must believe that farmers and fishers can be experts. Rural people often have keen interpersonal relation senses, and quickly recognize whether outsiders really believe that LK is relevant and can be developed. If extensionists are not sincere, locals are unlikely to take efforts by outsiders seriously.
- Do not be overly prescriptive. Learn from local people. Good extension begins with learning from people, not from trying to teach them. If outsiders can put extension ideas into the context of LK, local people are much more likely to take them seriously.
- Develop methods in which locals can actually see, feel or hear what is going on within aquatic ecosystems. Rural people are practical, and are unlikely to adopt practices that are unproven or cannot be easily understood and justified in the context of past experiences.

Hilsa (*Tenulosa ilisha*) is the most relished fish in the State of West Bengal in India. It is an anadromous fish that migrates up the Hooghly River for breeding. A local custom in West Bengal prevents the eating of the fish from July to mid-September. After that, on the occasion of Durga Puja, the fish is ceremoniously brought home to mark the beginning of the consumption season. The season of taboo coincides with the upriver migration and breeding season of the fish. By delaying consumption of hilsa, it is ensured that the fish completes breeding before it is caught. This is a covert conservation measure developed through LK about the fish's breeding behavior.

**Anadromous species are those that spend much of their lives in salt water environments, but migrate into freshwaters for spawning purposes.**



- Provide opportunities for locals to see the linkages between practices and results. This can be done by encouraging locals to participate directly in monitoring and evaluation activities. Let locals determine the agenda and the methods to be used. Encourage them to test hypotheses that they have developed, and provide opportunities for locals to analyze the results in research groups, encouraging them to communicate the results with each other. LK can act as a powerful peer review tool.
- Help disseminate information about management practices developed by locals and that can be justified in the context of LK. Certain members of communities inevitably possess more LK than others, and therefore can more easily conceptualize ways of solving problems. Extensionists can provide opportunities for locals to exchange information, either within villages or between them. Locals are more likely to accept ideas of other locals, since their references and experiences are similar.
- Make learning about ecosystems fundamental, as a good understanding of ecosystems will provide a strong basis for improving management over the long run.
- Encourage locals to be innovative, adaptive and flexible. Create conditions where locals do not feel that it is risky to try out new things, because they can always abandon or alter practices that do not work out as expected or hoped. It is important to recognize when doing extension that rural people are generally adverse to risk.
- Make the development of LK need-based. If locals do not see how developing a particular aspect of LK will benefit them in a practical way, they are unlikely to make much effort to learn.
- Work with children. Create opportunities for children to learn from elders. Children are the future. Moreover, their actions and ideas can have a profound effect on their parents, relatives and peers. Questions posed to elders by children can help adults make linkages that contribute to the development of their own LK.

## Conclusion

It is commonly believed in international development circles that people living in relatively subsistence societies, often referred to as the "poor", have little interest in environmental conservation and sustainable resource management. Moreover, many believe that poor people are not likely to take environmental protection seriously until they have gained a significant amount of material wealth. Unfortunately, this view extends to many urban people, and government officials. It is true a certain minimum level of food, shelter, clothing and medicine is required before people can consider finding alternative ways to survive and that poor people often do cause environmental damage to make a living. It is incorrect, however, to assume that people in rural areas generally do not hold a significant amount of LK about the environment and that they do not care about biodiversity. On the contrary, they rely on nature to such an extent that it is only logical that they care about its maintenance. We must recognize that biodiversity is important for local people, especially the poor, and that LK has a role to play in protecting it.



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## **Freshwater systems/Terrestrial systems**

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[Rice-Based Aquaculture in China](#)

[Enhancing the Performance of Irrigation Systems through Aquaculture](#)

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[Increasing Wild Fish Harvests by Enhancing the Rice Field Habitats](#)

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[Aquaculture in Stream-Fed Flow-Through Ponds](#)

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## Freshwater systems/Terrestrial Systems





# An Overview of Rice-Based Small-Scale Aquaculture



## Asian countries as rice-fish societies

Many countries in Asia can be called "rice-fish societies" in the sense that rice is the staple crop for basic subsistence, while fish is the main source of animal protein. The availability of rice and fish has long been associated with prosperity and food security. In Thailand, for example, the early inscription of the 13th century king, Ramkhamhaeng, states "in the waters are fish and in the field is rice" as an indicator of wealth and stability. In Vietnam, there is also a traditional saying that rice and fish are like mother and children.

The cultivation of most rice crops in irrigated, rainfed and deepwater systems offers a suitable environment for fish and other aquatic organisms. Traditionally a good deal of the fish for household consumption was caught from the paddy fields. With the conversion of wetlands into agricultural land and the intensification of rice production, this fishery has declined and farmers have turned to aquaculture as an alternative source of animal protein. It has to be recognized that such pressures have been uneven and there are still considerable areas of flood plain in the region where the fishery still offers an



adequate living to the local population.

In Cambodia, studies conducted by the Asian Institute of Technology (AIT) Aqua Outreach Program with the Department of Fisheries suggest that virtually all rice-farming households in the province of Svay Rieng, on the periphery of the Mekong flood plain, regularly collect substantial quantities of fish and other aquatic produce from their fields. A study in three communities in the district of Svay Theap showed an average per capita consumption of wild fish caught from ricefields and adjacent swamps of 25 kg. Each family member consumed 21 kg of other aquatic animals during the same period. During this period, virtually no fish or other aquatic products were purchased. The amounts caught vary according to the total amount and distribution of rainfall, with good rainfall early in the year increasing the catch.

The nature of this fishery varies with the season and the proximity of river systems. In Cambodia, in the wet season, the main fishery is in the rice field itself, as the fish move out of the main spawning grounds. The rice field fishery at this time is largely open access, signifying the relative abundance of the fish. The same is true for the cool season as the fish migrate back to the refuges. In the early part of the hot season, some farmers catch fish in deep trap ponds, some of them originally dug for fish culture by well-meaning projects. Some of the bigger trap ponds secure as much as 300 kgs of high value black fish, such as snakehead *Channa striata* (25-40% of the catch) or Clarias catfish (35-40%). These air-breathing species are well adapted to the swamp-like conditions of rice fields with fluctuating water levels and are highly appreciated wild fish in the capture system. They are carnivorous and will feed on other introduced fish but can be sold for twice the price of the equivalent cultured fish at local markets, as in Thailand. In Cambodia, they are also sold at high prices, leading Gregory and Guttman to claim that farmers in the areas are poor in all but fish. Clearly in such contexts, fish culture is unnecessary, although there are quite marked variations in the productivity of the fishery over rather short distances.

### **Rice-based aquaculture systems: Rice-fish culture or pond culture?**

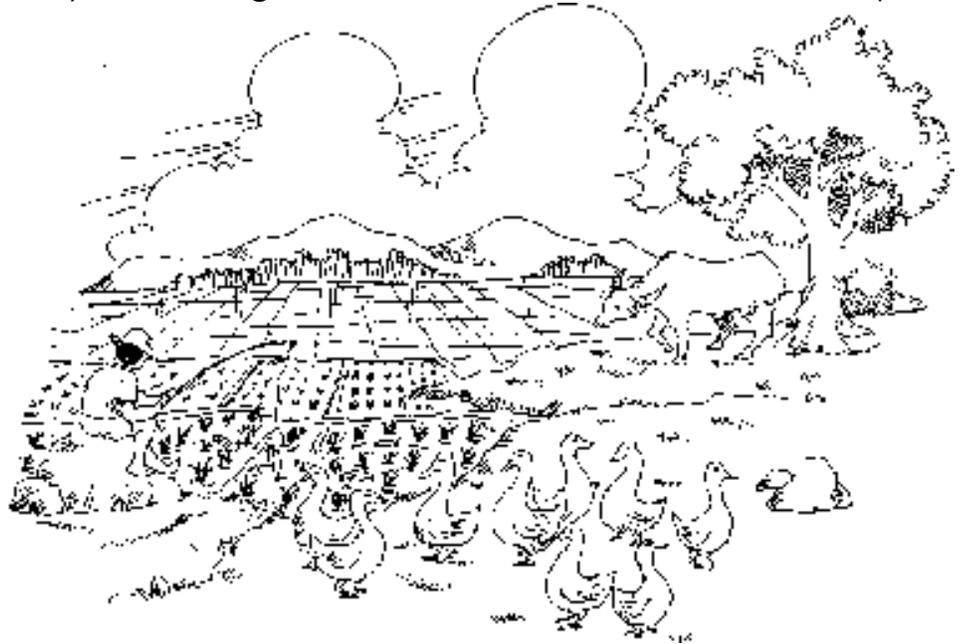
As the imperatives for a shift to fish culture emerge in rice-fish societies, an issue may be whether or not to try to replace the rice field fishery by developing culture in the paddy field or a pond. Culture in the paddy field attempts to recreate the environment of the rice field fishery, but with stocked and cultured species; pond culture effectively creates an additional artificial environment. It should be stressed that, even in pond culture, we are still talking about rice-based systems, since the farm economy where aquaculture takes place is usually still dominated by rice cultivation. In pond culture, the rice-based agricultural system offers resources for aquaculture but may also create and be constrained by competition in the use of those resources.

While these systems are often discussed separately in dealing with small-scale aquaculture, it is important to point out that, in many cases, farmers actually combine both. The pond is often linked to one or more of the surrounding paddy

fields at certain times of the year or in certain culture seasons to facilitate management of the rice crop and, if water is available, to extend the fish growing period. Fry are frequently stocked in ponds early in the season, but may be released into the paddy field to browse during the rice cultivation season, before returning to the pond when the fields are drained.

In developing aquaculture in rice-based farming systems, it is also important to understand the rich variety of those systems. At the broadest level of classification, rice is grown in irrigated, rainfed lowland, flood-prone, and upland ecosystems but very considerable differences exist within those systems. As is common in other traditional societies, rice farmers in South and Southeast Asia follow their own classification of rice lands, usually according to the level of inundation. For example, in Thailand and Cambodia,

in rainfed lowland rice systems, it is common to speak of lower paddies, middle paddies and upper paddies, which can usually be broadly recognized by the height of the bunds between the fields. In both countries traditional land holdings in rainfed areas were often composed of paddy fields of more than one elevation to offset the threat of crop loss from both drought and flood.



When rice fields were reallocated to individual households in Cambodia after the civil war, these principles were still used. The above classification refers only to rice lands, which can be cultivated normally in the rainy season. In Cambodia, there is a separate classification for lands which are too deeply flooded to allow wet season culture and can only be cultivated after the flood has receded.

Each of these types of paddy field is associated with different varieties of rice. Commonly, the higher paddies with limited water holding capacity tend to be associated with early maturing varieties or light rice. Lower-lying lands tend to be cultivated with late maturing varieties probably with a taller growth habit; these rices are usually called heavy rice. At the extreme level of flood, farmers often cultivate floating rice, with long stems that grow with the rise of the water. Of course, in areas of improved water control, such variations have largely disappeared and the traditional local varieties have, in many cases, given way to higher yielding varieties of rather uniform characteristics. However, in rainfed areas, the second and third generation improved varieties have had to be adapted to the specific local conditions.

## Planting

The other key dimension of rice cultivation traditionally has been the planting method. Rice may be broadcast directly to the field or transplanted, that is grown in a seedbed in the early stages before being uprooted and replanted to the main field. The latter method enables farmers to start cultivation in areas with better water availability early in the season, to concentrate resources on the seedlings and to better control weeds. However, it is more labor intensive and difficult to practice on large plots and with limited labor supply. In general, the water levels in broadcast rice fields tend to be shallower, the plants closer together and yields lower. In an area of extreme out migration of labor such as Northeast Thailand, much of the rice land has been shifted in recent years from transplanting to broadcasting to save labor costs.

These variations in the nature of rice cultivation have implications for the feasibility and productivity of rice-based aquaculture systems.

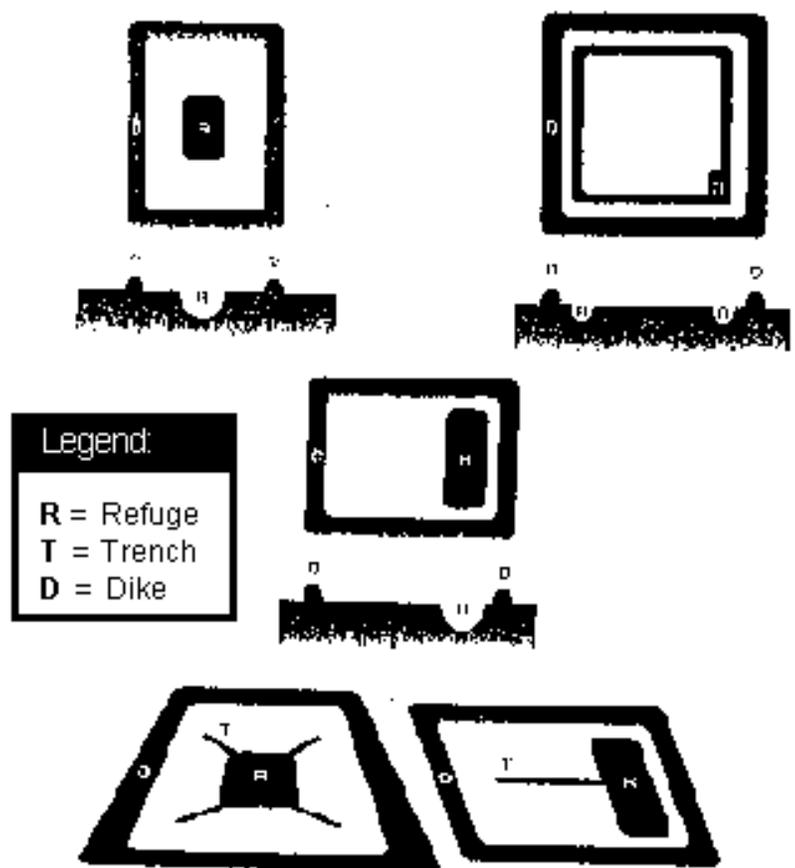
## Rice-fish culture

As a result of donors' and governments' focus on sustainable rural development, food security, and poverty alleviation, rice-fish farming systems have received a great deal of attention in the recent past. Several reviews on historical, socio-economic, and ecological aspects of rice-fish farming have been published in the past decade with either a global or a national focus. Country overviews have been provided for Bangladesh, China, India, Indonesia, Korea, Malaysia, Philippines, Thailand, Vietnam, and Madagascar. An extensive bibliography on diverse aspects of fish culture in rice fields was compiled recently.



In contrast to rice field capture fishery discussed above, farmers deliberately stock the fish in their fields either simultaneously or alternately with the rice crop. They raise them up to fingerling or table fish size depending on the size of fish seed available for stocking, the duration of the fish culture period (which may cover two successive rice crops), and the market need for fingerlings or table fish.

Technical details of the few physical modifications (bunds, trenches, water inlets and outlets) required to make the rice field suitable for fish farming have been described elsewhere. It is, however, interesting to note the differences in refuge shape and size. The refuge can be a pond within or adjacent to the rice field, or a trench which may be central or lateral, or a combination of the two. Very great differences in the size of the refuge area can be observed. For religious reasons, farmers just dig a small sump in the rice field terraces in the Ifugao province in the Philippines while in Vietnam up to half the rice field is sometimes dug up because profits from fish sales exceed those from the rice crop.



As noted above, traditional rice varieties are selected by the farmer for their suitability to agroclimatic conditions, topography, and also consumer taste. The local rice varieties are an important part of the wide biodiversity of plants and animals found in such systems. In large parts of Asia past increases in rice yields have mainly come from the gradual reallocation of land from traditional to the high-yielding modern varieties.

### Features of high yielding modern varieties

- Short
- Stiff-strawed
- Fertilizer-responsive
- Photoperiod-insensitive
- Short to medium growth duration (100-130 days).

The use of longer-stemmed and longer-maturing traditional varieties allows a higher water table and an extended period for fish farming. Although much of the expansion of rice-fish farming in the 1980s has been perceived to be associated with traditional rice farming, the case of the P.R. China with about 1.2 million ha under rice-fish farming in areas almost exclusively planted to modern varieties shows that the use of new rice varieties is not a constraint for rice-fish farming. Deepwater rice varieties are adapted to grow quickly with rising water levels reaching several meters deep. The farming of fish in these waters must be community-driven as individual property rights cannot be distinguished anymore.

Costs for stocking and keeping fish within fenced areas may be high but can be shared among members. More importantly, the importance of capture fisheries and particularly access to these resources by the landless are issues of concern in deepwater rice-fish systems.

## Cultured fish species

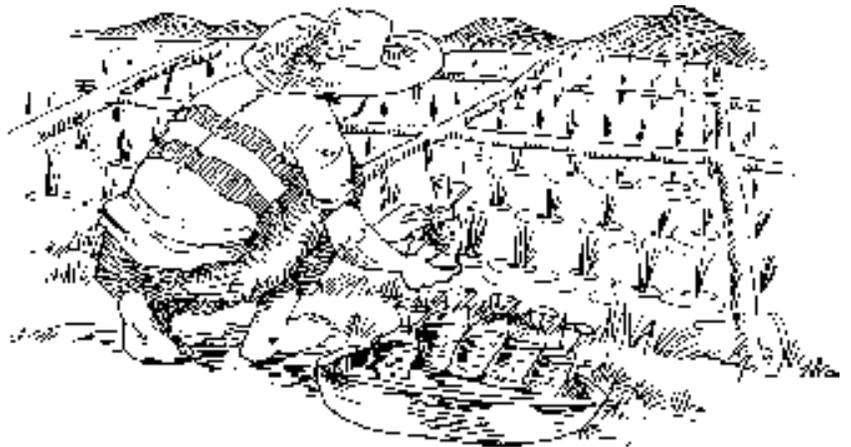
Many fish species are cultured in rice fields but only a few are commercially important. Fish species cultured in rice-fish farming:

- omnivorous common carp *Cyprinus carpio*; and
- planktivorous Nile tilapia *Oreochromis niloticus*. They feed low in the food chain and are therefore preferred species in the culture systems.
- Other popular species
- *Barbodes gonionotus*
- *Trichogaster* spp.

Often, the locally found wild fish such as snakehead *Channa striata* or smaller indigenous rice field species not only play an important role for food security and a balanced nutrition but are also important sources of income.

While farmers generally tend to exclude predatory fish from their stocked rice fields, farmers in Northeast Thailand allow the fish to

enter the field although many of the stocked fish fall prey to the wild species. This is, however, acceptable due to the high market value of the wild fish at local markets.



## Stocking

The stocking densities used in rice-fish farming vary widely. In general terms, with a low number of fish stocked in the field, naturally occurring rice field organisms are readily available as "free fish feed". In low stocking densities, overall costs are lower and therefore this practice may be more suitable for resource-poor and risk-averse farmers who are still experimenting with their farming system. Higher stocking densities require additional fertilization and supplementary feeding. Feed resources from the farm are widely used for that purpose, particularly rice bran (although the alternative uses of bran have to be considered). Farmers may supplement the readily available, naturally occurring fish food organisms in rice fields by collecting supplemental feed from the rice field and surrounding wetlands. An example is the regular collection by

hand of bigger golden apple snails (which the fish could not eat directly) by farm household family members who crush them into fish feed sizes.

Generally, integrated pest management (IPM) practices are recommended for rice-fish farming. The use of pest and disease-resistant rice varieties is encouraged minimizing the need for pesticide application. In rice monoculture, the chance of pests reaching a population level to justify control action is usually low. Potential income from fish would outweigh pesticide costs. Also, from an IPM point of view, fish culture and rice farming are complementary activities because it has been shown that fish further reduce pest populations. Evidence from the FAO IPM Intercountry Program in Indonesia shows that, through IPM, the number of pesticide applications in rice can be reduced from 4.5 to 0.5. This not only saves costs, but eliminates an important constraint in the adoption of fish farming. Therefore training in IPM for many farmers participating in the regional program in Bangladesh, Indonesia, or Vietnam has been an entry point to start rice-fish farming.

Simultaneous culture of fish and rice often increases rice yields, particularly on poorer soils and of unfertilized crops, probably because under these conditions the fertilization effect of fish is greatest. With savings on pesticides and earnings from fish sales, increases in net income on rice-fish farms vary considerably, but they are significant, with up to 100% reported increases when compared to returns from rice monoculture farms.

Selected economic indicators for the comparison of rice and rice-fish farming			
Indicator	Country	Change(%)	Comments
Increase in rice yield equivalent	Indonesia	+20	Research station results, fish yield expressed expressed in rice equivalent
Income from fish as percent of total farm income	Malaysia	+7-9	Figures for owners and tenants in double rice in double rice cropping area, respectively
Net return	Philippines	+40	Summary of results from nationwide field trials during the late 1970s to 1987 in irrigated rice areas
Net return	China	+45	Results from four farm households in Hubei Province
Net return	Thailand	+18 -35	Figures for research station and farmer field, respectively
Net farm income	Thailand	+65	Difference in rice yield equivalents

Cases with net return higher than rice monoculture	Thailand	+80	20 out of 25 farms had higher net-returns from rice-fish farming than from rice monoculture
Net benefit	Bangladesh	+64 +98	Net benefits are higher in the aman or wet season and lower in the boro or dry season
Net profit	Vietnam	+69	20% of the trench construction costs considered in capital costs. Operating costs increased by 83% for labor and 100% for irrigation, but had savings in the use of pesticides
Total farm cash	Vietnam	0	Mekong Delta, beneficial and net effects thought to be related to environmental sustainability, system biodiversity, farm diversification and household nutrition

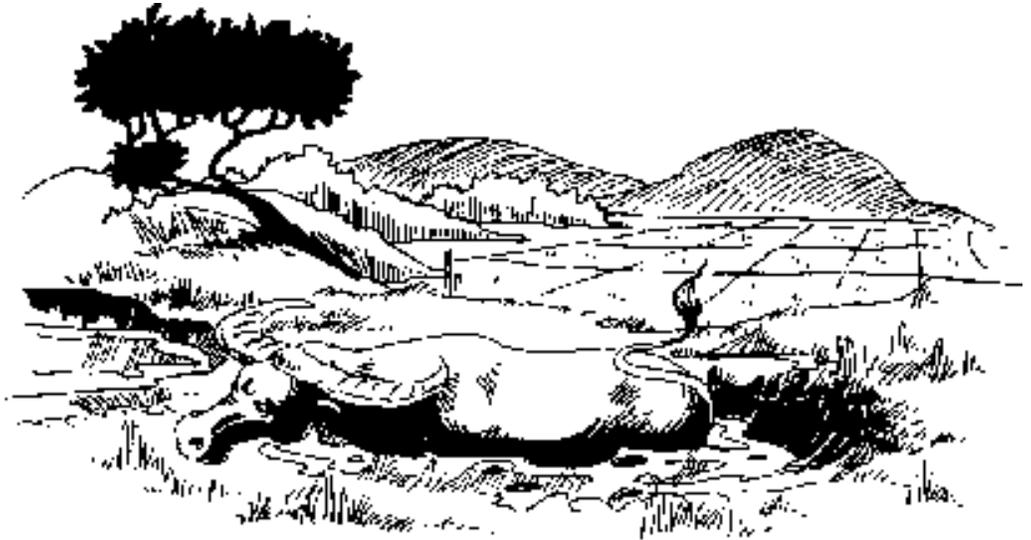
### Small pond aquaculture in rice-based agriculture systems

In small pond culture in rice-based agricultural systems, the key issue for aquaculture is resource availability. As the dominant element in the farm economy, the rice field is often the key resource for fish culture. The rice field offers several potential resources for fish culture, including rice itself. Aquatic plants such as duckweed and morning glory and a variety of other organisms including rice pests may be gathered as feed for fish (e.g., snails and termites).

Milled rice offers two potential products for fish feed, the rice itself, either cooked or uncooked, and rice bran, which can be mixed with other feed or given separately. The latter is often favored in the region since it allows farmers to observe their fish at regular intervals. Naturally the availability of rice bran depends upon the yield of rice obtained. Higher yielding systems will potentially have more rice bran available. In Vietnam, for example, double-cropped rice in the so-called intensive zone of the Red River delta may offer up to 12 tons of rice per ha per year, providing almost a ton of rice bran. In contrast, the less intensive systems manage a total production of only half that amount. Unfortunately, there are other factors in the equation which have emerged with modernization. In Thailand, little of the bran from milling rice returns to the farmers. The bran is retained by local millers, who mill the rice for free, for rearing pigs. Farmers needing rice bran have to buy it from the market. In a sense, therefore, fish culture competes with the livestock sector's demand for the available rice bran as feeds. In Vietnam, bran mixed with aquatic plants is often used as feed for pigs, rather than feed for fish. Pig manure becomes available as an input for fishponds. The more intensive the systems are, the higher the tendency to have more available manure. The balance in the use of these resources will be decided on

economic grounds. In southern Vietnam, in recent years, prices of pig meat have declined discouraging farmers from keeping pigs. However, if they produce local alcohol from rice, the resulting waste becomes a free source of feed for the pigs whose manure is used in fish culture.

Another essential part of the typical rice-based farming system in Southeast Asia is draught livestock, usually water buffalo, kept for plowing, harrowing and transport of seedlings and harvested rice. Livestock also offers a potential source of pond fertilizers for fish

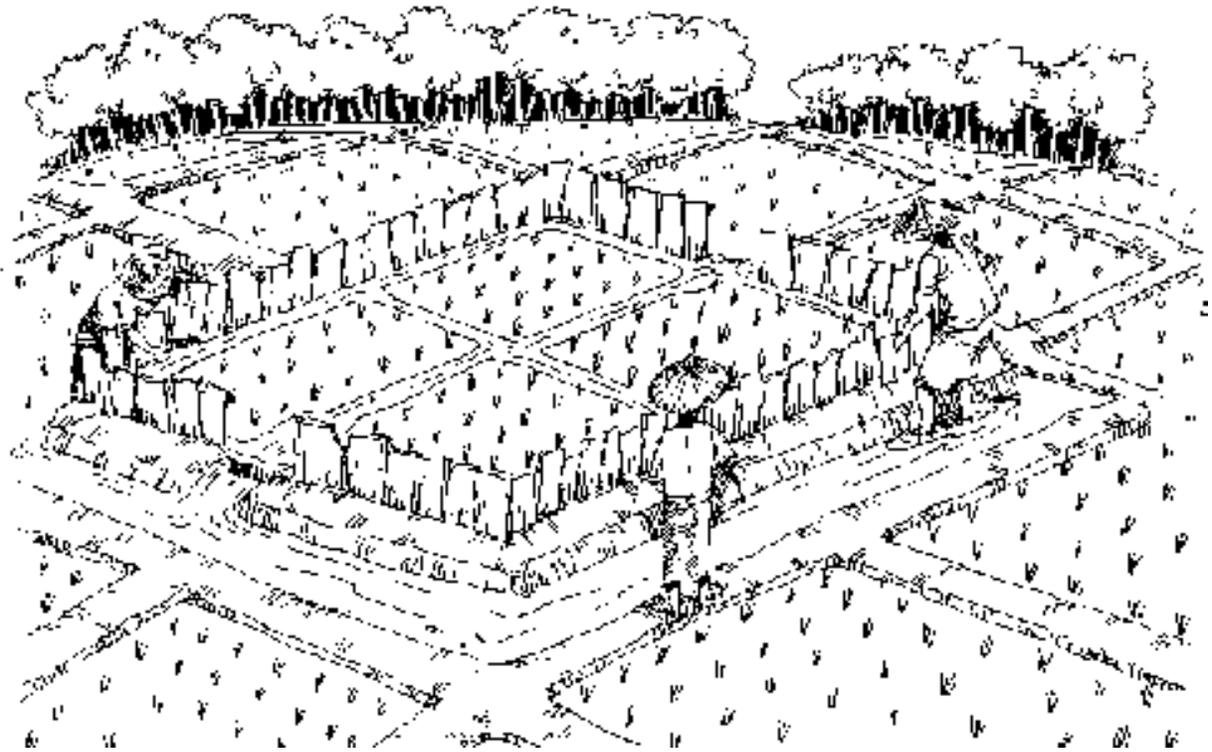


culture, although ruminant manure in general is poor in nitrogen. Once again, however, availability depends on possible competition for resources. Where buffalo are gathered in stalls at night, manure is traditionally used as fertilizer for seedbeds and paddy fields, especially in areas of low fertility away from the flood plains. Ruminants may also compete for the use of pond water, particularly where water is at a premium as in Northeast Thailand. The problem with such areas is that the rice-based farming system offers a very limited source of nutrients. While recommendations for low-cost fish culture for poor farmers usually stress the use of on-farm inputs, the typical rainfed rice-farming system in the more inland areas of the region rarely offers an adequate nutritional base for fish. After many years of work in such areas, the AIT Aqua Outreach Program has concluded that on-farm resources need to be supplemented by inorganic fertilizers if fish production is to achieve more than subsistence yields.

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Prepared by:  
**Harvey Demaine and Matthias Halwart**

# Rice-Based Aquaculture in China



Rice-fish culture is traditionally practiced in many rice-growing provinces in China. Traditional rice-fish culture is mainly used to obtain additional protein for household consumption. However, recent developments in rice field-based aquaculture focus more on the economic benefits of this family-scale business. Over 6.7 million hectares of rice lands can be brought under these systems.

Aquaculture commodities grown in a rice field result in significantly higher levels of income than when rice is grown alone. The price of fish is twice that of rice grain. In recent years, higher value aquaculture species, such as mitten-handed crabs and freshwater prawns, have been chosen by farmers for culture in their rice fields. The prices of freshwater prawns and mitten-handed crab are 10 - 50 times higher than that of rice, thus making these attractive economic propositions.

## Facts

**As of 1997**

**1.67 M ha** Total area of rice-fish culture producing about 700,000 tons of marketable aquatic animals

**419 kg/ha** Average annual yield

**By year 2000, it is expected that the total rice-aquaculture area will reach 3.3 M ha, covering about half of the total rice field area suitable for rice-fish culture in China.**



**In 1995-1997, an extension project for rice-aquaculture in Jiangsu Province in the lower reach of Yangtze River was carried out. The rice-aquaculture system was popular with local farmers, especially those who do not have access to water bodies, such as ponds and lakes, suitable for other types of aquaculture. As a result, the rice-aquaculture area expanded radically from 19,606 ha in 1995 to 68,973 ha in 1997, growing Chinese mitten-handed crab, local and exotic prawns and finfish.**

	Total area of culture (ha)	Total production of animals (kg)	Average yield of animals (kg/ha)	Profit (US\$/ha)
Rice-crab	36,113 (52.4%)*	16,245,000	450	2,898
Rice-prawn	13,867 (20.1%)*	5,712,200	411.9	2,536

\* Percentage of the total rice aquaculture area

## Models for integrating aquaculture into rice fields

### Rice field renovation

The rice field is renovated to include the following elements:

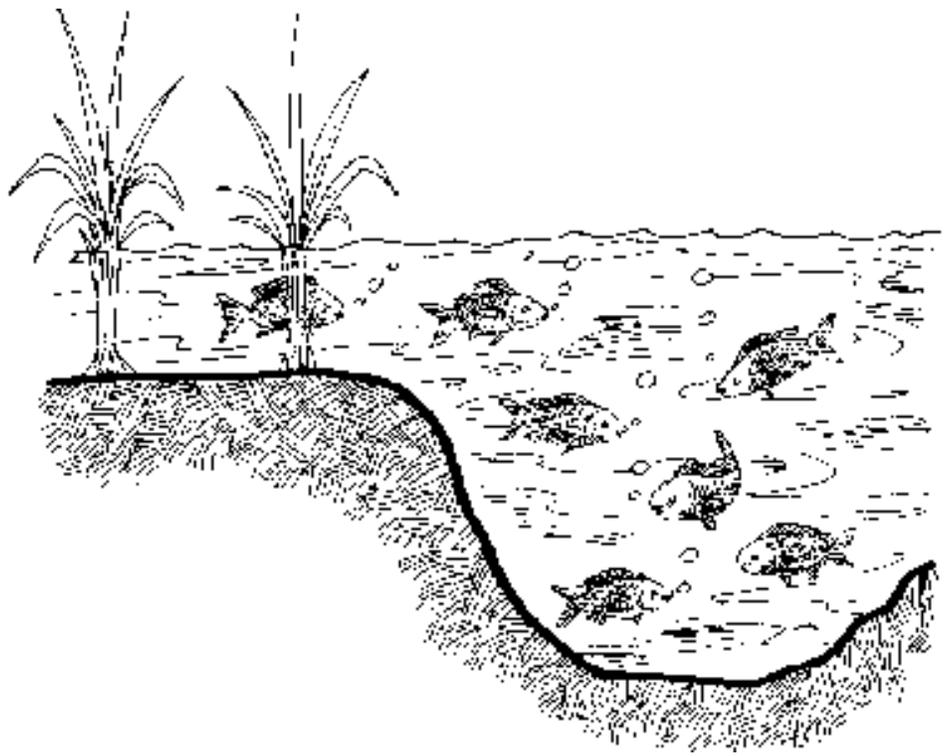
- elevated embankment to keep water and prevent cultured species from escaping;
- ditches or trenches, sumps and refuges to provide shelters. The dimensions of these structures of different patterns depend on the farmed species. The structures should occupy about 15-20% of the total area;
- sluice gates for inlet and outlet to regulate the water level to prevent losses; and
- fence or enclosure of appropriate height, shape and materials to restrain crabs and frogs.

Rice cultivars with strong stems should be planted. The variety should be able to tolerate manure application, especially if feeding and fertilization are applied during rice-fish culture. When the soil becomes very fertile, rice plants tend to lodge. However, there is scanty information about rice cultivars in rice-fish fields. Suitable rice cultivars for use in rice-fish culture have to be developed.

### Rice-fish culture

The species used for rice-fish culture should meet the following requirements:

- availability of quality fry and fingerlings in desired quantity;
- desirable herbivorous or omnivorous feeding habits;
- tolerance of high water temperature and low dissolved oxygen level at night; and
- desirable growth rate/performance.



### Species for stocking

Polyculture is used in most rice-fish culture systems. Several field-tested stocking models are available depending on the local situation.

Most commonly used fish species for polyculture in rice fields are:

- Common carp – *Cyprinus carpio* (several different strains or varieties)
- Grass carp – *Ctenopharyngodon idella*
- Crucian carp – *Carassius auratus*
- Tilapia (*Oreochromis niloticus*)
- Catfish (*Clarias gariepinus* gives high yields but its price is low due to poor acceptance by consumers. The hybrid between *C. gariepinus* and local catfish *C. fuscus* is better because of improved taste and high tolerance of undesirable environment conditions).

Rice-fish culture is not a particularly good method for growing very young fish to fingerling size (about 3 cm) because of low survival rate. Nursery ponds are better for fingerling production.

### Rice-crab culture

The culture of Chinese mitten-handed crab (*Eriocheir sinensis*) developed rapidly since 1994 probably because of high market value. A single crop of rice in a year is suitable for crab nursing or grow-out culture. To grow crabs in the rice field, a

peripheral trench should be dug with the following dimensions: width, 4-6 m. and depth, 1.2-1.5 m. Aquatic weeds should be planted in the water to provide shelter for crabs.

Crabs can utilize the natural food produced in a rice field by manuring or fertilization activities for rice. Artificial feeds are applied for crab culture. One-third of the water in the field should be

changed every 10-15 days to maintain desirable water quality (especially towards the end of the crop cycle). Dirty water often leads to molting problems and poor appearance at harvest (and low prices). During culture, the use of chemicals toxic to crabs should be avoided. Harvesting should be done before the temperature drops to 12°C to prevent crabs from burrowing into the mud.

<b>Stocking and expected harvest of crabs</b>		
<b>Stocking size</b>	<b>40-100 individuals/kg</b>	<b>80-160 individuals/kg</b>
<b>Stocking density</b>	<b>75-100 kg/ha</b>	<b>60-120 kg/ha</b>
<b>Stocking time</b>	<b>February - March</b>	
<b>Expected harvest</b>	<b>300 - 450/ha</b>	
<b>Average crab size at harvest</b>	<b>125 g</b>	

### **Rice-prawn culture**

The culture of native freshwater prawn *Macrobrachium niponensis* or the exotic freshwater giant prawn *M. rosenbergii* is a relatively new aquaculture practice in rice fields. Though the native species is smaller than the exotic prawn, it demands a higher price in the domestic market.

Preparation of a rice field for prawn culture is similar to that for crab culture. For local prawn, *M. niponensis*, brooders carrying fertilized eggs are stocked between mid-May and mid-June in a small cage installed in the sump for hatching. Brooders, along with the small cage, are removed after the hatching of eggs. The stocking density per hectare is 3-3.75 kg of 4-6 cm brooders. Larval development, which lasts about 15-20 days, takes place in the rice field. Natural food organisms and supplementary feeds like soybean milk greatly influence this development. Larvae estimated at 225,000-300,000/ha continue to grow in the field up to November. Crushed snails, clams and commercial prawn pellet feeds are applied during grow-out. The feeding rate is 0.5 kg per 10,000 prawns. This is increased by 0.5 kg every two weeks.

Harvesting is done in late November to December. Market-size shrimps are taken out and sold live. The small ones are returned to the fields for further growth.

For *M. rosenbergii*, seeds are purchased from hatcheries and the post-larvae stocking density in the rice field is 30,000 per ha. The routine management is similar to *M. niponensis*. Harvest should be done in October before the temperature drops.

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## Conclusion

- Despite the loss of area for the rice crop resulting from excavations undertaken specifically for fish culture, rice production increased by 10%-15%.
- Rice-aquaculture farming does not alter the basic function of rice fields to produce grains. Aquaculture does not compete with crops for land.
- Rice farming and aquaculture on the same piece of land complement each other with no adverse impact on the environment. The use of chemicals for rice cultivation is minimized by the introduction of aquaculture. Rice-fish culture also helps eliminate mosquito larva and vector organisms.



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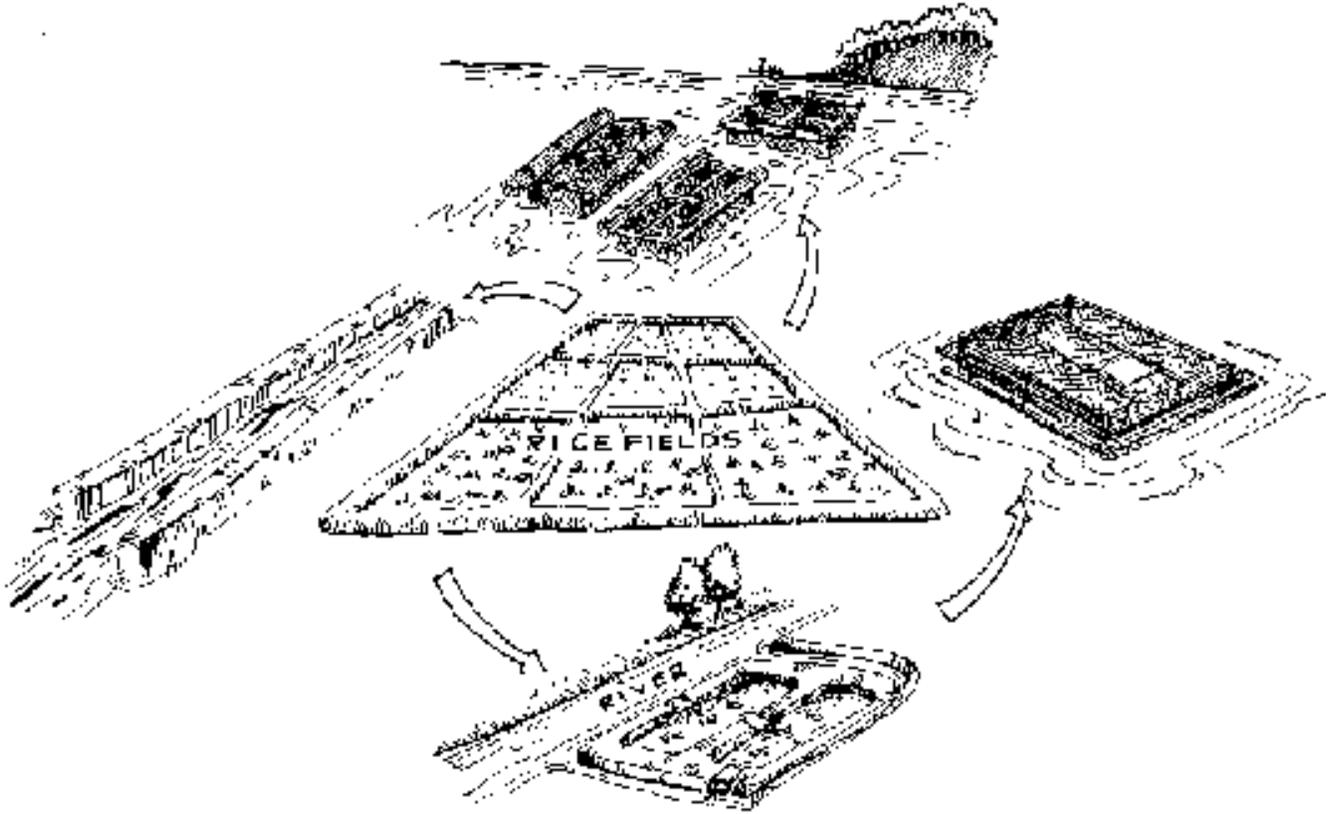
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# Enhancing the Performance of Irrigation Systems through Aquaculture

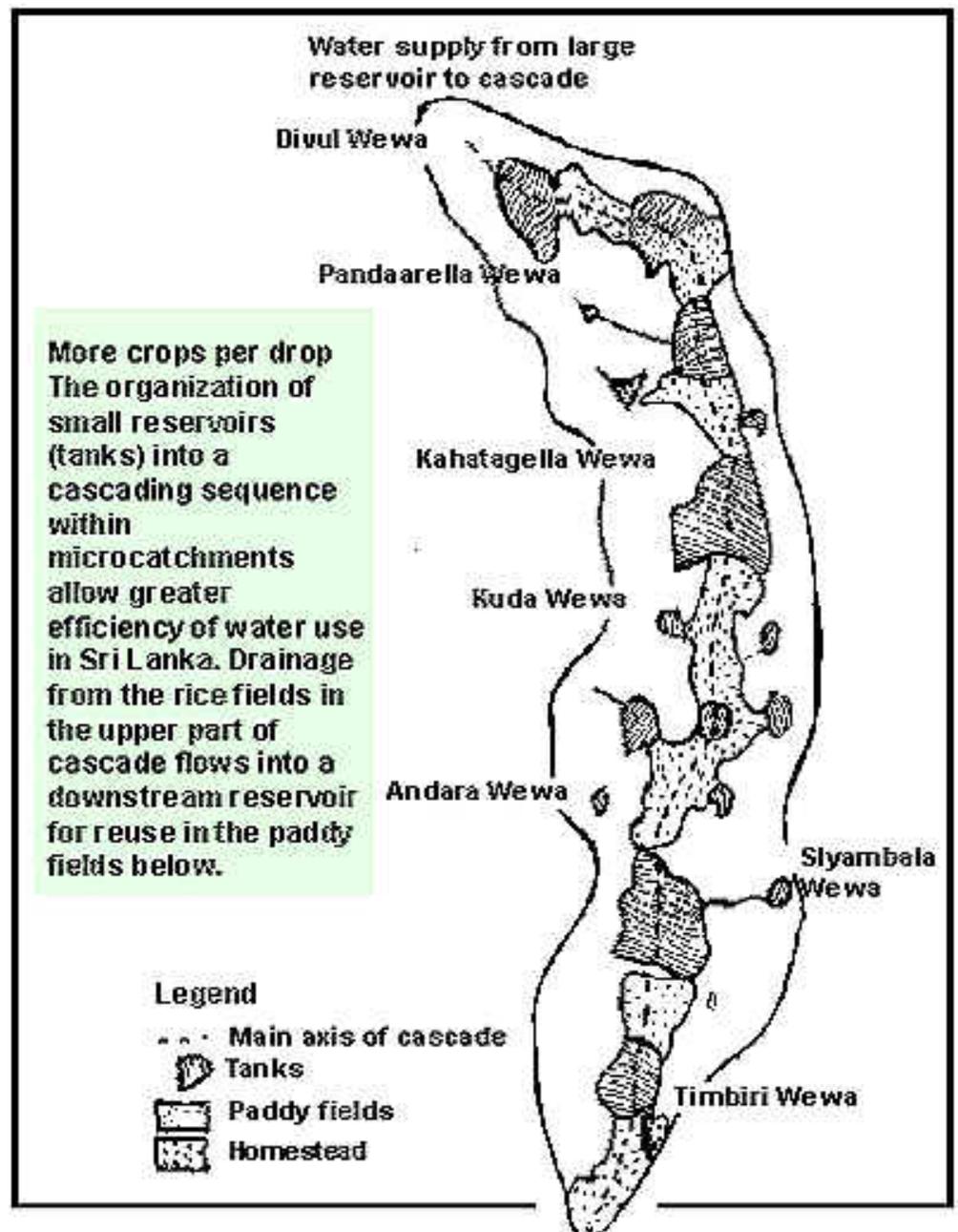


Harvesting fish from irrigation systems, sometimes involving some form of husbandry or even culture, has been a long time practice. Although seldom recorded, it seems to have been widespread in the tropics and subtropics, especially in rice fields. Improved management of land-based crops and the successful raising of aquatic organisms were not generally considered to be compatible. But with the advent of integrated crop protection (e.g., integrated pest management), this situation has changed.

Irrigation systems using stored or diverted water have increased exponentially during the past 50 years, but the expansion of fish farming within these irrigated systems has not kept pace. The integration of fish farming could significantly mitigate some of the negative effects associated with irrigation systems, such as an increase in human disease vectors.

## Water use imperative

Currently, water scarcity is emerging as the dominant constraint in efforts to expand food production. Increasing irrigation efficiency and water productivity – getting more crops per drop – must therefore become one of the top priorities. Integrated water resources management is now widely recognized as a basic principle of water management.



## Possibilities for integration

An approach to fish farming development at the irrigation system level is proposed. The reservoir fishery, particularly in large shallow reservoirs as found in Sri Lanka, is highly productive. The farming of fish in Chinese reservoirs has also resulted in spectacularly high yields. The culture and capture of fish in irrigation canals are practiced in several countries such as Egypt, Pakistan, China and Thailand. Pond culture can be highly productive as Chinese and other Asian

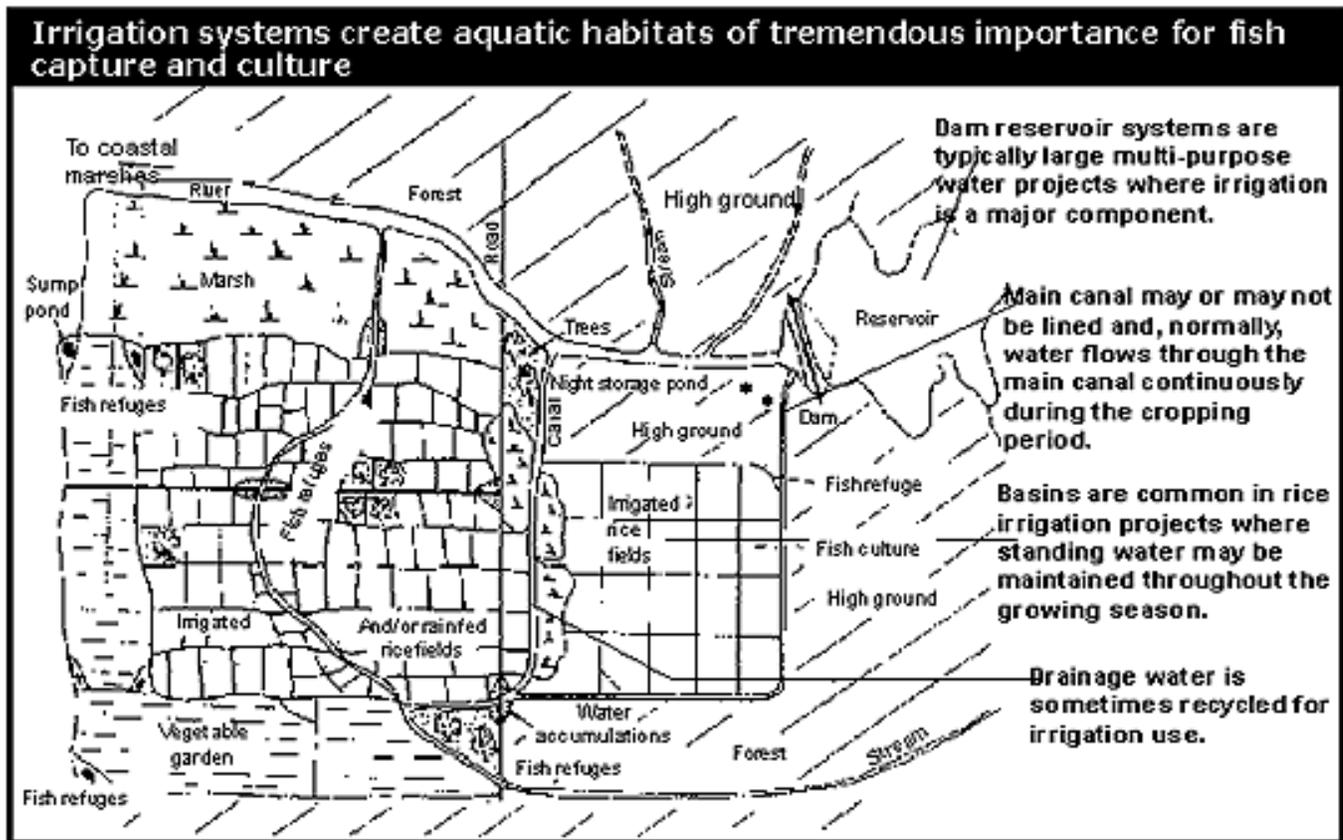
### Potential sites for nursing or grow-out of fish

- Small and large irrigation reservoirs
- Extensive network of main and secondary irrigation canals and main drainage canal
- Irrigated fields
- Adjacent ponds and night storage ponds
- Aquatic refuges of various sorts



experiences show, and fish capture and culture in rice fields have received new impetus with the increasing spread of integrated pest management practices. Even though substantial profits can be achieved when fish farming is done in individual irrigation components, it is proposed that the development of fish farming in several or all components of the system is more likely to succeed because it will alleviate constraints that are inevitably encountered if only one component is developed (Fernando and Halwart, 2000).

An example is the use of rice fields as fish nurseries. If only rice fields were used for fish farming, the fish harvested at the end of the cultivation period would generally be too small for human consumption. However, if the fingerlings can be sold for grow-out in other components of the irrigation system, e.g., reservoirs or canals, the constraint of harvesting small, unmarketable fish can be overcome. On the other hand, grow-out operations are often constrained by limited fish seed supply. The demand for fingerlings can be met by rearing fish fry in nearby rice fields under concurrent or rotational systems.



For example, stocking material of species suitable for reservoirs can be obtained from irrigated rice fields where the short maturation period of the crop only permits the harvest of fingerlings. If a pragmatic and flexible approach is applied to use all aquatic habitats for fish production and conservation, there could be a year-round supply of fish and a minimum of wastage of stocks of cultured fish.

In many countries, fish seed is now relatively accessible even in inland areas.

Permanent water bodies should be stocked with a central pool of culture species harvested from short-lived habitats serving as nurseries. A flexible system of moving culture fish within the system of habitats should be feasible.

The use of high-yielding fish of good quality is essential for economic viability. In areas where a high diversity of fish with the requisite biomass of desirable species already exists, the indigenous fish can be harvested. However, the yields may only be adequate for low-income rural areas. Common carp has been a preferred cultured species. Tilapia is proposed as an alternative because the fish is cheap to raise, gives high yields and is quite palatable.

Aside from economic revenues, this type of integration also leads to ecological and social benefits. High densities of fish in irrigation systems enhance the yield of land crops, minimize crop pests, and reduce the populations of vectors of diseases in man and domestic animals.

From a planning and development perspective, the major challenge for the future of fish farming in irrigation systems is likely to be related to issues of inter-agency coordination, consultation and, in some cases, external mediation to harmonize interests of the different line agencies.

### **Utilizing several components of the irrigation system can boost fish production – From rice field nursery to cage grow-out**

Traditionally, rice-fish systems in West Java, Indonesia, supplied seed fish for further growing in family ponds and fish for direct consumption by people living within the rice-growing districts. Fish markets increased in size due to tremendous population pressures in West Java. The number of ponds and rice-fish systems also increased. Running water systems moved from the laboratory to commercial-scale, increasing the demand for seed fish and contributing to the expansion of rice-fish and pond nurseries. In the 1980s, demands for freshwater fish continued to expand, but the number of traditional fish ponds remained relatively constant due to urbanization. Rapid development of reservoir cage culture created increased demand for seed fish for stocking, resulting in further expansion of rice fish nursery systems.



In the Cianjur and Subang Regencies, West Java, a combined minapadi-penyelang nursery system produced four crops of fish and one crop of rice with total yields of 370 kg/ha and 5,667 kg/ha, respectively, in six months. (Costa-Pierce, 1992).

## **The Challenge: Consultation and Coordination**

The participation of all resource users and other stakeholders at an early stage is indispensable to effective land use planning and zoning, not least because of their intimate knowledge of local socio-economic conditions and the state of natural resources. At the government level, the functions of the various agencies with regulatory and development mandates need to be well coordinated. Two broad distinctions can be made in the wide range of possible institutional arrangements leading to integrated planning and development at irrigation system level:

- **Multisectoral integration.** This involves coordinating the various agencies responsible on the basis of a common policy and bringing together the various government agencies concerned, as well as other stakeholders, so they can work towards common goals by following mutually agreed strategies.
- **Structural integration.** Here, an entirely new, integrated institutional structure is created by placing management, development and policy initiatives within a single institution.

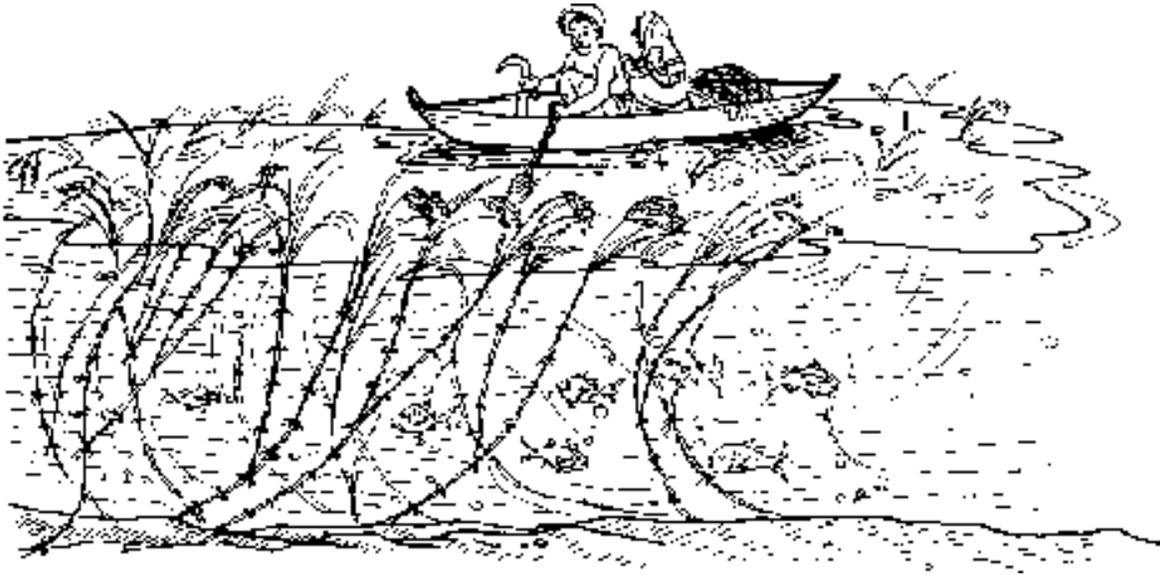
Multisectoral coordination tends to be preferred, since line ministries are typically highly protective of their core responsibilities, which relate directly to their power base and funding. The establishment of an organization with broad administrative responsibilities overlapping with the traditional jurisdictions of line ministries is often likely to meet with resistance rather than cooperation. Integration and coordination should be considered as separate but mutually supportive.

**Source: Willmann, Halwart and Barg. 1998.**

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# Rice and Fish Culture in Seasonally Flooded Ecosystems



## Farming in a flood-prone environment

Seasonally flooded ecosystems play an important role in the livelihoods of people in Asia. These areas are also the densely populated valleys and deltas of the major rivers: the Ganges, the Brahmaputra, the Godavari, the Irrawaddy, the Chao Phraya and the Mekong. In these floodplains, farmers have traditionally grown rice in a variety of systems. The main system, in which rice was farmed in the post-flood season in shallow-flooded areas (5 to 50 cm), was to sow rice into the moist areas after water had just receded and to grow the crop into the dry season. A different set of systems was used in the deep-flooded areas (50 cm to 6 m) where farmers grew either rice varieties that were submergence-tolerant (up to 1 m for four weeks), or grew floating rice varieties in areas flooded at greater depths (up to 6 m) for longer durations. In these systems, seeds were sown into the dry or already moist soil just before the rainy season and the rice harvested at the end of that season.

These floodplain areas also play a very important role in the supply of living aquatic resources (LARs) during the flood season. During this important time of the year, people engage in a wide range of fishing activities in these flooded areas, harvesting fish, crustaceans, mollusks, frogs, turtles, insects, etc. The harvests play an important seasonal role in the diet of rural poor as the highly nutritious foods make up for the nutrient deficiency during the preceding dry season. They are also a major source of income, especially for the landless, who often rely on these activities for their entire annual income and therefore are highly dependent on the existence of, and their access to, these resources.

In the last few decades, flood-prone ecosystems in Asia have undergone dramatic

changes due to the construction of Flood Control, Drainage and Irrigation (FCDI) systems. Flood patterns have changed and the abundance of LARs have been reduced. Through increased availability of irrigation, a second crop of rice is now grown in the dry season. As these are high-yielding rice varieties and their cultivation periods last almost to the onset of the floods, farmers in many areas who were previously culturing rice during the flood season have abandoned this practice, leaving the areas fallow. Rice yields from the flood season are low as improved varieties are not available.

An opportunity for increased production is the cultivation of fish in the deeper flooded areas. Two culture systems can be distinguished: (1) sequential culture of dry season rice followed by stocked fish only during the flooded season (i.e., without rice) in an enclosed area (e.g., as in a fish pen); (2) simultaneous culture of stocked fish and submergence-tolerant rice varieties or floating rice varieties. On an annual basis, these approaches offer an overall improvement of agricultural production from a given area of land through a diversification of technologies. In the flooded area, individual land holdings are not visible. Therefore, activities require a group approach by the rural community. These include the landless who have traditionally accessed the flooded areas for fishing, but would lose this essential resource if they were denied access because the areas were stocked with fish (i.e., which have become a commodity, aside from the existing "wild" fish).

## **Basic principle**

After the cultivation of dry season rice, when fields are flooded to a depth at which individual ricefield boundaries (i.e., bunds) cannot be distinguished, floods form a water body for 4 to 6 months. The farm is usually left as flooded fallow, but it can be used to grow deepwater rice and/or fish. Given adequate topographic site characteristics (i.e., a lowland area of rice plots almost enclosed by natural elevated lands, raised homesteads, dams for roads, train tracks, canals, etc.), ideally it should be such that only a small bottleneck-type opening is left to let floodwaters in, it is possible to close the bottleneck with a fence and stock the enclosed water body with fish. Deepwater rice can be grown as a substitute to the second dry season rice crop if the field is left fallow during the dry season. It is sown into the dry soil just before the flood season.

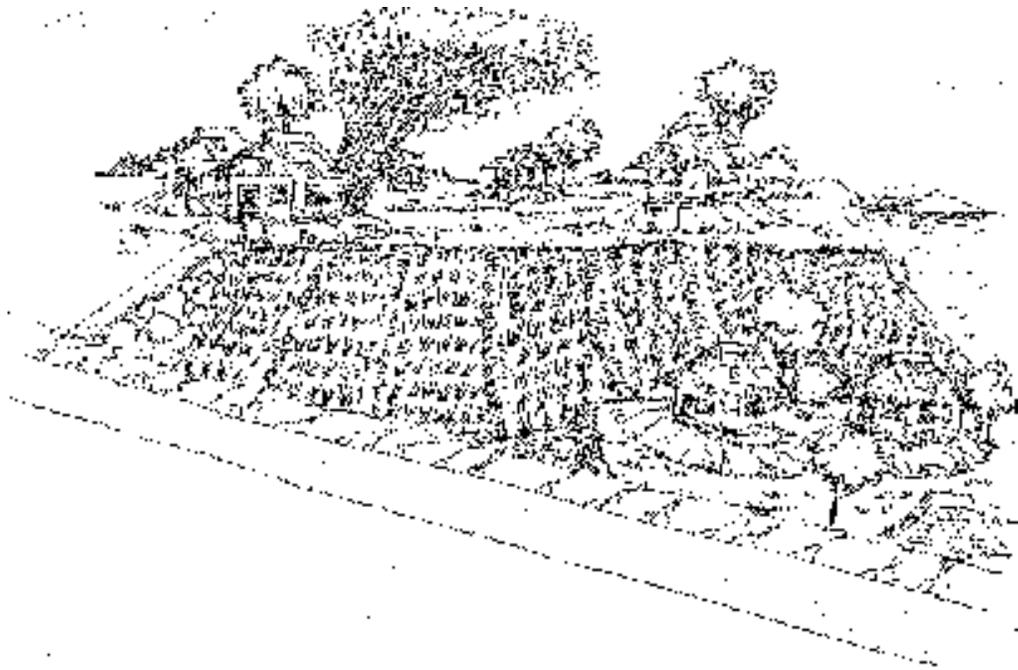
## **Criteria of managed areas**

The areas considered for concurrent or sequential rice-fish culture are flooded annually and have shallow (30 to 80 cm) to medium (80 to 150 cm) flooding depths.

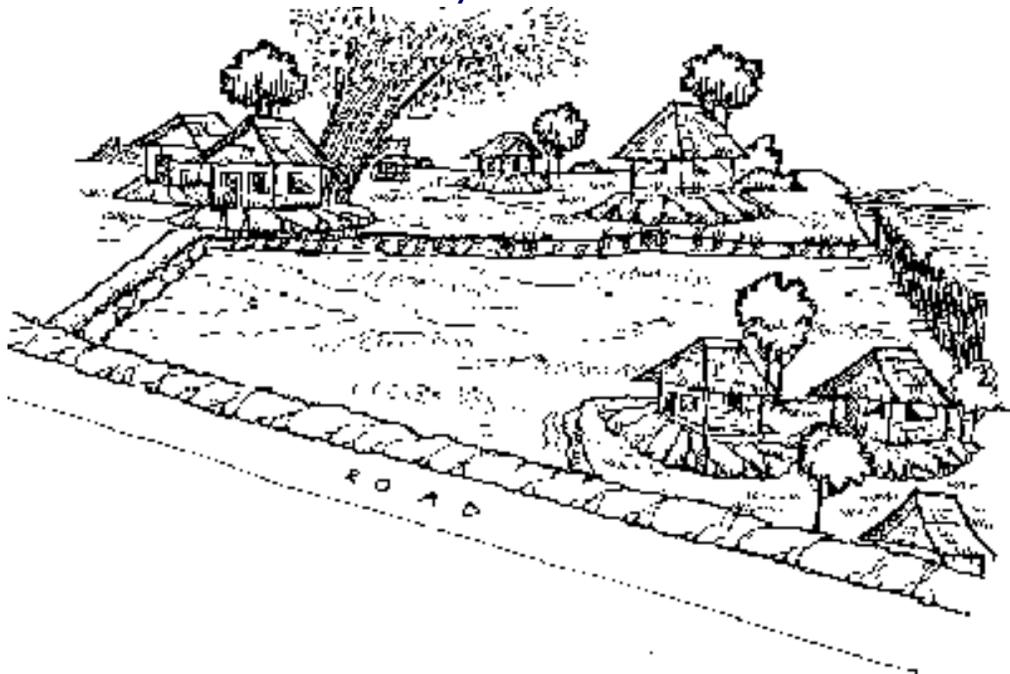
Site selection is based on the following criteria:

- adequate size, i.e., 2 to 10 ha;
- natural or existing artificially elevated lands (e.g., homesteads, dams, etc.)

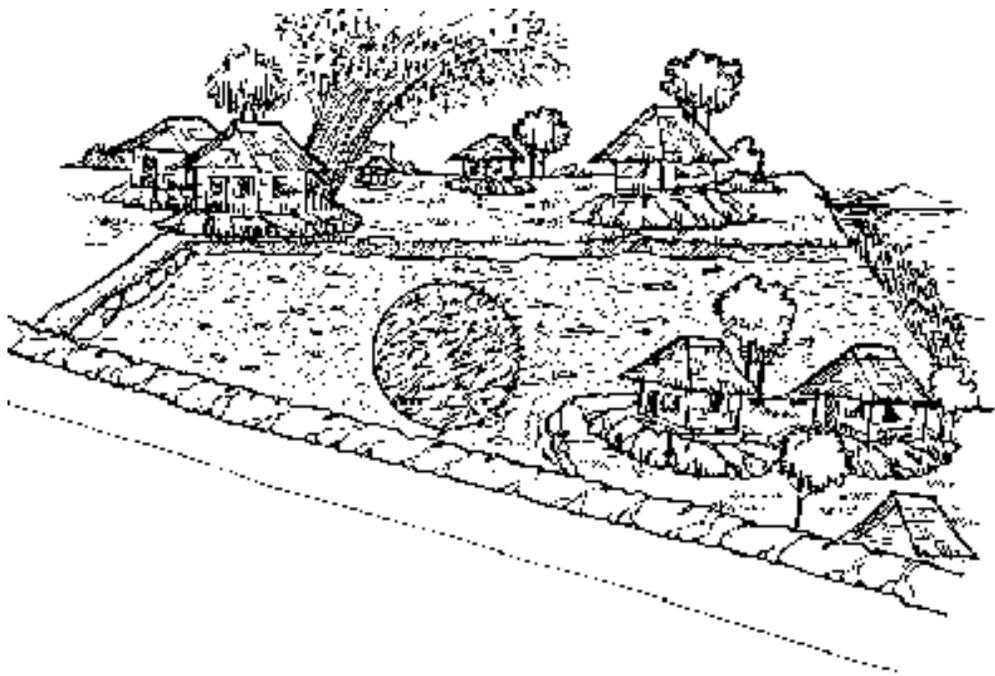
- enclose the area on three sides to allow fencing off;
- stakeholders of a water body, including landowners, leaseholders, landless fishers (who may have customary rights to fish in the flooded waterbody but are denied access during the dry season) can be involved in a shared management arrangement; and
  - groups are not too large (<30 persons) to avoid organizational problems.



**Dry rice field**



**Flooded field stocked with fish**



### **Flooded field with deep water rice stocked with fish**

**Comparison of dry season rice field (upper drawing of bird's-eye view of village) with two options for cultivation in flooded fields: 1. Flooded field stocked with fish only (middle drawing); 2. Flooded field planted with deepwater/ floating rice stocked with fish (lower drawing).**

## **Group formation, cooperation and sharing arrangements**

Groups are usually composed of around 20 households each, consisting of landowners, fishers and landless laborers. Landowners may be participating or non-participating. Non-participating landowners receive a share by just providing their land, but are otherwise not active in group activities. Actively participating landowners in the group activities receive an additional share for their role as group members aside from what they already receive as landowners.

Farmers groups will have to negotiate and agree on cooperative sharing arrangements, rules, technical details and schedules of operation. These may be influenced by other existing agreements and ongoing conflicts.

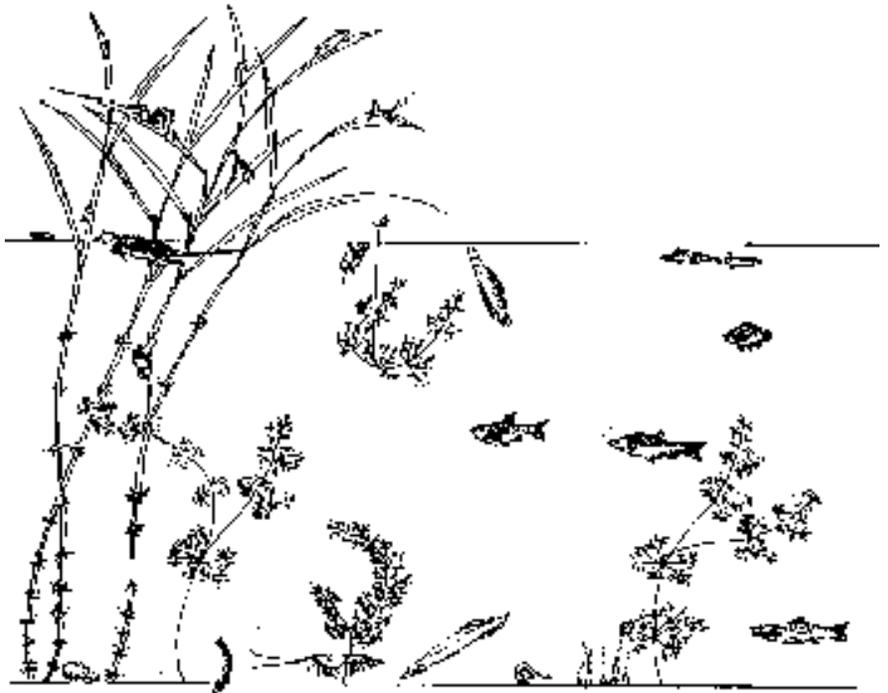
Sharing arrangements include rules of access, duties and rights of participating (active) and non-participating (passive) members; investors of land (granting use rights) versus investors of labor (landless with customary access rights to fishing in season), etc.

The group covers all costs from the proceeds of rice and/or fish sales. A common arrangement in Bangladesh for sharing the remaining returns is 40% for landowners, and 60% for group members. Landowners are usually keen on joining the activity as they receive returns from land that is usually fallow during the flood season.

## Enclosure

The enclosure should be designed and built by the cooperating farmers. It is usually a fence made of locally available materials like bamboo, reed and wood, but can also be made of netting material, which lasts longer if available locally at affordable cost.

In some locations, natural saucer-shaped depressions not connected to another open water body or river provide ideal situations for fish culture. The fish could not escape and



construction costs are eliminated. Additionally, farmers get the chance to implement different rice cultivation strategies in the shallow and deeper parts of the water body.

## Investments

The groups will have to invest in a fence or dike (where necessary), fingerlings, labor (fence or dike construction and maintenance, feeding, harvesting) to successfully master the activity.

### **Sequential dry season rice and flood season fish culture**

If farmers decide to maintain two crops of high-yielding rice varieties per year and do not want to substitute the second crop for deepwater rice, specifically stocked fish species can be grown within the enclosure.

### **Concurrent deepwater rice and fish**

After transplanting rice, bigger fingerlings can be stocked into the ricefields and reared until the water dries up, usually after rice harvest. Bigger-sized fingerlings are costly, but the expenses can be recovered by increased growth and survival (i.e., less escapes and losses to fish predators) and ensuing greater returns. The availability of larger fingerlings in adequate sizes and quantities can pose a problem and should be planned for, e.g., through fry-to-fingerling rearing in rice fields in the preceding dry season, or in small ponds in the deepest parts of the enclosed area.

# Deepwater rice technologies (for concurrent rice-fish culture)

- **Rice varieties**

Use taller rice varieties, characterized by (1) more than 160 cm total plant height at harvest time, and (2) a taller seedling height.

- **Fertilization of deepwater rice**

Fertilizers should be given but only in basal dose form for deepwater rice.

- **Pesticides**

No pesticides should be applied.

## Fish technologies

### Species combinations

Fast growing species like silver carp, common carp, rohu, silver barb and Nile tilapia are recommended. Other species chosen by farmers for stocking are grass carp, catla and snakeskin gourami.

Fry and fingerlings of naturally occurring fish species can enter into the enclosed areas at the time the flood rises. The indigenous or "wild" species can grow and reproduce for harvest by small-scale fishers.

### Stocking density

Stock at 2,000 to 4,000 per hectare, depending on the size of fingerlings (around 5 to 15 g) at stocking.

### Feeding of fish

Fish can feed on natural food and by-products available in the ricefield, both in concurrent culture and in sequential culture without rice. However, when growth is slow, supplemental feed (e.g., rice bran) may be given at a later stage.

## Additional technical options

With a short-duration rice crop, an intercrop of soy bean, maize, green leafy vegetables, etc., can be grown before the flood.

## Benefits

**Fish yield.** 500-1200 kg per hectare.

**Rice yield.** The basic rice yield is about 10 t/ha/y for two crops. The introduction of fish does not result in rice yield decrease. In fact, it has been shown to increase marginally by about 500-1000 kg/ha/y.

**Increase in profitability.** US\$300-400/ha/y, or an increase of 30 to 40% over the previous profitability of US\$1000.

**Impact on landless laborers.** Income and per-capita fish consumption increased substantially.

## Role of external support

To start this type activity through a demonstration in a given area, the initial input of local service institutions, NGOs or other organizations is necessary to provide local experience and facilitate site selection, group formation, decision on technical issues and other processes mentioned below.

From experience, as a result of the demonstration, other groups establish themselves without external inputs or stimulus and establish their own sharing arrangements. Second-generation groups arrange for their own funding and other logistical requirements, such as fingerling purchase and transport, while first-generation groups tend to remain dependent for funding and other support on the service institution that helped establish them.

Site selection survey should be conducted together with a group to enhance comprehension. The idea can be raised during discussions with individuals, then with groups of landowners, landless, etc. Meetings to facilitate the presentation of the idea to a larger group, including discussions towards consensus, establishment of a "management committee", and to the formulation of a sharing arrangement, should be conducted. External groups should act as credible provider of technology and witness and arbitrator. It is necessary to assist groups in the selection of fish species and rice varieties, stocking densities and sourcing of fingerlings and to provide guidance on the proper transport and stocking method to ensure high survival. Repeated visits are necessary to ensure smooth interactions among group members and to facilitate meetings to solve/settle problems and brewing conflicts. Farmers/actors who will do the work (fence construction, stocking, feeding) should be trained and the group should be assisted in financial accounting, harvest methods and equipment (nets), marketing of harvest and the actual sharing of the yield both in terms of fish and cash.

## Startup loans

The initial investment in the fence can be considerable and groups might hesitate to adopt a new technology with risks involved, especially when its effectiveness has not yet been demonstrated to them. Farmer groups may be wary of the investment in fingerlings for stocked fish. Startup loans, to be repaid upon harvest, have eased the adoption process and given the groups confidence to embark on the activity.

## Sustainability

Fence material may decompose after one season and has to be replaced at high cost sometimes. Socioeconomic factors include setting aside part of the returns for reinvestment the following year on a fence (mending, renewal, etc.) and for restocking (fish, rice). Social factors include group enforcement of rules and elements of the agreement.

## Factors influencing adoption

- **Socioeconomics**

Homogeneity of households in a group is a positive factor for adoption of technology. Heterogeneity of households within a group will create problems for the operation, since complex social issues and factors influence success. With larger groups, there may be economy of scale but also an increased risk of internal conflict.

- **Biophysical**

### factors

Fluctuations in the onset and duration of the rainy season, as well as average flooding depth, affect rice-fish culture. With longer duration rice -- or with floods rising before rice is harvested -- farmers cannot grow an intercrop or transplant deepwater rice. Harvesting rice with rising water can be difficult and laborious. With the water rising, deepwater rice can only be broadcast. It is more straightforward to undertake rice-fish culture in a relatively flood-controlled environment.

- **Biotechnical factors**

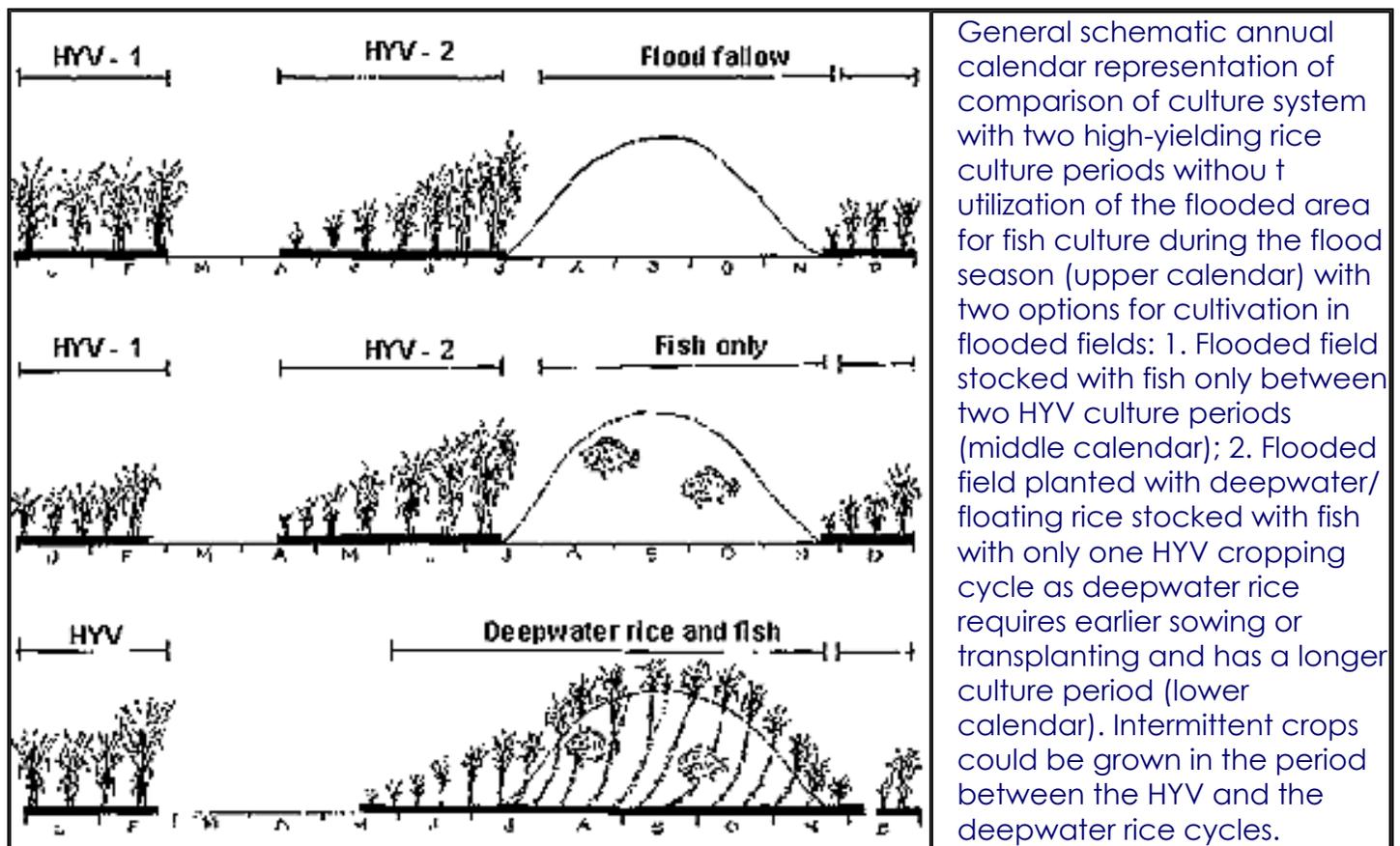
Availability of fingerlings of species (desired by farmers) in appropriate sizes and quantities for stocking can pose problems and should be planned for.

- **Institutional issues**

Presence of, or possibility of forming rural organizations and/or farmers groups, is essential.

## Potential areas for adoption

Medium-flooded areas of Bangladesh, Mekong Delta of Vietnam, and eastern India can be brought under this technology. It seems possible to introduce the technology into similar environments in Africa and Latin America, depending on further on-farm testing.



## Validation status

Three years of field trials with two communities in the Red River Delta, three communities in the Mekong Delta, and a total of nine communities in Bangladesh.

This technology has been adopted in provinces in northern Vietnam by local governments and the Department of Science and Technology with considerable investment and is being disseminated among farmers.

In Bangladesh, the country-wide operating NGO – Proshika – has adopted the technology as part of its rural development program. The Department of Agriculture

Extension will implement the technology on a wider scale in one of its projects (ADIP/DAE) funded by IFAD.

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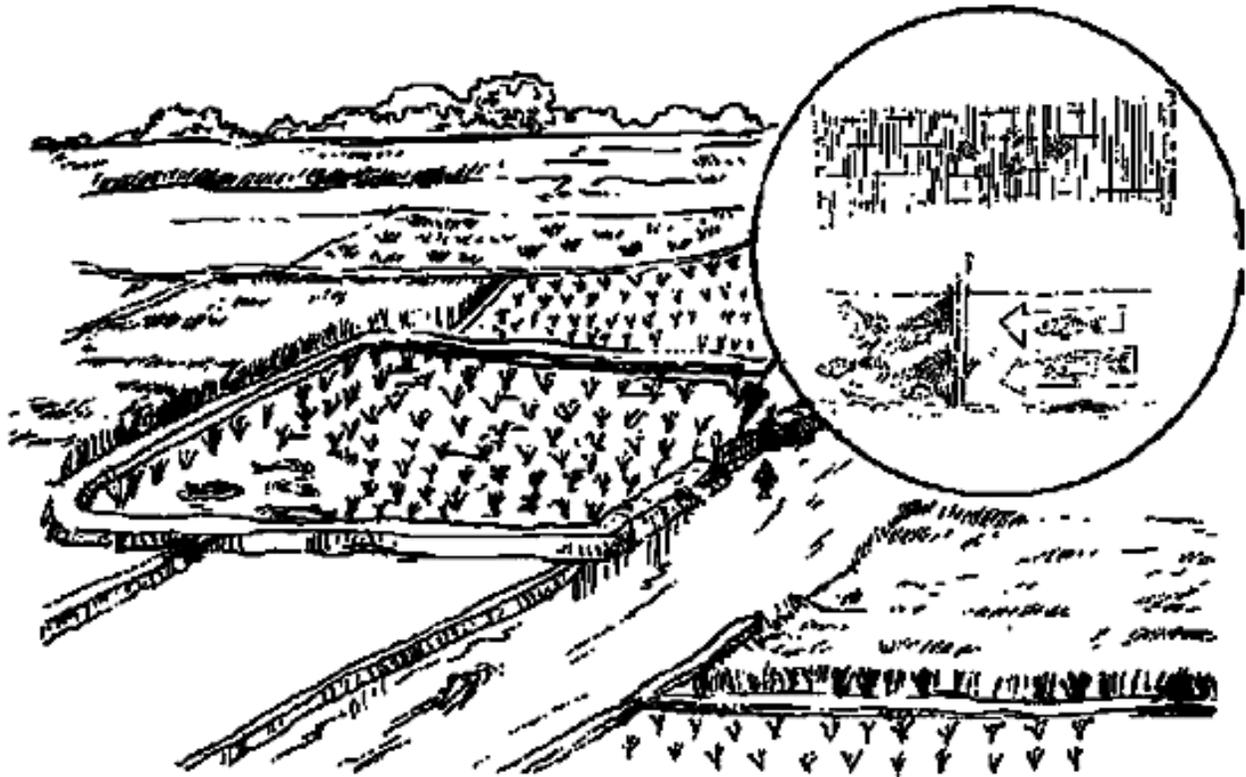
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Prepared by:

**Mark Prein and Madan Mohan Dey**

# Increasing Wild Fish Harvests by Enhancing Rice Field Habitats



Aside from producing the carbohydrate staple, the rice paddies of Bangladesh are also known as reliable sources of fish. Large quantities of fish enter the flooded paddies during the rainy season, spawn and grow there. In the past, this was possible without any active management as the rice fields were full of indigenous small fish. Today, however, the quantity and diversity of wild species have decreased significantly. If this downtrend continues the fishes in the rice fields and flood plains may completely disappear. This will have dire consequences for poor people who depend largely on the rice fields for fish, a major source of animal protein in their diet.

Taking this into consideration, the Aquaculture Unit of New Options for Pest Management (NOPEST) of CARE Bangladesh (funded by European Union) conducted a small-scale survey in its project area in Mymensingh and Comilla districts to:

- identify the naturally available fish species in rice fields;
- identify their annual migration patterns (how/when they arrive in the rice fields);
- examine those factors leading to a decrease in the amount wild fish in the rice fields;
- review methods of improving water management at the farming community

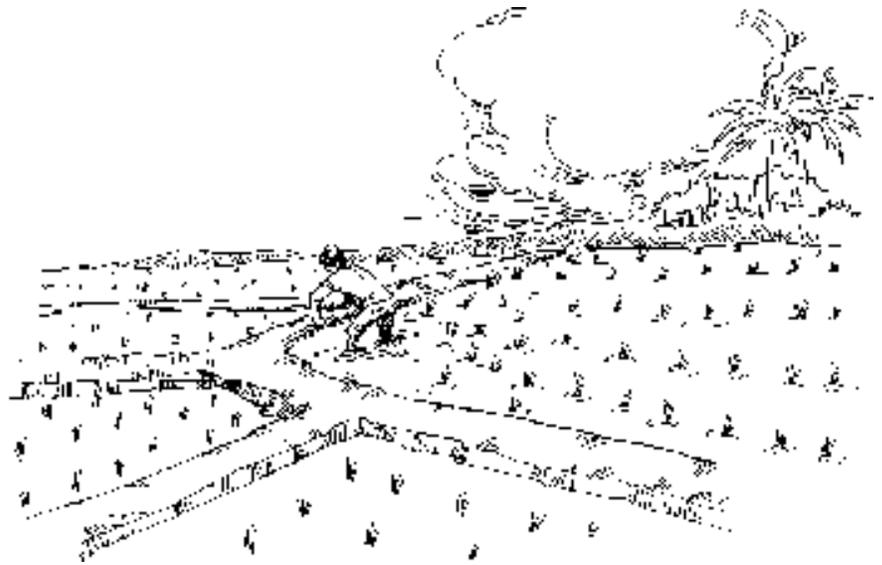
level, which can restore or improve the fish habitat.

## Wild fish yield and diversity in rice fields

In the study areas, it was found that wild fish production without any intervention was about 60-85 kg/ha during *amon* (a rice-growing season in Bangladesh lasting from July until December), which is a significant amount.

However, fish production in the fields under rice and fish cultivation averages 125 kg/ha and some farmers can harvest up to 200 kg/ha within a five-month cultivation period. Higher yields are due to the location of the plots near lowland water-bodies (beel), and the use of ingenious traditional equipment in dikes. The dikes allow fish to enter the plot but prevent them from swimming out.

Species diversity fluctuates from area to area and even plot to plot because of the various distances of the fields to a beel and the number of connections between them. As the distance to the beel decreases, fish quantity and diversity increases. Good beel connections facilitate wild fish migration. Longer periods of inundation also result in bigger catches as higher amounts of rainfall and longer monsoon periods contribute to the spread of indigenous wild species. Early season rains are important but the consistency of rainfall is more important as it is during dry periods that the diversity and the number of fish decrease.



### Caution!



**Some Organochlorine pesticides are commonly used in Bangladesh. A few drops of Endrin or Aldrin are enough to kill all fish in a field.**

Fluctuations in species diversity are also due to pesticide applications. Fields containing pesticide residues make less favorable habitats for fish, resulting in lower yields and fewer species.

Species mentioned in Table 1 are perhaps the only ones now generally found in rice fields of Mymensingh and Comilla. Some other species (including major carp) were found but not in

significant numbers.

**Table 1. Common and scientific names of the fish species in the study areas, their frequency, characteristics and their sensitivity to pollution**

Common local name	Scientific name	Frequency	Characteristics (all species bred during moonsoon)	Sensitivity to pollution
Kuche	<i>Monopterus cuchia</i>	+	Carnivorous	-
Darkina	<i>Rasbora daniconius</i>	++++	Omnivorous	-
Chale puti	<i>Puntius chola</i>	+++	Plankton feeder	---
Taki	<i>Channa punctatus</i>	+++	Carnivorous	-
Lal kholisha	<i>Colisa fasciata</i>	+++	Omnivorous	--
Koi	<i>Anabas testudineus</i>	++	Carnivorous	--
Local chingi		++	Detritus feeder	--
Mola	<i>Amblyphyrangodon mola</i>	++	Plankton feeder	----
Kachiki	<i>Corica soborna</i>	++	Omnivorous	---
Tara bain	<i>Mastocembelus aculeatus</i>	++	Bottom feeder	--
Tengra	<i>Mystus vittatus</i>	+	Carnivorous	---
Shing	<i>Heteropneustes fossilis</i>	+	Carnivorous	-
Gasua	<i>Channa orientalis</i>	+	Carnivorous	-
Shol	<i>Channa striata</i>	+	Carnivorous	-
Magur	<i>Clarias batrachus</i>	+	Carnivorous	-
Gutum	<i>Lepidocephalus spp.</i>	+	Omnivorous	--
<b>Legend</b>				
+ = Least frequent - = Least sensitive				
++++ = Most frequent ---- = Most sensitive				

## Role of the rice field in the life cycle of wild fish

Wild fish enter and thrive in the wet paddy environment so rice-field fishery is possible. Traditionally, no management inputs were necessary for these fields. However, farmers still know how the fish came to be in their fields.

### According to the farmers

- Wild fish come from nearby rivers, canals, and lowland water bodies when the fish enter the fields through channels, drains, or ground surface runoffs during the rainy season (May-August). In most cases, beels are found to be the source of wild stock in the paddies.
- Water runs off towards the beel areas and the rice paddies become inundated and merge with the beels. A single shallow sheet of water is formed as the dikes are flooded, which serve as the spawning grounds for wild fishes.
- Broods of wild fishes move towards the upland areas where the water is shallower. There, the fish spawn and lay their eggs, the rice field being an

integral part of their life cycle. Rice fields also act as nursery grounds providing a favorable habitat for spawn and fry. This is reflected in farmer's comments such as "In the monsoon season when we catch fish from the canals or drains, the fishes' bellies are full of eggs, while at the end of monsoon the harvested fish are without eggs and small in size".

- After the monsoon, when the water flow stops, the migrant fish and their juveniles try to return to the beels. Some of them make it back to the beels and continue their life cycle but most are unable to escape from the rice fields because of the dikes and those that remain are eventually trapped and caught.

## **Factors responsible for the decrease in fish stock**

### **● Loss of habitat and sedimentation**

Expanding network of flood control, irrigation structures and roads built over the last twenty years are interfering with the cycle of fish regeneration. These structures block migration pathways and degrade natural spawning and feeding grounds.

Dying vegetation in the marshy lowland water and the annual accumulation of soil, nutrients and debris carried by the monsoon rainwater through the canals towards the beel lead to siltation and sedimentation. These deposits reduce the surface area, depth and water carrying capacity of both the beels and canals.

### **● Drying out**

During the dry season, majority of these water bodies dry out and as a result no fish are left to spawn in the monsoon. As a result, less brood fish can migrate to the upland rice field areas to spawn.

### **● Water pollution**

Household wastes and fertilizers in the lowland water bodies, come from the runoff of agricultural land during the monsoon season. This is a problem in the beels (permanent habitat of wild brood fishes) during the dry season when the water level is at a minimum resulting in the growth of plants and algae. These plants cause oxygen depletion resulting in frequent suffocation of fish and oxygen is further depleted through the decaying process of decomposers.

### **● Introduction of high yielding varieties of rice**

Farmers have increased their use of pesticides since they began to cultivate high-

yielding rice varieties. They perceive these varieties require more pesticide and chemical fertilizers, hence there is a continuous increase of pesticide and other chemical residues in the beel through rice field run off. This has an adverse impact on the reproductive system of fish among others. These pesticide residues remain in the water body or rice fields year after year, having a cumulative negative impact on aquatic life. There has been evidence from studies on rice field fisheries in Malaysia that prior to the introduction of high yielding varieties, capture production averaged 135 kg/ha in the range 10 to 400 kg/ha. More recently however, based on records of capture production in Asian countries, the range is from 1.5 to 84 kg/ha.

## ● **Disease**

Indigenous wild fish species such as snake headed fish, local cat fishes, *Puntius* spp., *Anabas* spp., etc., are more susceptible to ulcerative disease. In the past ten years, these species have been greatly reduced. The disease causing factors have not been diagnosed yet, but may have spread into Bangladesh from neighboring countries. In some instances, fish develop immunity to certain diseases and this may well happen in Bangladesh over the years.

## **I Over fishing**

In monsoon, during spawning and the migration towards rice fields, traps, small mesh sized drag nets and current nets are placed in locations close to each other throughout the narrow waterways. There is very little chance of any fish escaping through these traps to spawn. With increasing human population, more people are involved in wild fish harvest with a greater use of various types of equipment and nets. This, combined with traditional seasonal fishing, leads to an intensification of fishing thus reducing the wild fish population in the rice fields. Many rice fish projects actually do not recommend that wild fish should be present in the rice field together with cultured fish. This is also responsible for the reduction of wild fish stock.

## **Interventions to restore and improve fish habitat**

### ● **Community responsibility**

The Bangladesh government has plans to implement huge flood control and irrigation projects and construct more roads and highways. If these were planned well, the effect on the life cycle and migration patterns of wild fish may be minimal. Through proper management and maintenance of the drains, brood fish habitats would not be lost. As these interventions affect the community, they should be involved to ensure good management. These communities should be responsible for ensuring that waterways are dug out regularly and dead canals are re-excavated.



- **Integrated pest management (IPM)**

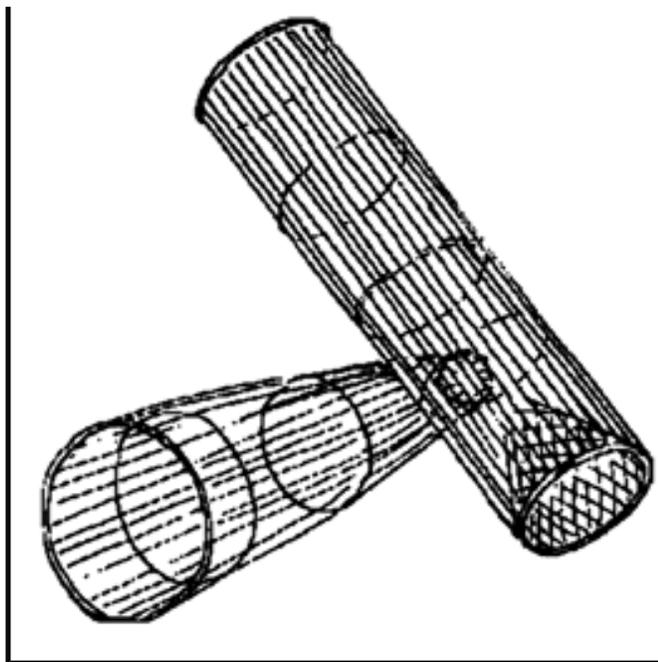
IPM may improve fish habitats over time, leading to an increase in fish populations. Intervention should consider that changes to the overall crop management will have a profound impact on the rice ecology. A healthier rice ecosystem will offer wild fishes a sound environment to breed and live in.

- **Use of dikes**

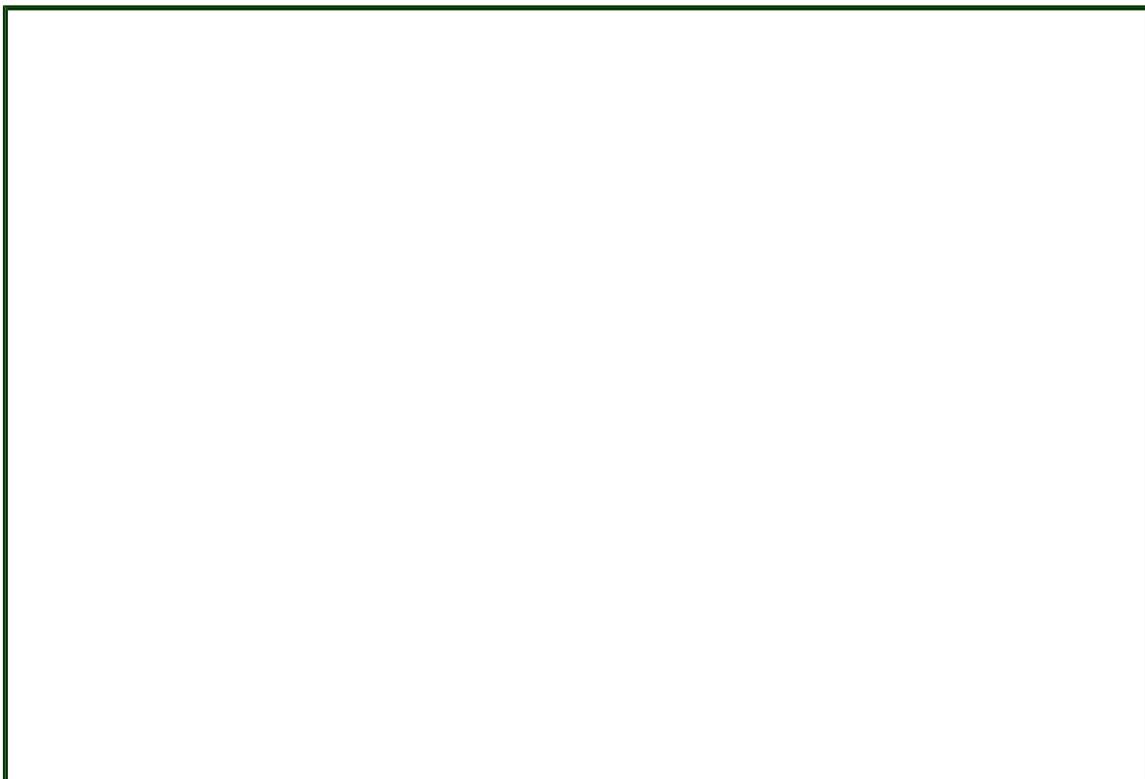
Some farmers construct dikes in the lowest portion of the rice field. During drought these provide shelter and after draining the field for harvest, fish can easily be collected from there. These dikes normally surround the fields so by raising the dikes, fields are protected from flooding, which removes fish from the field. Farmers fit traps

Using traps in dikes allows wild fish inside the ricefield and prevents them from escaping.

in the dikes in monsoon season that allow fish to enter the field from the open water but prevent them from swimming out from the rice field. The objective of this system is to collect wild broods, allowing them to grow in the rice fields until the dry season.



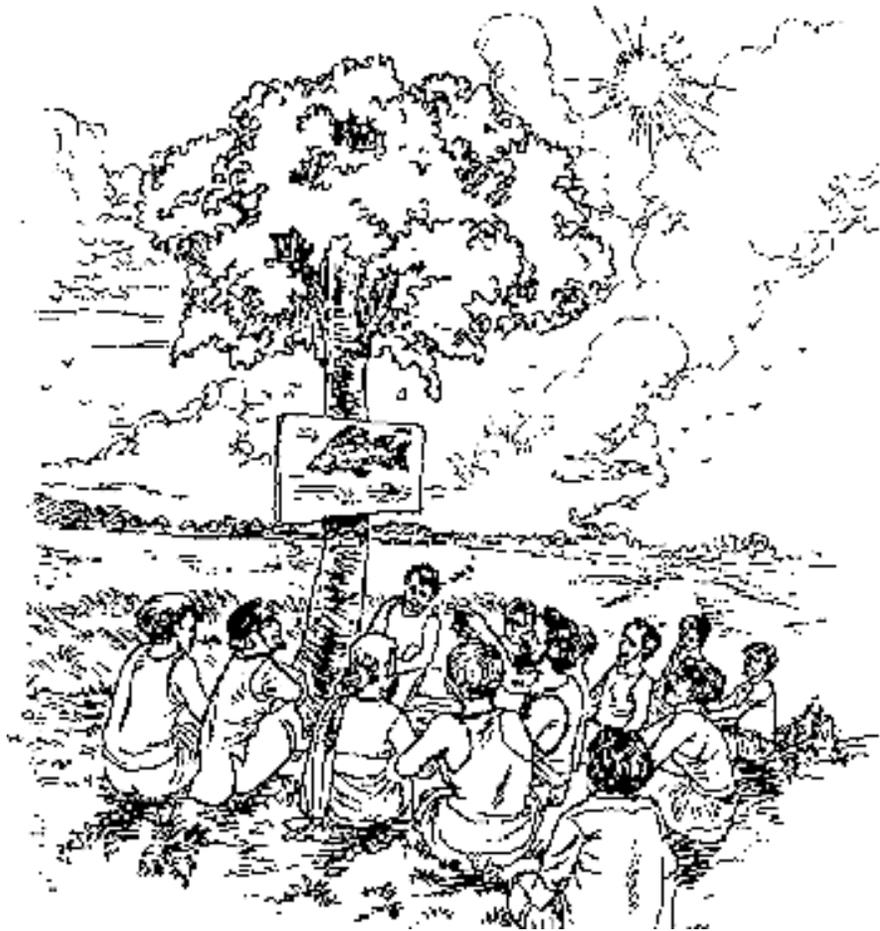
Farmers also use branches of "shewra" tree that attract the fish to take shelter within the dikes. This is an indigenous management technique leading to yield rates that are high even in comparison to rice-fish cultivation production. After harvesting rice in November and December, the fish harvest can continue until January as the branches provide a refuge for the fish.



Most development organizations avoid working in lowland areas that are remote and susceptible to flood, considering it unfeasible in terms of project outputs. Hence, people of these lowland areas are deprived of all kinds of development activities and they unwittingly destroy their wetlands.

Increased understanding of the rice field ecology would increase productivity and indigenous wild fish numbers during the monsoon season.

Adopting this approach, fish harvest could go up to 250 kg/ha/crop in amon with little effort (confirmed from trials). In rice fields where wild fish are allowed to enter through the bana (bamboo net), even up to 400 kg/ha can be harvested. Rice yield and stocked exotic fish production were not affected unlike rice fields completely surrounded by massive dikes.



## Conclusion

The wetlands of Bangladesh should be incorporated into small-scale development programs to create new opportunities for deprived farmers. When they are empowered to learn about rice field ecology and water management, they will be able to make better decisions on wild fish conservation.

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Prepared by:

**A. K. M. Reshad and Harald van der Hoek**

# Polyculture Systems: Principles and Basic Considerations



Polyculture is a strategy to utilize the different food niches in an aquatic system and harness maximum possible amounts of nutrients and energy in the form of fish. Aimed at harvesting the productivity at different trophic levels, the approach incorporates different fish species, based on the availability of food and the feeding habits of the species.

This paper focuses on freshwater systems as there are no established polyculture practices in brackish waters and marine systems.



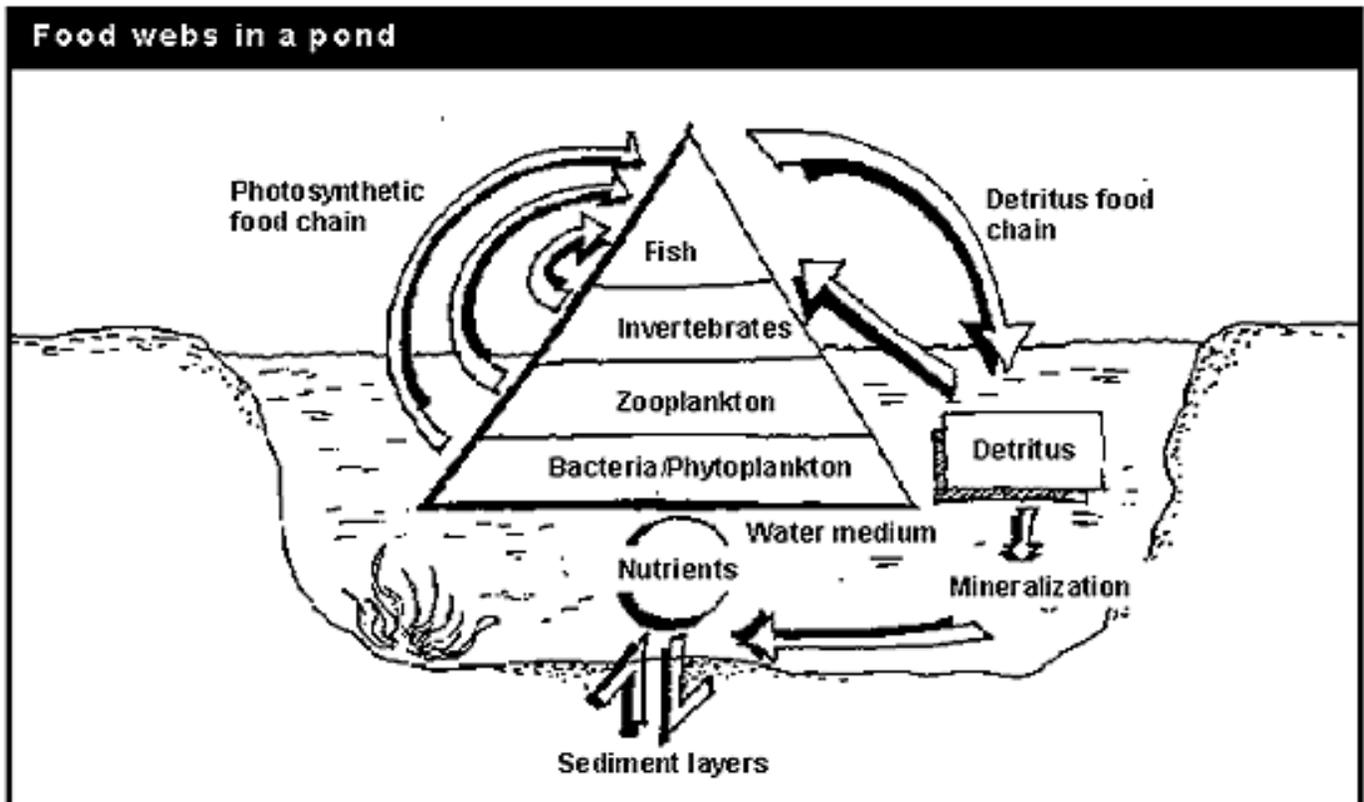
## Food chains in a pond system

The polyculture systems put considerable emphasis on the natural productivity of the water bodies. Photosynthetic and heterotrophic food chains operate in the process of energy transfer from solar radiation to the fish biomass. Producers, consumers and decomposers are the key players in these chains.

In a photosynthetic food chain, the primary producers (phytoplankton and bacterioplankton) synthesize organic matter and utilize inorganic nutrients in the presence of solar radiation. These are grazed by the zooplankters (primary consumer level) which, in turn, are preyed upon by the higher level consumers like fish and

shellfish.

The heterotrophic food chain is characterized by intense activity of the decomposers. These decomposers degrade organic matter into simpler compounds that are further mineralized into inorganic nutrients. The detritus resulting from the process becomes an important food source for fish and shellfish. This also reduces the number of steps in the energy transfer process, enabling higher productivity levels.



## Components of polyculture

*Cyprinids*, referred to as carps, have been the mainstay of polyculture practices all over the world. The feeding habits of the carps, herbivorous and detritivorous, ensure optimal utilization of the resources in the aquatic systems (in terms of the two food chains previously discussed). Asian aquaculture is dominated by carp polyculture, on account of the fish's filter feeding habit, differing strata of feeding in the water body and compatibility with each other. Carps are grouped into three categories, major, medium and minor, based on growth rates. The fish attain individual sizes of 1,000-1,500 g in a year's time. Compatibility, mainly with regard to feeding habits, schooling and dwelling habits, are the key criteria for the incorporation of new species.

## Typical mixed farming systems

### Thailand

- Silver barb
- Tilapia
- Common carp/  
mrigal

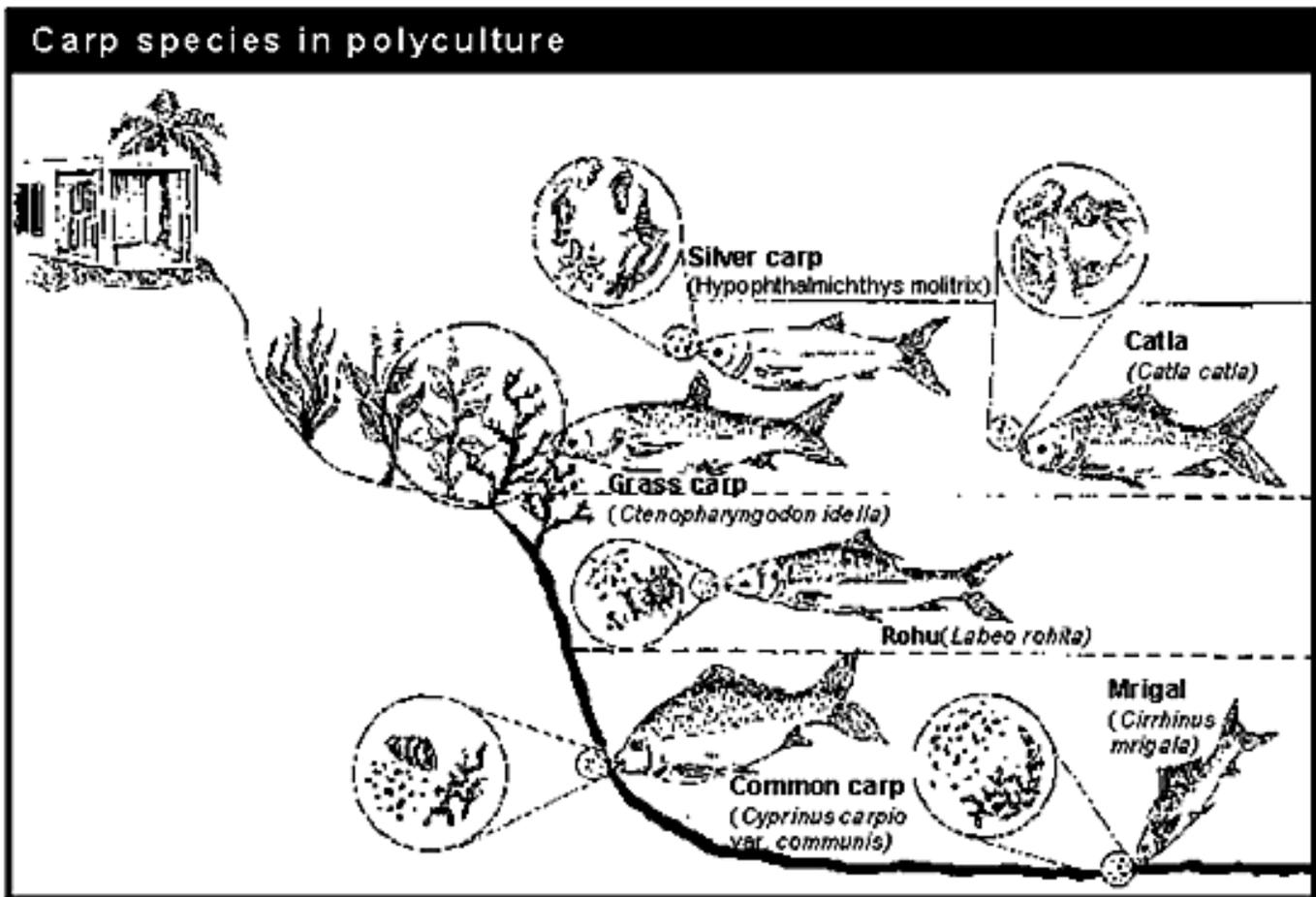


### Vietnam

- Silver barb – Grass carp  
Giant gourami
- Tilapia – Kissing gourami  
Common carp

The typical South Asian polyculture employs a combination of major carps:

- Silver carp (*Hypophthalmichthys molitrix*) largely filter feeds on phytoplankton with its fine gill rakers.
- Grass carp (*Ctenopharyngodon idella*) grows on macrovegetation and sustains the growth of a number of other species which feed on its feces containing partially digested plant material.
- Common carp (*Cyprinus carpio* var. *communis*, scale carp), an omnivore, is able to use a variety of food niches in the pond system, like decomposing organic matter and plankton.
- With their different feeding habits, three Indian major carps, catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) fit ideally into a polyculture system. Catla is a surface feeder, rohu dwells in the column waters and mrigal is a bottom feeder.
- Silver barb (*Barbodes gonionotus*), Kalbasu (*Labeo calbasu*), *Puntius pulchellus*, *Cirrhinus cirrhosa* and freshwater prawns (*Macrobrachium* spp.) are also included in polyculture systems, as substitutes for some of the components or for adding value.



## Culture systems

### Polyculture in ponds

Polyculture technology provides a scientific basis for the optimal use of resources. With combinations of three Indian major carps or six species at densities ranging from 4,000-10,000 fingerlings/ha, production levels of 2,000-10,000 kg/ha/year have been recorded.

Intensification of culture practices comes in the form of supplementary feeding. This includes the provision of a mixture of rice bran or wheat bran and oilcake in equal proportions of three to five percent of fish biomass on a daily basis. Every month, the feeding proportion can be increased in proportion to the growth of the fish. Water replacement of up to 10% of the volume of the pond is another measure to enhance production.

## Management measures

- Pond preparation in terms of clearing the pond of aquatic vegetation and fish predators.
- Fertilization at a rate of 10 tons cowdung or 2 tons poultry manure, or 5 tons of pig dung per ha per year at bimonthly intervals.
- Urea at a rate of 100 kg nitrogen/ha/year, i.e., 212 kg urea in a hectare of water in a year.
- Superphosphate at a rate of 50 kg phosphorus/ha/year, i.e., 325 kg single super phosphate in a hectare of water area in a year.
- Supplementary feeding of rice bran, wheat bran and oilcake.



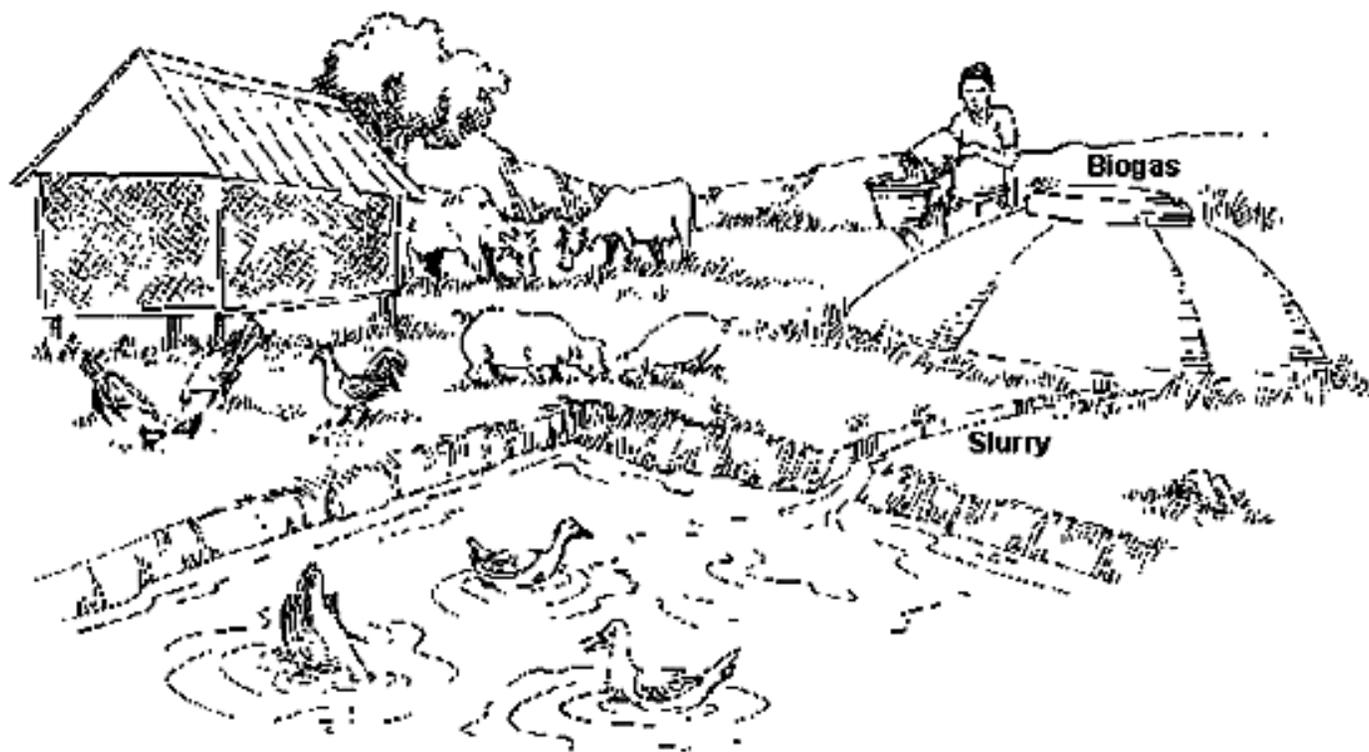
The practices allow a great deal of flexibility in terms of scale of operations, species, densities, fertilizers and feed ingredients, depending on the local resources, consumer demand of species, etc. Many farmers have employed two to three species like rohu and catla, feeding at frequent intervals and high levels of water replenishment. This has led to high levels of fish production, 10-12 tons/ha/year, as in Andhra Pradesh, a state on the east coast of India. Fish from this region are supplied to several parts of India and neighboring countries like Bangladesh, Nepal and Bhutan.

## Integrated fish farming

Integrated fish farming refers to a combination of practices, incorporating the recycling of wastes and resources from one farming system to the other, to optimize production and achieve maximal biomass harvest while maintaining eco-harmony. Agriculture and livestock by-products are recycled for use in fish culture systems. Fish-livestock farming, combined with crop raising, has been well demonstrated in Chinese small-scale farming systems.

Rice-fish system, horticulture-fish farming, integration of fish farming with livestock (i.e., cattle, poultry, ducks, pigs), mushroom cultivation, sericulture, etc. have not only allowed the recycling of organic wastes as manurial resources in aquaculture, but also helped greatly in environmental upkeep.

Polyculture of carps has enabled the use of different food compartments in these systems, as well as through coprophagy of some of the species. A cattle head or 3-4 pigs or 50-60 poultry birds or 20-30 ducks per 0.1 ha area of pond are suggested for integration with fish farming to meet the nutrient requirements of fish production levels of 300-600 kg in a year.



**Integrated fish farming**

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Prepared by:  
**S. Ayyappan**

# Promoting Rice-Based Aquaculture in Mountainous Areas of Vietnam



An indigenous rice-fish culture system using a local strain of common carp, *Cyprinus carpio*, was carried out in valleys in the mountainous areas of northern Vietnam. The self-contained, family-level system provided fish primarily for household use. Excess fish were dried or made into fish sauce for consumption during the dry season.

Broodstock of the local strain of common carp are over-wintered in small ponds or cages. At the beginning of the rice season, they are taken to the rice field. Eggs are usually placed on branches or other structures placed in the field for that purpose. Hatching, nursing and grow-out are carried out in rice fields. Small fingerlings are stocked in rice fields at a density of 2000-3000 fish/ha.



Fields are not structurally modified, though some have small banded fish refuges, which are 1.5-2.0 m in diameter and 1.0 m deep. The refuges are usually located at the center or corner of the field. Several openings allow frequent exchange of water and fish between the ricefield proper and the refuge.

The refuges serve as a cool place for the fish when the rice field temperature is high. In some places, a certain percentage of the fish is harvested earlier to avoid losses when the rainy season starts.

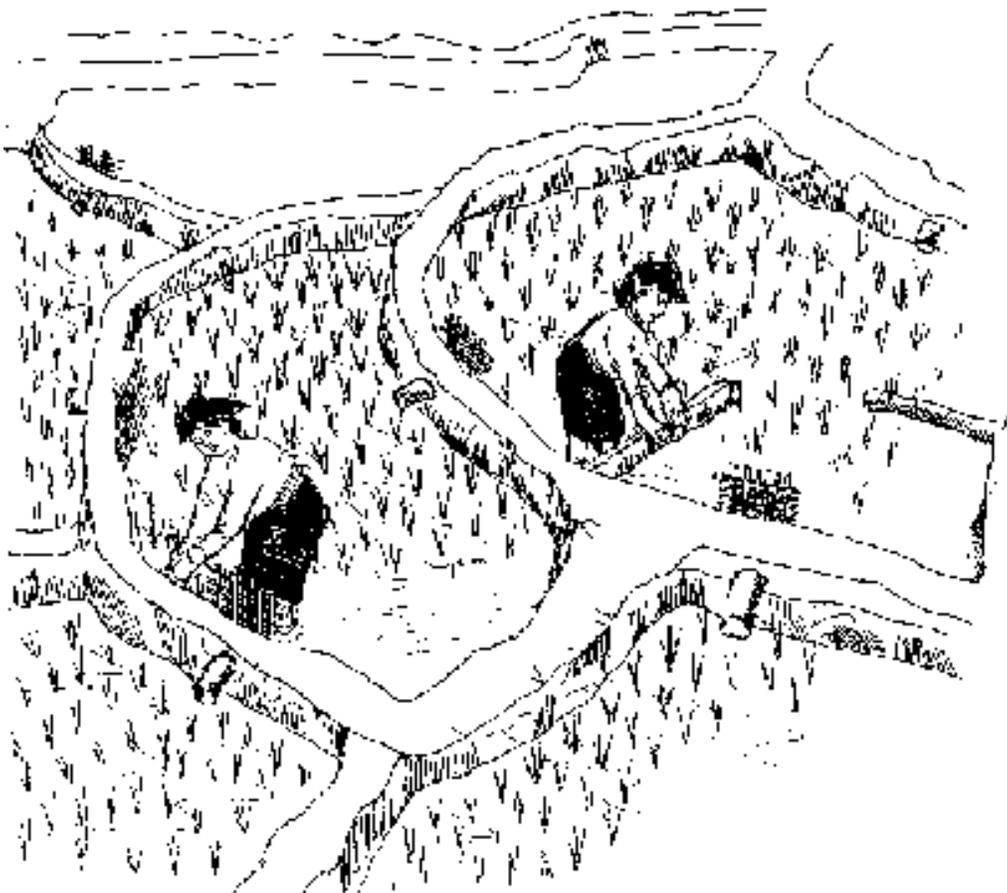


In the early 1960s, fish farming in rice fields declined in areas where cooperatives focused on intensive rice production. However, this trend has been reversed with households increasingly reverting to rice-fish farming. Over 80% of the households in Thuanchau and Tuangiao are now growing fish in ponds or rice fields.

## Benefits from rice-fish culture

The crop is profitable because both fish and rice are high-value products.

**Fish culture in rice field is not exclusively for consumption but also for producing fingerling to be stocked in cages.**



Cultivating rice and fish together provides other benefits:

- fish reduce pests, insects and weeds harmful to rice and provide additional nutrients for rice.
- The feeding activity of the fish helps to aerate the soil and to increase the availability of applied fertilizers.

## Designing the rice fields

### Requirements

The design of a rice-fish field requires a suitable mechanism of water filling/drainage for a water pH of 6.5 to 7. There are two methods to check the acidity of water:

- A traditional method involves the use of betel juice. Spit betel juice into the water. If the betel juice remains red, the water is safe for fish culture. If the color turns black, it means that the water is acidic and unsafe for fish-culture.
- Use litmus paper. If the paper turns blue, the water is safe for stocking fish.

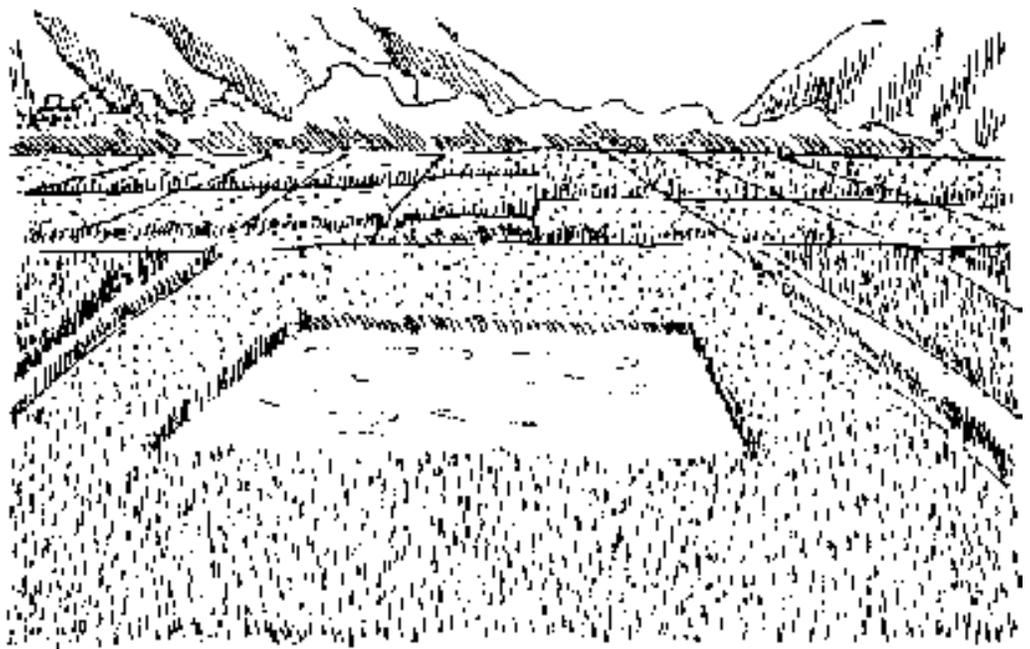


### Field design

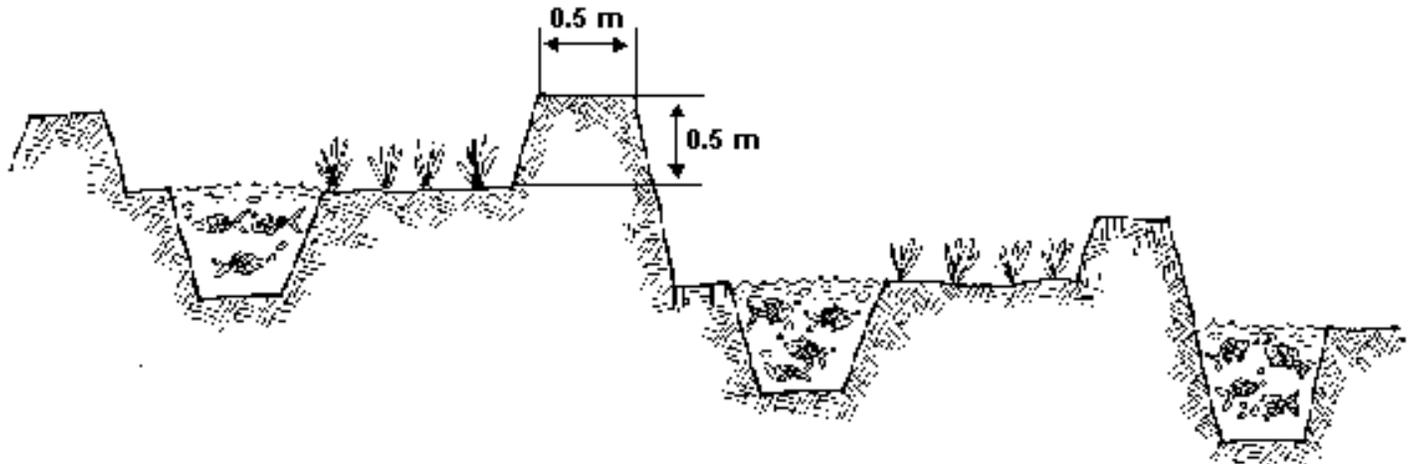
Due to the mountainous topography, inlets and outlets should be created for the terraced plot.

A system of trench and trap pond is recommended, which covers five to ten percent of the area of the plot.

At the outlet, a fence is necessary to prevent



the escape of fish.



## Field upgrading

- Drain the pond completely after harvesting the last crop products.
- Fill the trench/trap pond with 10 to 12 kg of quicklime/100 sq m. If pH is less than 5, use 20 to 24 kg per 100 sq m.
- Add animal manure at 20 kg/100 sq m.
- To drive away predaceous fish: Chop derris roots and add water. Splash the solution over the trench/pond on a sunny day. Leave the solution for three to five days before filling the pond.



## Stocking period

The fingerling can be released eight to ten days after transplanting rice. Preferred stocking density, size and ratio of various species are recommended in the following table.

<b>Stocking density and size</b>					
<b>1fish- 1rice crop</b>			<b>2rice- 1fish crop</b>		
– stocking density: 2500 fish/ha – polyculture ratio and stocking size			– stocking density: 2000 fish/ha – polyculture ratio and stocking size		
Common carp	50%	6-8 cm	Common carp	50%	6- 8 cm
Rohu	5-10%	6-8 cm	Rohu	5-10%	8-10 cm
Grass carp	20-25%	8-10 cm	Silver carp	5%	8-10 cm
Silver carp	5-10%	8-10 cm	Tilapia	20-25%	4-6 cm
Tilapia	10-15%	4-6 cm	Silver barb	5-10%	4-6 cm

## Transportation of fingerlings from rearing site

The best way to transport fish is to use a plastic bag containing two thirds oxygen and one third water. Often, middlemen deliver (on motorbikes) fish seeds brought from the lowlands.



Before releasing the fish, make sure that the water temperatures inside and outside the bag are balanced to reduce temperature shocks. This is ensured by dipping the bag into the water for 15 minutes.

## Care of the field

In May or June, prior to harvesting the spring-summer rice crop, fish are given rice bran at a rate of 3-4% of its body weight. In addition, 10-12 kg of animal manure per 100 sq m plots can also be added on a weekly basis.

Immediately after harvesting the rice, the field should be plowed and harrowed in preparation for the next rice crop.

The following should be closely monitored everyday:

- water level;
- fish activities;
- fence;
- inlets and outlets;
- rice growth; and
- damage by pests and insects.



If necessary, spray with pesticide as part of the Integrated Pest Management (IPM). To do this, drain the rice field gradually to force the fish into trenches and trap pond. Then, spray the rice field and leave it for six to seven days before refilling the rice field.

## Harvesting

The pond is drained and a net is used to catch all the fish. This is done before complete harvesting.

Harvesting is done at the end of the autumn-winter rice crop (November-December).

### Harvesting size (g/fish)

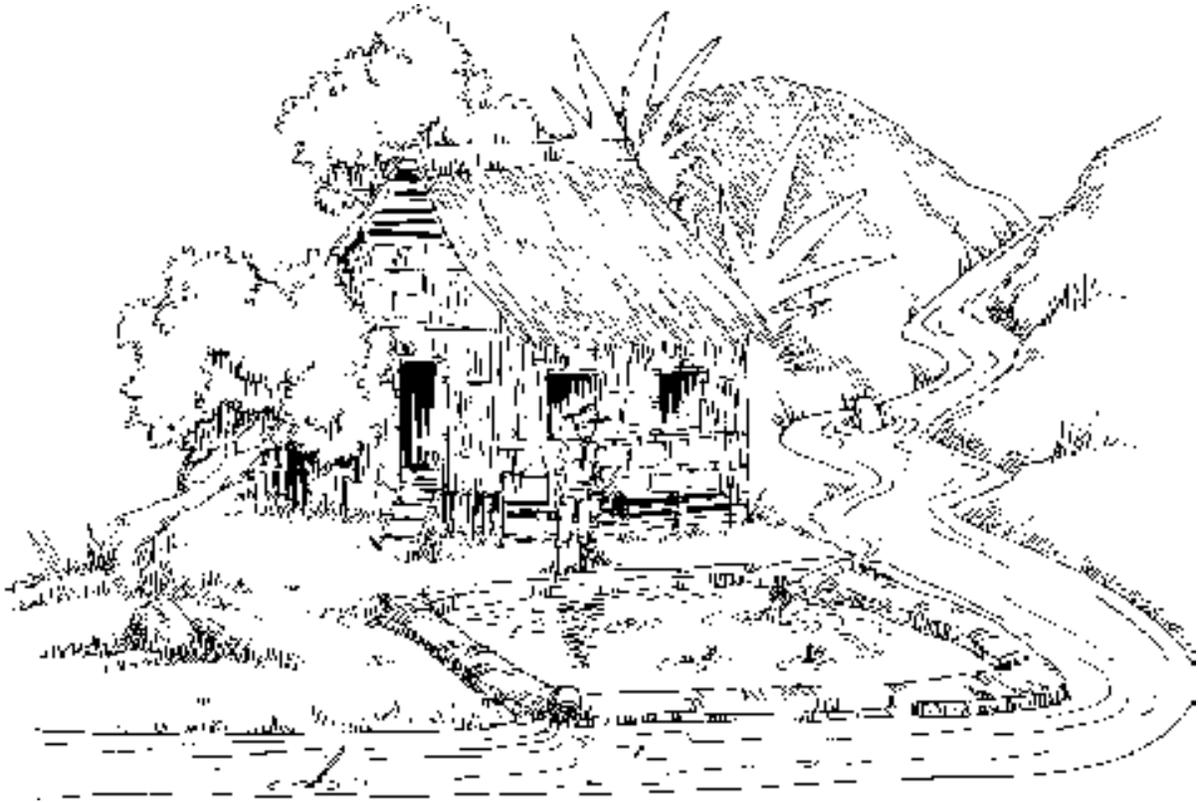
<b>Common carp</b>	<b>300- 500</b>
<b>Rohu</b>	<b>300- 500</b>
<b>Tilapia</b>	<b>50 - 150</b>
<b>Grass carp</b>	<b>800- 1000</b>
<b>Silver carp</b>	<b>300- 400</b>

<b>Yield</b>	<b>60-1000 kg/ha/year</b>
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Prepared by:

**Nguyen Huy Dien, Tran Van Quynh, Matthias Halwart and Dilip Kumar**

# Aquaculture in Stream-Fed Flow-Through Ponds



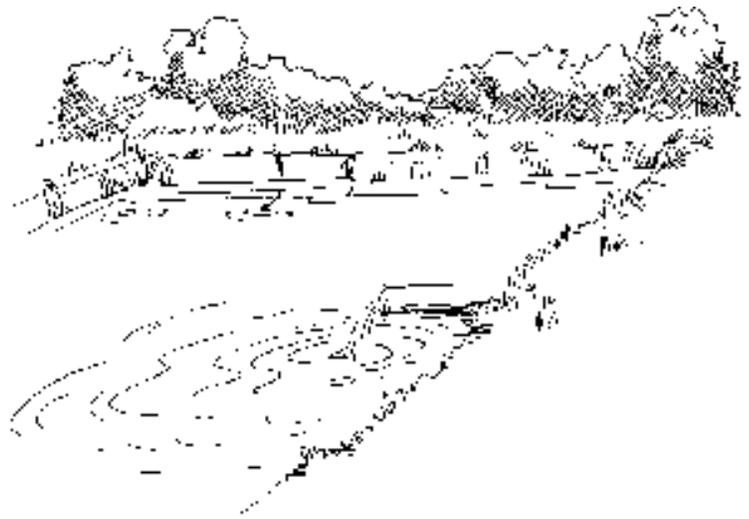
Stream-fed, flow-through pond systems are a low cost and highly efficient small-scale aquaculture system being introduced in the upland areas of Vietnam. The main cultured species in this system include some herbivores: grass carp (*Ctenopharyngodon idella*); "bong" (*Spinibarbythis denticulatus*); silver carp (*Hypophthalmichthys molitrix*) and tilapia (*Oreochromis niloticus*).

The system is considered semi-intensive because the water flow through ponds allows fish to be stocked at high densities. The circulating water flow maintains a good pond environment, preventing a drop in oxygen level and waste accumulation. As a result, the incidence of fish diseases is minimized. However, during the rainy season, the water supply gets turbid and contaminated with sediment and wastes from the catchment area. Farmers may sometimes encounter the problem of red spot disease in grass carp in the rainy season.

## Pond construction

## Construction sites

- These areas are close to stream, rivulet, channels, canals and other places where free-flowing water source is available.
- Gravel, rocky or barren soil bottom is suitable as the pond is fed by flowing water.



## Pond shape

- Depends on the topography but with an area of about 50 to 1000 sq m.

## Inlet and outlet size

- Depends on pond area.
  - Makes use of 10 cm (diameter) bamboo pipes connected to the water source.
  - Larger ponds need 2-3 inlets to ensure adequate water flow and to provide daily water exchange rate of up to 1/4-1/3 of the pond volume.

Both ends of the inlet need to be screened with a net to prevent small fish from escaping, and rubbish from entering the pond. Outlets are also screened to prevent fish from escaping.

## Pond cleaning

Bailing and dredging of pond are done annually or at least once every two years. To ensure adequate water level, maintain the pond depth.

## Liming

### Acidic pond water

Add 10-20 kg of quicklime/100 sq m.

### Neutral pond water

Apply quicklime at 7-10 kg/100 sq m to disinfect the pond and kill wild fish.



# Stocking

## Stocking density

2-3 fish/sq m

Stocking rate

Grass carp: 65%

Mrigal: 15%

Silver carp: 5%

Common carp: 10%

Tilapia: 5%

## Stocking size

Grass carp: 15 - 20 cm

Mrigal: 8 - 10 cm

Silver carp: 8 - 10 cm

Common carp: 6 - 8 cm

Tilapia: 5 - 7 cm



## Common cultivable species

- Grass carp
- “Bong”
- Mrigal
- Common carp
- Silver carp  
(*Hypophthalmichthys molitrix*)
- Tilapia (*Oreochromis niloticus*)



## Sample fish feeds

- Maize leaves
- Cassava leaves
- Banana leaves
- Native grasses
- Cassava tuber
- Banana trunk
- Sweet potato
- Duckweed



Chopped leaves can be given to small fishes. Starched feed such as rice bran and maize powder can complement green feed.

## Feeding and post-stocking care

Feeding is undertaken twice a day. Feed quantity is estimated at 25-30% of the total fish body weight. Keep starch feed (1-2%) at one of the pond corners. Wastes and remains from the previous feeding should be removed before new feed is added.

Daily monitoring is very important. When fish surfacing is observed, add water as necessary. Semi-intensive levels require more frequent supervision.

## Harvesting marketable fish

### Harvesting size

Grass carp: 2 - 3 kg

Mrigal: 0.4 - 0.8 kg

Silver carp: 0.7 - 1.5 kg

Common carp: 0.4 - 0.8 kg

Tilapia: 0.15 - 0.25 kg

Expected yield/year: 3 - 5 tons/ha

Small fish could be retained for the next crop. Ponds need to be prepared for the next season.

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Prepared by:

**Nguyen Huy Dien and Tran Van Quyhn**

## Short-Cycle Aquaculture in Seasonal Ponds



Using seasonal ponds for aquaculture is often an overlooked opportunity. These are ponds that lose their water during the dry season or overflow during the rainy season. Three to six months can be adequate to produce a fish crop in such an environment. Care is needed not to overstock the ponds to ensure that there will be sufficient food for the fish to grow in such a short time. Selecting the species to be used will depend on local conditions and availability of seed stock and market demand. The fish carrying capacity of an un-enriched pond is often within 50-200 kg/ha depending on the natural fertility of the system and the type of fish present.

By enhancing the natural fertility through fertilizers and organic manures, it is possible to increase carrying capacity to over 1000 kg/ha. To do this, the stocked fish need to be low on the food web or of mixed species, each taking advantage of different food niches in the pond. Fast growing fish like carps and tilapias are particularly suited for this sort of aquaculture. Even high value organisms such as *Macrobrachium* prawns could be considered for stocking. For short production cycles, start with medium-sized fish and work to get them up to premium market size in the time available.

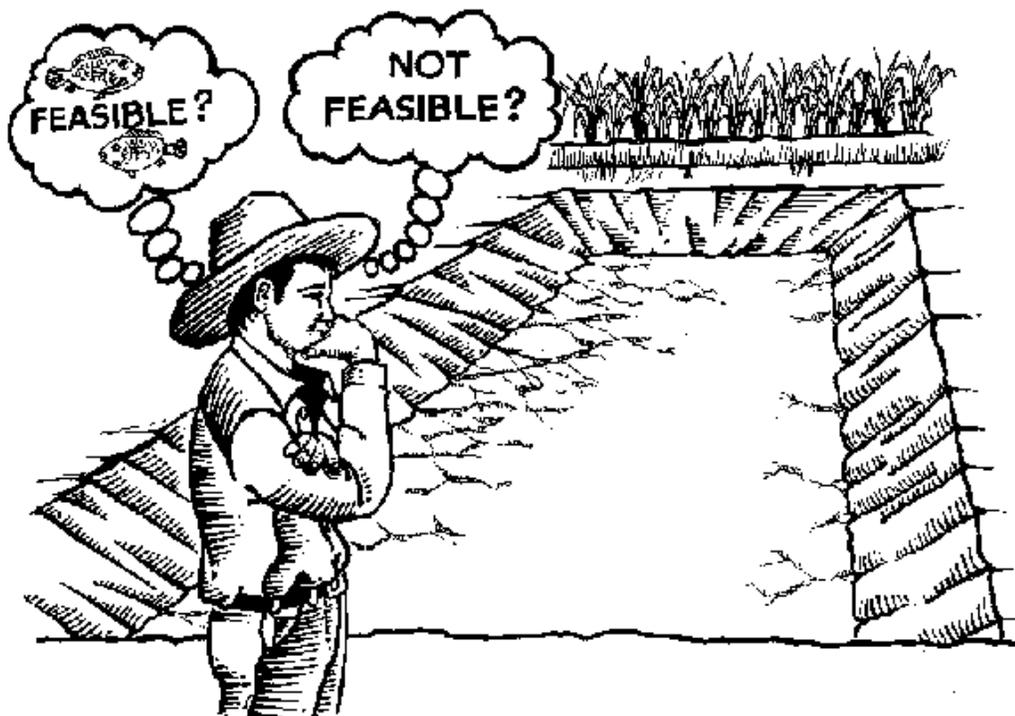
Even greater carrying capacities can be achieved by using supplemental or complete feeds. The higher the percentage of externally produced feeds, the higher the quality of the feed must be. Feeds can be costly so the economics -- profit on investment -- need to be watched closely. The capacity of the pond to assimilate organic manures or feeds without losing the dissolved oxygen during nighttime is limited so the pond should not be overloaded with organic enrichment.

Sri Lanka has 10,000 seasonal village tanks ranging from 0.3 to 50 ha. Stocked with mixed carp species, these can typically yield about 400 kg/ha in the 6-8 month production season just from the manure left by grazing animals during the dry season. Fish yields as high as 2,500 kg/ha have been recorded with the addition of fertilizers and supplemental feeds (Jayasekara 1998).



Good aquaculture management practices for perennial ponds also apply to seasonal ponds. These include security measures, control of unwanted pollution from erosion or harmful pesticides, removal of unwanted wild fish and destructive predators, and a marketing strategy. Local conditions should dictate what aquaculture practices to consider. The basic considerations are:

- Availability of stocking material (e.g., must larger fingerlings be held over from the previous year to get a jump on the production season?)
- What species and size of fish will sell well (including possible fingerlings from a nursery operation)



- How can the fish be harvested? Are there value added options that could increase

In Bangladesh, a widowed woman stocked newly hatched carp fry into a seasonally flooded borrow pit beside her farm house. She realized a quick profit in 60 days by selling the resulting fingerlings for others to grow out in perennial ponds.



- profitability (such as fee fishing, live hauling to fresh fish markets or making a processed product like smoked fish)?
- Are dikes adequate to retain water or prevent flooding?

Ownership or use rights of seasonal ponds and the exposed dry area could be a source of conflict, thus, should be clarified. If the resource is of communal ownership or there is a tradition of open access, this could be problematic and could hinder any sort of investment for aquaculture production.

In starting such a venture, it would be useful to know the following:

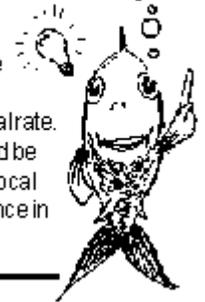
- the surface area of the pond water at stocking and the expected area near harvest time;
- some things about water alkalinity (ponds with low alkalinity may need lime applications to help in the production of natural foods); and
- the average daily temperatures during the culture period.

## Reference

Jayasekar, A.M. 1998. Rural Aquaculture: Role and Trends. Paper presented at National Workshop on Aquaculture for Rural Development, Sarasavipaya, Colombo, Sri Lanka.

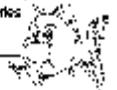
### Possible system

A sex-reversed male Nile tilapia has the biological potential to grow from a 50-g fingerling to a 500-g fish in 6-8 months. A well-fertilized pond with a good plankton bloom should have a carrying capacity of at least 1000 kg/ha of the fish. Thus, a stocking rate of 2000 fingerlings/ha (pond area at harvest time) has the prospect of yielding a bigger sized fish in a relatively short growing season provided that water temperatures stay above about 25°C and assuming a high survival rate. This basic model should be modified according to local conditions and experience in a particular system.



Prepared by:  
John Grover

Resources: PRODUCED THROUGH SUPPORT BY WORKSHOP ORGANIZED BY: International Institute of Rural Reconstruction (IIRR), International Development Research Centre (IDRC), Food and Agriculture Organization of the United Nations (FAO), Network of Aquaculture Centres in Asia-Pacific (NACA), International Centre for Living Aquatic Resources Management (ICLARM), Asian Institute of Technology (AIT), The Netherlands Embassy in the Philippines, German AgroAction (GAA) and Southeast Asian Fisheries Development Centre (SEAFDEC).



## Low-Cost Aquaculture in Undrainable Homestead Ponds



Low-cost aquaculture has been practiced extensively throughout Bangladesh and some eastern states of India like West Bengal, Orissa, Tripura, Assam and Bihar. It has been proven to be ideal for enhancing food and nutritional security and supplementing cash income of families. The system is based on better utilization of food niches available in the pond ecosystem by stocking Indian and Chinese major carp species with compatible feeding and dwelling habits.

Suitable for families with the following resources

- Pond

Undrainable, seasonal or perennial (all year round), family owned or leased, nall

homestead (up to 0.1 ha) or communal (less than a ha to a few ha)

- Manure

Organic manures (5-7 kg of manure/day for a 0.1 ha pond)

– Animal excreta from family livestock like cattle dung, poultry/duck droppings

– Farm wastes

– Compost

- Kitchen wastes
- Green manure using leguminous plant (dhanicha/sun pat/green gram)

Inorganic fertilizers (200-250 g/day for a 0.1 ha pond)

- Urea
- Triple super phosphate
- Muriate of potash

- Supplementary feed

Rice bran and deoiled cake (to limited extent)

- Piscicide

Any of the following: mahua oil cake, locally available materials of plant origin, rotenone, bleaching powder, phostoxin tablets, etc.

- Lime

- Fish seed

Fingerlings of Indian and Chinese major carps, juveniles of freshwater prawn, etc.

- Family labor

Contributed by women, men and children

## **Package of practices**

### **Pre-stocking management (Pond preparation)**

#### **Eradication of weeds**

- Trim the branches of trees shading the ponds to ensure maximum penetration of light.
- Remove all the submerged, rooted and floating aquatic weeds to avoid nutrient

trapping and to ensure penetration of sunlight.

- Drain and dry the pond (once every three to four years for perennial ponds which retain water throughout the year). Draining is done during summer months when water level is low.
- When the pond has dried, scrape off the upper layer of the bottom sediment and repair the pond dikes. The sediments removed can be utilized as good manure for crops.
- In some cases, when the pond dries up (especially in case of seasonal ponds) the bottom is plowed and any green manuring agent like dhanicha (*Sesbania spp.*) is sown at 30-35 kg/ha.
- After 30-40 days, plow the plants down and allow them to decompose in the rainwater which has accumulated in the pond.

**Advantages**

- Quick return – about 45-50% of the cost is recovered within 3-4 months.
- Due to smaller daily dose, any abrupt change in the water quality is avoided.
- Depends largely on own farm/household resources.



#### Eradication of predatory and other small fishes

The best course is to drain and dry the pond once in two to three years. An alternative method is to apply any of the following locally available piscicide material and to remember that toxicity usually lasts for seven to 10 days.

- Bleaching powder at 50-70 g/sq m/m depth.
- Rotenone powder at 2-3 g/sq m/m depth.
- Mahua oil cake (deoiled cake of the seed of mahua tree, *Bassia latifolia*) at 250 g/sq m/m depth.
- Though aluminum phosphide (Phostoxin tablet) is not recommended, many farmers in Bangladesh have been seen using it at 1 tab (3 g)/10 sq m depth.

**Caution!**

Residual effects of aluminum phosphide (Phostoxin) tablets are unknown and may cause health and environmental hazards.



#### Liming

- Apply lime to the pond at 25 g/sq m/m soon after draining or after applying piscicide.
- Increase the quantity of lime for older ponds with relatively thick, soft bottom sediment or soil with low pH.
- Lime does not have to be added when bleaching powder is used to eradicate weed/predatory fishes.

**Tip**

Lime has broad spectrum impact on pond environment and nutrient dynamics. It acts as a disinfectant and kills disease-causing agents, prevents abrupt changes in pH and enhances the mineralization process.



## Bottom raking

**(Exceptions: newly dug out and sandy ponds)**

Vigorously rake the bottom of the ponds after liming by dragging a rope tied to stone or brick pieces. Heavy rings of burnt clay materials are also used for this purpose. Raking enhances the rate of the microbial decomposition process and release of marshy gases.



## Base manuring

After five to seven days of liming, both organic and inorganic manures are applied to the pond.

## Organic manure

- Cattle dung at 100-150 g/sq m
- Poultry/duck droppings
- Compost at 50-75 g/sq m

**Inorganic fertilizers** (any of the following)

Urea at 200-250 g/100 sq m

Triple super phosphate at 100-125 g/100 sq m

Muriate of potash at 50 g/10 sq m

**Note**

■ Do not apply manure when the water in the pond turns deep green within a week of liming.

■ Base manuring is not required if green manuring was done.

■ The amount of manure required for base manuring is equal to the amount applied for one month through daily doses.



The desired quantities of organic and inorganic manures are mixed with adequate water (three times the volume of manures) and applied uniformly by sprinkling throughout the pond surface.

Compost can be easily made by using farm wastes, water hyacinth, straw and other plant materials. A pit is made

- ① and these materials are dumped in layers of
- ② 25-30 cm, alternating with urea applied at
- ③ the rate of 2% of the total plant material's weight. After making several layers, the pit is covered with soil. Several holes are made and within three to four weeks the compost becomes ready for application.



**Stocking management**

When to stock:

One to two weeks after manuring.

Larger fingerlings from the previous year's stocks are preferred for better survival and quick growth.

After rearing for three to five months, partial harvesting is done and the stock is replenished by restocking.

**Stocking density and combinations**

Depending upon the culture practice, two levels of stocking densities are followed:

- When there is no possibility of providing supplementary feed on a regular basis keep stocking density at 5000-6000 pcs/ha.

- When farmers have the capacity to provide supplementary feed on a regular basis increase the stocking density to about 7000-9000 pcs/ha.
- Stocking density may be reduced if bigger individual size is targeted for harvesting. Bigger size fish sells at 10-20% higher price.

The common species stocked in the ponds are combination of native and exotic major carps such as catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*), etc.

**Tip**

Larger size fingerlings (10-15 cm) ensure better survival, growth and bigger individual size at harvesting.



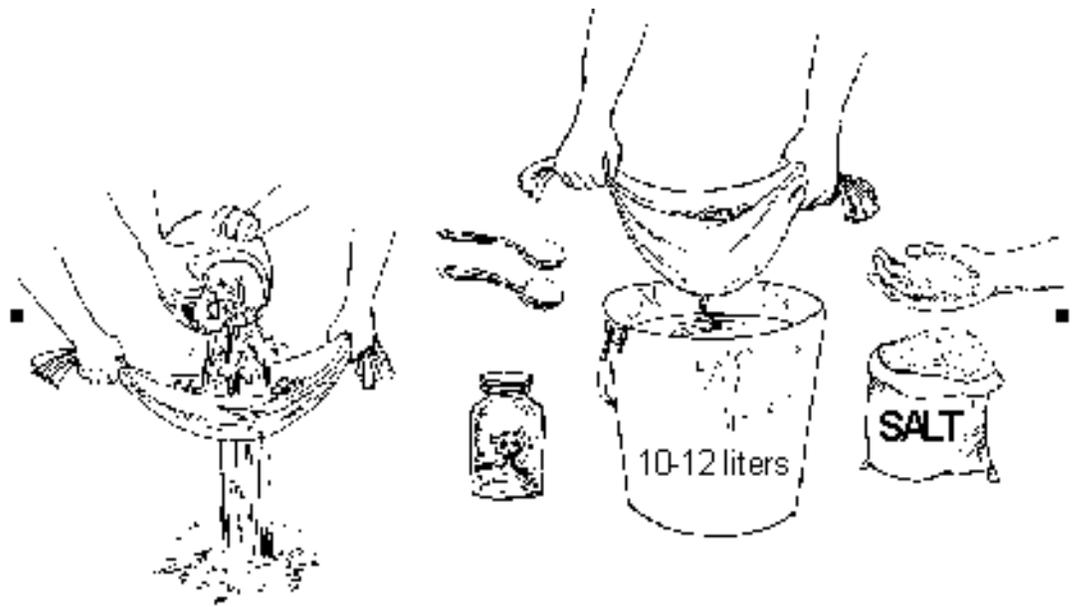
Species combinations for stocking also vary depending on the nature of ponds (shallow or deep, newly dug out or older, sandy bottomed or heavily loaded with organic materials, etc.), local market demand and local availability of larger size fingerlings. The percentages of column and bottom feeders are generally increased in deeper and older ponds, respectively.

Stocking of juveniles of freshwater prawn (*Macrobrachium rosenbergii*) with carps is also becoming popular. In such cases, the number of bottom feeders is reduced to about 5-10% and juveniles of prawns are stocked at the rate of 2500-4000 pcs/ha.

Niche	Species	Stocking density
Surface feeders	Silver carp ( <i>Hypophthalmichthys molitrix</i> )	40-50 %
	Catla ( <i>Catla catla</i> )	
Column feeders	Rohu ( <i>Labeo rohita</i> )	20-25 %
Bottom feeders	Mrigal ( <i>Cirrhinus mrigala</i> )	20-25 %
	Common carp ( <i>Cyprinus carpio</i> )	
Microphyte eaters	Grass carp	5-10 %

## Prophylactic treatment

Before stocking, bathe fingerlings for one to two minutes in either common salt (1-2% or two hands of full salt in 10-12 l of water) or potassium permanganate solution (1-2 teaspoon/bucket of 10-12 l of water).



## Post stocking management

### Fertilization

- Mix the desired amount of organic manure and inorganic fertilizers with water three times that volume and sprinkle throughout the pond during bathing time (noontime).
- Reduce or suspend fertilization if the water turns deep green (such incidents are common with old ponds with thick bottom sediment and community ponds surrounded by dense human settlement).

### Important

Regular manuring is very important to ensure continuous availability of natural fish food organisms in adequate quantity.



- For one bigha (0.133 ha) of pond area, which is the common size of homestead ponds, the farmers usually follow the manuring schedule.

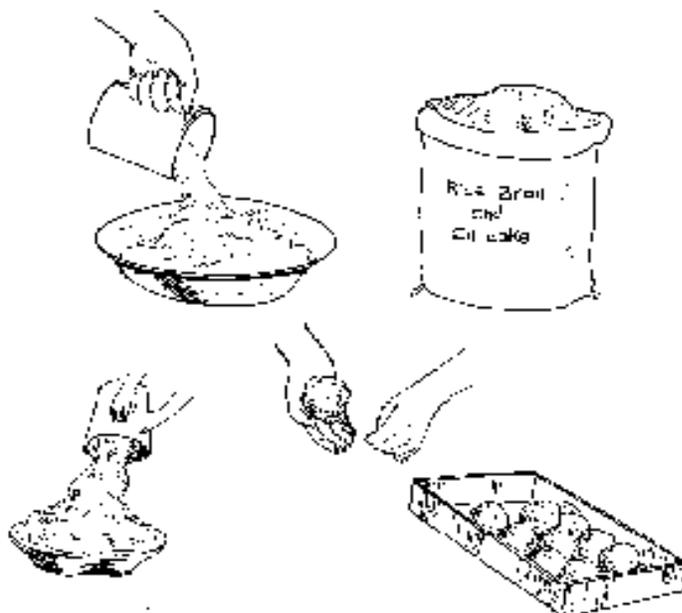
Manuring schedule	
Organic/inorganic fertilizers	Amount applied for 1 bigha of pond (0.133 ha)
Cattle dung	1 small basket (5–7 kg)
Poultry/duck dropping/compost	½ basket (3-4 kg)
Urea	Two hands full (100-150 g)
Triple super phosphate	One hand full (50-75 g)
Muriate of potash	Half handful (20-30 g)

## Feeding

Supplementary feed is considered to be the most expensive input in pond aquaculture and can account for over 60% of the total culture cost. As a result, most of the farmers do not apply feed on a regular basis.

However, for better yields and profits supplementary feed applied on a regular basis, if affordable, is helpful.

Locally available feed materials like rice bran and deoiled cake of mustard, and other oil seeds are used in equal proportions and applied at the rate of 1-2% of the fish biomass on a daily basis. Depending upon the availability and cost considerations, some farmers use only rice bran. Feed is given either in powdered form or dough. Again, depending upon their availability, macrophytes or green leafy plants are used as supplementary feed for grass carp.



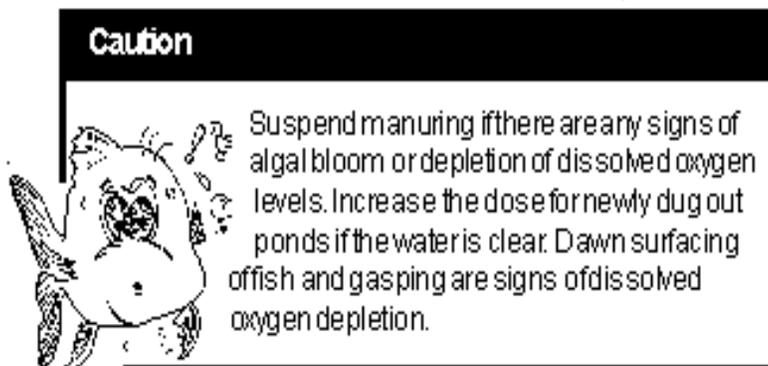
Periodical netting is done at least once a month to check the health and growth of the fish and take the weight of individual species. Feeding rate is adjusted after estimating the fish biomass.

## Bottom raking

Rake the pond bottom of older ponds with thick, organic deposits.

This speeds up the decomposition process, releases marshy gases and aerates the bottom sediment. It is best to do the raking during noontime.

## Harvesting



## Partial harvesting

Some of the fish species like catla, silver carp and common carp (mirror carp) grow relatively faster and reach marketable size within three to four months of rearing.

Growth is also remarkable when bigger size fingerlings are stocked (eight to 10 months old) during warmer months (March-April). Some of the species can grow to about 1 kg size within four to five months and partial harvesting is carried out after four to five months of rearing.

Restock immediately after harvesting to restore density.

### Fish yield and benefit cost ratio

Based on the survey covering over 700 ponds in Bangladesh, the average cost of production was found to be about US\$ 1,100 (1996 price). The benefit-cost ratio was about 3:1 at a yield level of 4.1 t/ha/yr.



## Final harvesting

Final or complete harvesting is done once a year, usually in February to May. Harvesting is also synchronized with certain social and religious events when the fish price increases due to increased market demand.



## Homestead Fish Culture: An Example from Bangladesh



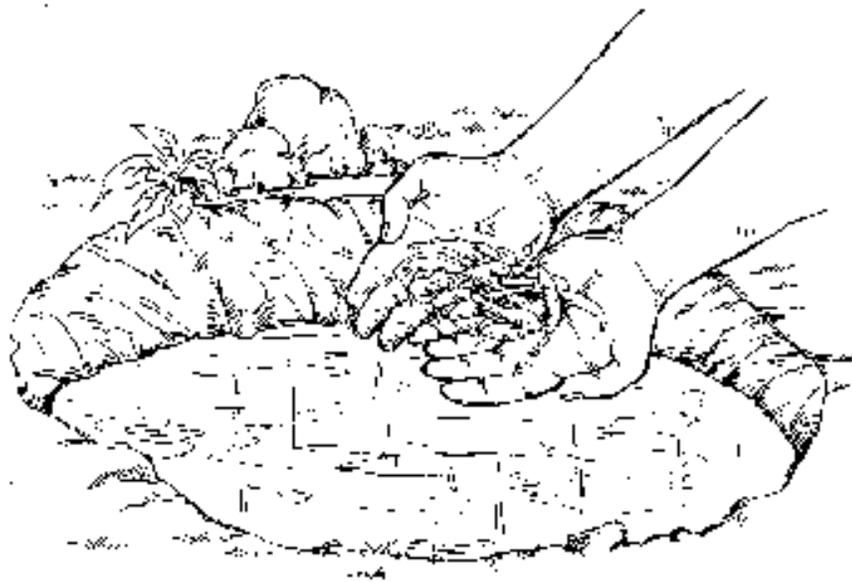
A large percentage of the Bangladesh population is poor. The poorest find themselves in a vicious cycle because they do not have collateral for prime income-generating activities. Many attempts have been made to break this cycle. The micro credit schemes operated by several non-governmental organizations (NGOs) are a good example of such attempts. The main idea is to give people access to resources with which to generate income that they can use to acquire more resources to generate more income.

Instead of providing money or other means for acquiring resources to generate income, another approach to the poverty problem is to try to find a way to generate income with available resources. In Bangladesh, most poor people can work. They have access to labor, some land on which their shack is built, water, and other things the area (or fields) around their home can provide.

An income generating activity making optimal use of these resources is homestead catfish culture, practiced in the project area of the Compartmentalization Pilot Project (CPP) in the central region of Bangladesh. This practice was taken up by the CPP and further refined into a homestead fish-culture program. Requirements for this activity are:

- food for fish;

- a small pit;
- water; and
- fry



Fish food can be collected from the surroundings of the homestead (snails, bivalves, termites, ants, slaughter waste, etc). The pit does not have to be large: one square meter is enough for 50 fry and it can be dug by the participants themselves. Catfish fry is widely available in Bangladesh at reasonable prices (between 10 to 50 Taka [US\$0.2 to US\$1] for 50 pieces). After a rearing period of four months, 5-6 kilos of African catfish can be harvested, valued

at approximately 400 Taka (US\$8).

### **The concept of homestead catfish culture**

The basic concept of a homestead catfish culture program is to introduce the poorest people to an easy method for culturing fish in small holes or pits around the homestead. The African catfish (*Clarias gariepinus*) is used because it is known to take up oxygen from air, has a high growth rate and is very disease resistant. Experience shows that people adopt the method as soon as they are introduced to it. After successfully raising a first batch of fish, initiatives are undertaken for continuing the activity (such as contacting local fry traders or trying out different food sources locally available).

Training is done on site, at the homestead. Field staff work with around 50 participants at a time. The first step was the identification of participants. To ensure that the poorest of the poor received priority, a general review of the participants' situations was made. To be selected for the program, potential participants had to meet a few criteria.

They had to be landless (people with less than 200 sq m of land are considered landless in Bangladesh).

Their general situation was poor.

Their house had mud, bamboo or jute walls.

Potential participants who met all criteria were asked about their interest in the program, which involved their buying fry for a reduced price (10 Taka, US\$0.20) from the field officer.

Four basic rules for catfish culture were provided the participants who bought the fry:

1. The fish should be fed every day (preferably until they do not want to eat anymore).
2. The food can be anything, except grass and plastic, but the best is protein-rich feed.
3. Water in the pit should be changed as soon as it started smelling bad.
4. Special attention should be paid to the sizes of the fish (they have to be of about the same size range to prevent cannibalism) during the change of water.

Two to three days after the sale of fry, the field officer visits the participants. Participants not visited within these three days have failed to rear their fish successfully. After the first two contacts, the household was visited every three to four weeks to monitor their progress and to answer any questions concerning fish culture.

### Participating households

Two hundred households participated in the homestead catfish culture program. The average size of the households was around five. Most male household members (84%) had an income-earning job that paid on average 49 Taka per day. On the other hand, most of the women in the selected households stayed home (90%) and were not earning money. The women who did have jobs earned less than the men as the average daily income for women was 15 Taka. A small number of children (2%) generated additional income, on average 22 Taka per day each. Sixty percent of the children went to school, with primary level being the highest reached by the children. On the whole, the daily income per household was around 60 Taka. The participating household members had two to three meals per day, consisting mainly of rice and vegetables. Three times a week the vegetables included pulses (dal), which have high levels of protein. Twice a week meals were supplemented with fish, once every two weeks with meat, and once a month chicken. Eggs and milk were consumed less than three times per week.

### Care of the pit

Women took care of most of the pits (80%), followed by the men (15%), then children (5%). Care of the fish consisted mainly of collection of fish food, which could come from around the homestead since catfish eat almost anything. Children assisted caretakers in the collection of food. Food collection costs amounted to zero. Supplied food consisted mainly of snails (46%), rice (18%), wheat bran (9%), rice bran (9%), bivalves (6%), or slaughter waste (5%). In some cases, termites, earthworms, wheat powder, cow dung, fish, bread and duckweed were used. On average, the water in the pit was changed every 10 to 12 days. The average time spent on the system was 1 hour per day. Caretakers themselves made decisions concerning management of the pits and, more importantly, what to do with the fish.



## Season

African catfish will grow when the water temperature is higher than 20°C. For the program to succeed, a minimum water temperature needs to be guaranteed. This can be done by either having a growth season during the summer or ensuring a supply of water with a minimum temperature of 20°C. Some of the participants replaced the water in their pit everyday with tube-well water (usually 21°C).

20 households were not able to grow their fish to marketable size (>75 g) due to several reasons:

- ⊗ Insufficient guidance by the project staff (not visiting the household within 3 days after distribution of the fish or not visiting the household every three to four weeks).
- ⊗ Not enough time spent on the management of the pit by the responsible person in the household (less than one hour per day).
- ⊗ Escape of fish (after flood, or heavy rain).

Over a 6-month period, 158 new households took up this method of fish farming without intervention from the regular program for a diffusion ratio of  $158/200 = 0.79$ .

#### Impact

One can describe the women involved in the program (80% of the participants) as being extremely dependent on their husbands. Only a small number of them (10%) earned a meager income (15.2 Taka/day, US\$0.30). The rest relied solely on what their husbands earned, or made some money from occasional jobs and barter trade. An example of one of these occasional jobs is "biri" stick production. "Biri" is the local cigarette and "biri" sticks are the paper tobacco holders. The sticks are produced in the homestead and women earned 2.5 Taka per thousand sticks. On average, an adult can produce that number in three hours, so this means an income of 0.75 Taka (US\$0.15) per hour. Catfish culture requires, on average, one hour per day and it takes four months to produce five kilos of fish that sell for 400 Taka -- a return of 3.33 Taka per hour.

Evidently, the Homestead Fish Culture Program has had an enormous impact on people in the above-described situation. Five kilos of catfish (400 Taka, US\$8) in four months may not be much in the developed world but for participants they can mean the difference between food on the plate and nothing to eat at all.

## Environmental aspects

In the homestead fish-culture program, the African catfish (*Clarias gariepinus*) is being used because of features mentioned earlier. These features are unique to the African catfish. The main reason for preferring the African over the local catfish (*Clarias batrachus*) is growth rate, which is much higher. Some reservations about the use of this exotic species exist: it is popularly believed in Bangladesh that the African catfish is a ferocious predator, capable of eating even small goats. It is feared that the African catfish will wipe out local fish populations. However, during the implementation of the homestead fish-culture program in Bangladesh, no evidence was found concerning the ferociousness of this fish. On the contrary, it was perceived as a lazy omnivore, eating whatever comes in front of its mouth.

## Supply

At present there is a thriving industry in Jessore (south-west Bangladesh) where millions of catfish fry are produced per month. This industry produces for (illegal) export to India, and for the local market. Fry traders all over the country sell the African catfish. Previously the demand for catfish fry within the project area was low, so the market for these fry traders was not important. With the homestead fish culture program running now,



demand is

rising and fry traders are moving in to sell their fish. The traders distribute fry to homesteads directly, making it possible for women to buy fry at their homesteads.

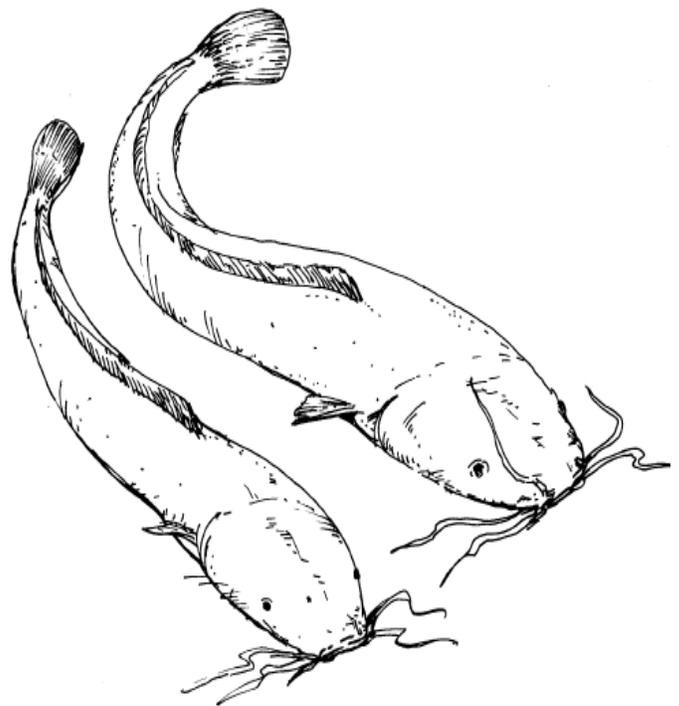
## **Sustainability**

The sustainability of the program depends completely on the availability of fry of the species involved. As long as the fry is available, the program has an opportunity to succeed.

## **Recommendations**

The program used a species exotic in the Indian sub-continent. To prevent problems associated with the use of exotic species, this method should be tried with local species, which should meet the following requirements:

- Be able to survive in anoxic water (water without oxygen)
- Be easy to keep, should be able to eat what is available around the homestead
- Be fast growing
- Fry should be cheap and available
- Species must be acceptable to participants and the market



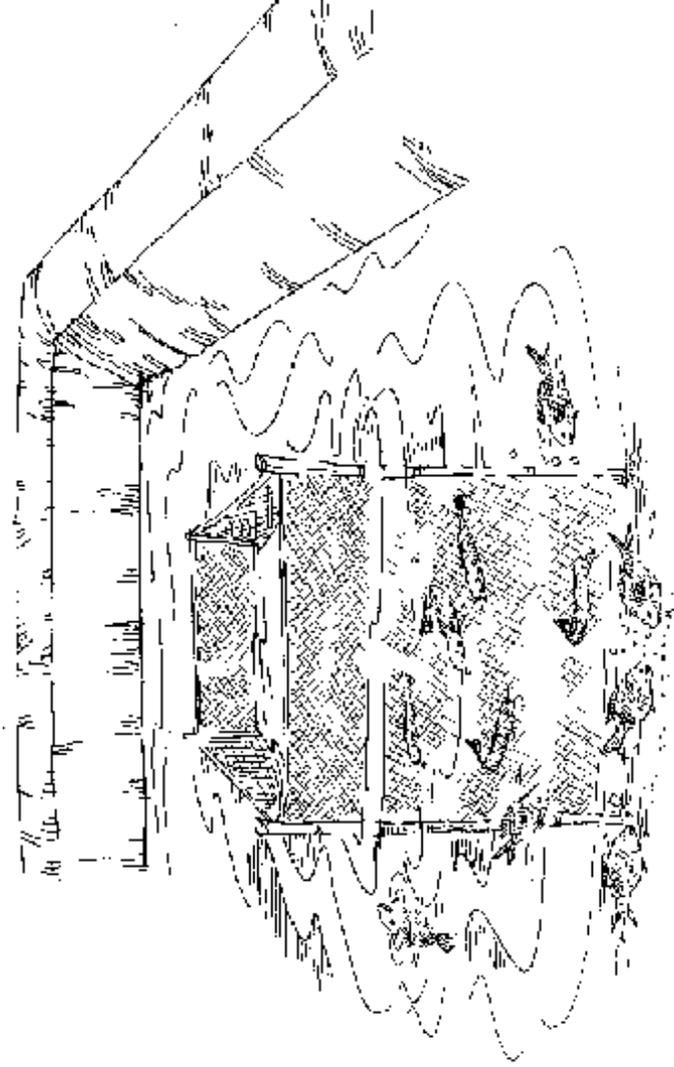
To ensure the African catfish does not contribute to serious environmental problems, research has to be undertaken on the ferociousness of the species before a large scale program is set up to spread this method.

As the poorest people will use common resources around their homestead, an impact assessment has to be made on the effect of homestead fish culture on the environment immediately surrounding the homestead.

Although it was not an objective, the program contributed to the improvement of the status of women. The method turned out to be a highly successful way to reach the poorest segments in the project area. The participants were highly motivated and very innovative. If proper research shows that there is no potential negative

impact, the method should be considered for wider use in Bangladesh and elsewhere.

# Integrating Intensive and Semi-Intensive Culture Systems to Utilize Feeding Waste



In intensive fish culture, fish are generally fed with high protein diets. The nutrient-rich wastes derived from feeding are often directly or indirectly released to the surrounding environment, becoming a source of pollution. The wastes from intensive fish culture can be used for culturing filter-feeding fish species such as Nile tilapia (*Oreochromis niloticus*) at low cost. Dual integrated culture systems, namely cage-cum-pond and pen-cum-pond culture systems, have been developed to maximize fish production and profitability from given inputs and to minimize the environmental impact of intensive fish culture.

## **Integrated cage-cum-pond culture system**

- It is a system in which fish species intensively cultured with high protein diets are stocked in cages suspended in ponds.
- The filter-feeding fish species is stocked in open water to utilize foods derived from cage wastes.
- Cages are suspended at least 20 cm from the bottom of small earthen ponds. This system has no water exchange and aeration. If provided, aeration can increase both fish growth and nutrient recovery rates.

- Extending open-pond fish culture for sometime after harvesting caged fish can further reduce nutrient loading in pond effluents.

### Example 1: Catfish/tilapia integrated cage-cum-pond culture

Hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) are usually cultured intensively using high protein diets, while Nile tilapia (*Oreochromis niloticus*) are cultured semi-intensively in fertilized ponds. These two species are used in the following

**Summary of growth performance of caged hybrid catfish and open-pond Nile tilapia for 122 days**

Performance measures	One cage per pond		Two cage per pond	
	Caged catfish	Open-pond tilapia	Caged catfish	Open-pond tilapia
Surface area (m <sup>2</sup> )	4	250	4	250
Water volume (m <sup>3</sup> )	3.2	220	3.2	220
Water depth (m)	0.8	1.0	0.8	1.0
Stocking				
Density (fish/m <sup>3</sup> )	275	2	275	2
Total number (fish/pond)	880	440	1760	440
Catfish:Tilapia ratio	2:1		4:1	
Total weight (kg/pond)	12.6	3.1	26.4	3.0
Mean weight (g/fish)	14.3	7.0	15.0	6.7
Harvest				
Survival (%)	95.8	90.5	87.5	69.8
Mean weight (g/fish)	273.8	179.2	270.2	297.2
Net yield (t/ha/year)	26.1	8.1	46.9	10.3
Gross yield (t/ha/year)	27.6	8.5	50.0	10.6
Total net yield (t/ha/year)		34.2		57.2
Total gross yield (t/ha/year)		36.1		60.6

This integrated cage-cum-pond culture has been practiced by small-scale farmers in Northeast Thailand.



example.

### Example 2: Large/small tilapia integrated cage-cum-pond culture

Nile tilapia is commonly grown in semi-intensive ponds based on fertilizers or in integrated systems with livestock. Size at harvest, under such systems, usually averages 200-300g in five months. Larger Nile tilapias (around 500 g) fetch a much higher price than smaller ones (<300 g) resulting in a trend to culture bigger fish in intensive culture systems. Supplemental feeding of Nile tilapia, starting at 100-150 g in size, is the most effective way to produce large-sized fish. In this example, large tilapia fingerlings are fattened in cages with high protein diets, while small fingerlings are nursed in open ponds by utilizing natural foods derived from the cage wastes.

### To optimize the system:

- Fatten large-size tilapia (approximately 140 g) to more than 500 g or bigger, in two cages in a pond with a surface area of 300-400 sq m and water depth of 1.2 m.
- Small-size tilapia (approximately 20 g) can be nursed to around 140 g size in open-ponds by utilizing cage wastes. These are removed every three months to restock the cages.

### Integrated pen-cum-pond culture system

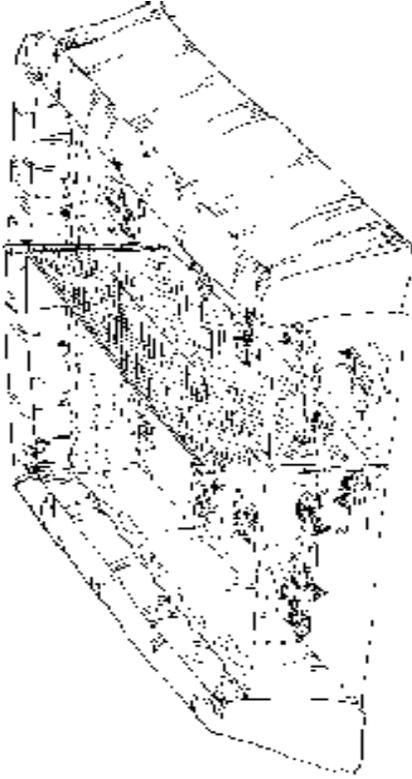
- It is a system in which a fish pond is partitioned into two compartments using netting material.
- The fed fish and filter-feeding fish are separated to utilize high protein diets more effectively and the natural foods derived from feeding wastes.

### Example: Catfish/tilapia integrated pen-cum-pond culture

- Earthen ponds with surface area of 200 sq m and 1 m water depth are partitioned by 1-cm mesh plastic net into two compartments: 1/3 for hybrid catfish

Summary of growth performance of both caged and open-pond Nile tilapia with two cages per pond for 85 days			
Performance measures	Caged tilapia	Open-pond tilapia	
Surface area (sq m)	4	300-400	
Water volume (m <sup>3</sup> )	4	300	
Water depth (m)	1.0	1.0-1.2	
Stocking			
Density (fish/m <sup>2</sup> )	50	1.4	
Total number (fish)	400	462	
Large: Small tilapia ratio		1:1.2	
Total weight (kg/pond)	49.4	7.2	
Mean weight (g/fish)	124	16	
Harvest			
Survival (%)	98.8	92.0	
Mean weight (g/fish)	466	124	
Net yield (t/ha/year)	18.2	6.2	
Gross yield (t/ha/year)	24.9	7.1	
Total net yield (t/ha/year)	24.4		
Total gross yield (t/ha/year)	32.0		

Growth performance of hybrid catfish and Nile tilapia cultured for 87 days		
Parameters	Catfish	Tilapia
Compartment area (sq m)	67	133
Stocking		
Density (fish/sq m)	26	2
Total number of fish/pond	1675	266
Catfish: Tilapia ratio	6.3:1	
Mean weight (g/fish)	19.2	19.5
Total weight (kg/pond)	32.2	5.2
Harvest		
Mean weight (g/fish)	237.8	114.9
Survival rate (%)	93.8	92.8
Net yield (t/ha/year)	213.6	7.2
Gross yield (t/ha/year)	233.8	8.9
Total net yield (t/ha/year)	76.0	



and 2/3 for tilapia.

- Catfish are fed with commercial pelleted feed.
- In the first month, fertilize the tilapia compartments weekly using urea and TSP at rates of 28 kg N and 7 kg P/ha/week.

Gross yield (t/ha/year)	233.8	8.9
Total net yield (t/ha/year)	76.0	
Total gross yield (t/ha/year)	84.0	



	Advantages	Disadvantages
Cage- or Pen-cum-pond integrated systems	<ul style="list-style-type: none"> <li>Wastes derived from high protein diets in intensive fish culture can be reused as a valuable nutrient source to produce an additional crop of filter-feeding fish.</li> <li>Nutrients in wastes derived from intensive fish culture can be recovered. Nutrients contained in effluents, which are usually released directly or indirectly to the surrounding environment are thereby reduced.</li> <li>Both systems can be used in poly culture ponds to confine costly high protein diets to the target, high-value species.</li> <li>Both systems are environmental-friendly and suitable for small-scale farmers especially those with only one pond.</li> </ul>	<ul style="list-style-type: none"> <li>The ratio of fed fish and filter-feeding fish is very important; an unbalanced ratio may cause high fish mortality.</li> </ul>
Cage-cum-pond system	<ul style="list-style-type: none"> <li>This system can be used in sub-tropical or temperate regions, where tropical fish species can make full use of growing seasons and facilitate harvesting without draining the ponds.</li> <li>Large fingerlings can be fattened with high protein diets in cages. Small fingerlings can be nursed with natural foods derived from cage wastes in open water (in the same pond where the cage is placed).</li> </ul>	<ul style="list-style-type: none"> <li>The caged fish could be easily poached.</li> </ul>
Pen-cum-pond system	<ul style="list-style-type: none"> <li>It is simple, convenient and cheap compared with the cage-cum-pond system.</li> </ul>	<ul style="list-style-type: none"> <li>The wastes derived from intensive culture may not circulate well to the semi-intensive culture section due to restriction of water flow through nets.</li> </ul>

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# Low-Cost Fertilization in Inland Pond Aquaculture



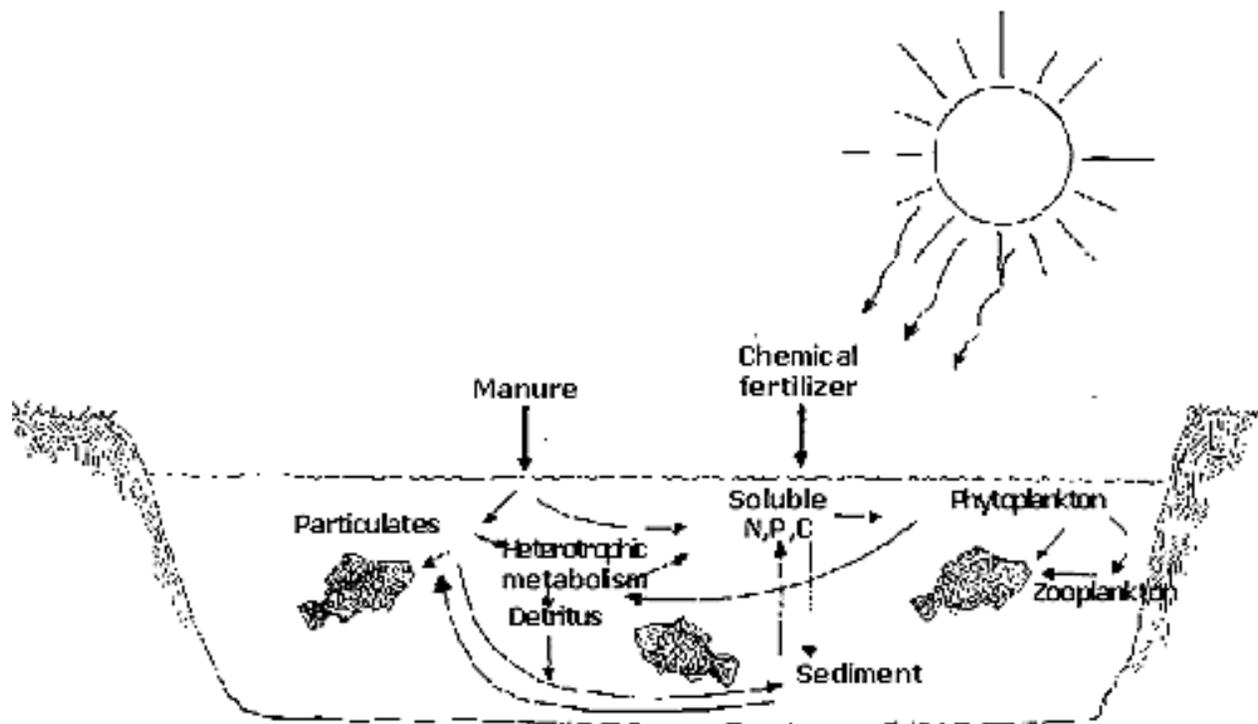
The introduction and/or improvement of aquaculture in small-scale agriculture systems is constrained by the limited availability of on-farm resources for use in fish culture. However, pond fertilization, using animal manure, has long been practiced in many Asian countries. The general goal of pond fertilization involves:

- increasing natural food production;
- optimizing nutrient utilization efficiency and cost efficiency; and
- maintaining a favorable growth environment for culture species.

Although fertilization of ponds with manure lowers fish production costs, the quality of available pond inputs is often poor. Intensification through supplementary fertilization of fishponds, with low-cost, off-farm inputs (i.e., chemical fertilizers) is one option to increase fish production of small-scale aquaculture. When added to fishponds, manure and chemical fertilizers may ultimately increase fish yields through soluble and/or particulate pathways.

<b>Representative availability of nitrogen (N) and phosphorus (P) in various animal manure</b>			
<b>Animal manure</b>	<b>Moisture (%)</b>	<b>N (% dry weight basis)</b>	<b>P (% dry weight basis)</b>
<b>Poultry litter</b>	28	2.8	1.2
<b>Chicken (bagged)</b>	38	2.0	3.0
<b>Duck (fresh)</b>	82	3.7	1.7
<b>Buffalo (fresh)</b>	77	1.7	0.1
<b>Dairy cattle (fresh)</b>	86	0.5	0.1
<b>Swine (fresh)</b>	89	0.6	0.2
<b>Sheep (fresh)</b>	77	1.4	0.2

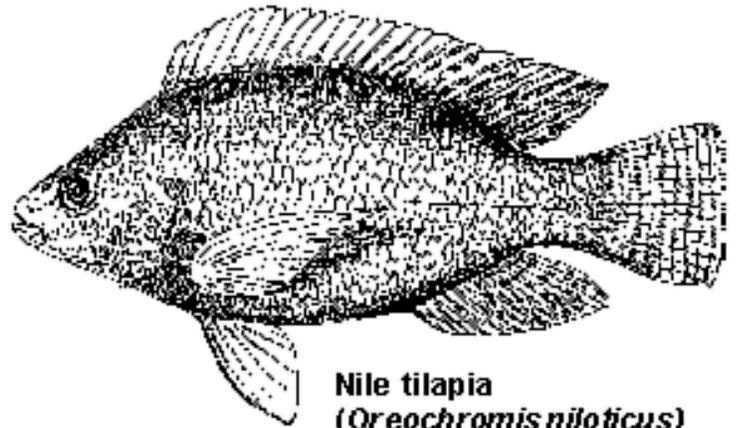
<b>Approximate nutrient contents of commonly used chemical fertilizers</b>		
<b>Chemical fertilizers</b>	<b>N (%)</b>	<b>P (%)</b>
<b>Urea</b>	45	0
<b>Ammonium nitrate</b>	35	0
<b>Superphosphate</b>	0	10
<b>Triple superphosphate (TSP)</b>	0	20
<b>Diammonium phosphate (DAP)</b>	18	24



## Low-cost fertilization strategies for Nile tilapia grow-out

For more than a decade, the Thailand Component of Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) has developed various Nile tilapia pond culture strategies. The low-cost fertilization strategies include the use of:

- animal manure alone;
- chemical fertilizer alone; and
- the combination of animal manure and chemical fertilizers.



**Nile tilapia**  
**(*Oreochromis niloticus*)**

While the nutrient input rates and ratios are the most important factors, these fertilization strategies provide wide choices for small-scale farmers with various resources. Chicken manure (CM), urea and TSP have been chosen by PD/A CRSP as major sources for pond fertilization because they are widely available in many countries. The type of manure and chemical fertilizer is not of particular importance. The cost of nutrients and their availability are essential factors in selecting which source to choose in a particular locale. For farmers with sufficient resources, the selection of a strategy should be based on simple economic evaluation of the market prices of fish, manure and chemical fertilizers. The extended culture period of two to three months could result in larger fish sizes at harvest. Larger fish fetch higher prices resulting in an increase in net economic returns.

**Example of production and economic return of sex-reversed male Nile tilapia cultured in ponds of 1m water column for two-month cycles**

Strategies kg/ha/week	Stocking density (fish/sq m)	Final size (g)	Mean gross yield kg/ha/year	Mean net yield kg/ha/year	Net revenue (US\$/ha/year)
<b>Chicken manure alone</b>					
125	0.88	180	3,000	2,500	1,120
250	0.88	210	3,200	2,800	1,115
500	0.88	215	3,500	3,000	910
1000	0.88	240	3,900	3,500	550
500	1	180	2,900	2,300	620
500	2	110	3,500	2,300	760
500	3	75	3,600	1,900	-350
<b>Chicken manure supplemented with chemical fertilizer</b>					
CM Urea TSP					
225 + 51 + 6	1.76	180	5,000	4,700	915
175 + 54 + 12	1.76	170	5,100	4,800	920
125 + 56 + 19	1.76	205	6,200	5,900	1,360
75 + 59 + 25	1.76	255	7,600	7,300	1,955
25 + 61 + 32	1.76	190	5,500	5,200	900
<b>Chemical fertilizer alone</b>					
Urea (62)+TSP (35)	2-2.7	150	7,100	6,400	1,733

*Note: Production is 10-15% lower when using mixed-sex Nile tilapia*

Pond production of Nile tilapia often utilizes manure as part of its fertilization strategy. As fish yields increase with greater manure rates, it becomes important to balance organic and inorganic nutrient inputs to reduce the threat of deoxygenation.

## Technical recommendations

Using results from on-station and on-farm trials in Northeast Thailand, the Asian Institute of Technology (AIT) has developed a package of technical recommendations for low-cost fertilization strategies for small-scale farmers.

### Fertilization rates

- **Manure alone:** types and rates of manure depend on availability.
- **Manure supplemented with chemical fertilizer:** amount of chemical fertilizers is adjusted to the amount of applied manure to provide 28 kg N and 7 kg P/ha/week. The following formula is used.

### Caution!

**Excessive fertilization may cause deoxygenation which could lead to fishkills.**



$$\text{N-fertilizer (kg/pond/week)} = \frac{[28 \cdot (\text{manure rate}) \times (\text{N\% in manure})] \times [\text{pond surface area(sq m)}]}{(\text{N\% in N-fertilizer}) \times (10,000 \text{ sq m})}$$

$$\text{P-fertilizer (kg/pond/week)} = \frac{[7 \cdot (\text{manure rate}) \times (\text{P\% in manure})] \times [\text{pond surface area(sq m)}]}{(\text{P\% in P-fertilizer}) \times (10,000 \text{ sq m})}$$

- **Chemical fertilizer alone:** the applied amount of chemical fertilizers will provide 28 kg N and 7 kg P/ha/week (urea at 62 kg/ha/week and TSP at 35 kg/ha/week). The required amount of chemical fertilizers can be determined using the above formulae. In acid-sulfate soils, the P input level might have to be raised four-fold.

## Fertilization methods

- Manure is applied daily or weekly across the entire pond.
- N-fertilizers are applied weekly after dissolving in water.
- P-fertilizers are applied weekly after soaking overnight.

## Liming

- Liming is applied to maintain alkalinity above 50 mg/l as CaCO<sub>3</sub>.
- Liming is normally done at the beginning when using the "chemical fertilizer alone" strategy or when the pond soil is acidic.

**Liming is applied at the following rates using different limes one week before pond filling**

<b>Agricultural lime (CaCO<sub>3</sub>)</b>	<b>1000-2000 kg/ha</b>
<b>Quicklime (CaO)</b>	<b>600-1200 kg/ha</b>
<b>Hydrated lime [Ca(OH)<sub>2</sub>]</b>	<b>750-1500 kg/ha</b>
<b>Dolomite [CaMg(CO<sub>3</sub>)<sub>2</sub>]</b>	<b>900-1800 kg/ha</b>

## Stocking

- Fish should be stocked one to two weeks after pond filling.
- Stocking density ranges from 0.5 to 3 fish/sq m (5,000 to 30,000 fish/ha), depending on fertilization rates.
- It is better to nurse fry to around 5 g (6-8 cm) in hapas prior to stocking.

## Pond management

- Water exchange and aeration are not needed.
- Water is added weekly to compensate for loss due to evaporation and seepage to maintain at least 1 m water column.

## Conclusion

Low-cost fertilization strategies are suitable for small-scale farmers engaged in tropical pond aquaculture. Rates of manure and chemical fertilizers may be adjusted based on local conditions, availability of nutrients and cost.

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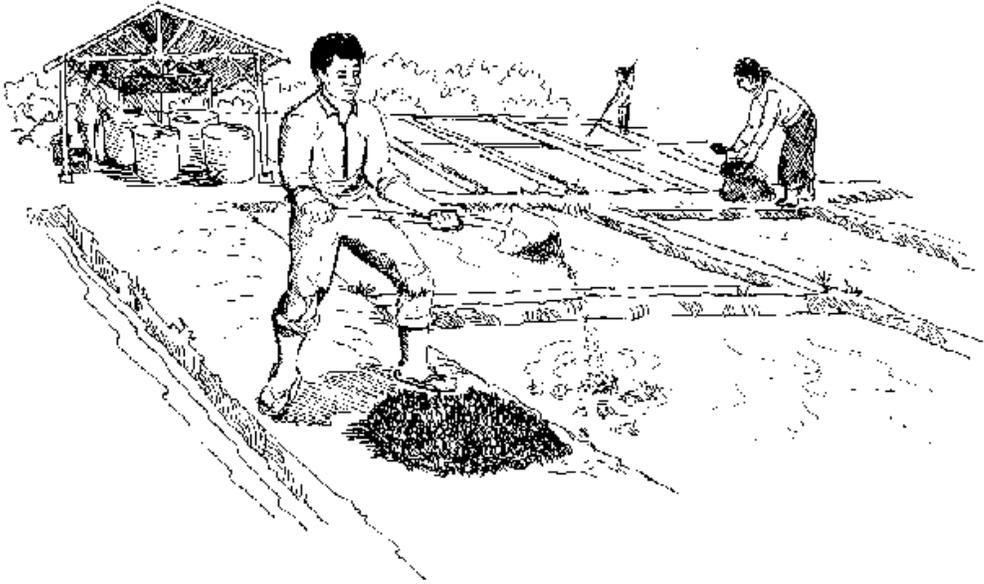
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Prepared by:

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# Culture of Fish Food Organisms and Biofertilizers



Intensification of aquaculture exerts pressure on the trophic potentials of an aquatic system. Fertilization and planned introduction of fish food organisms are two measures employed to enhance the natural productivity of a habitat. This is of great importance in the hatching and production stages of several fish and shellfish species.

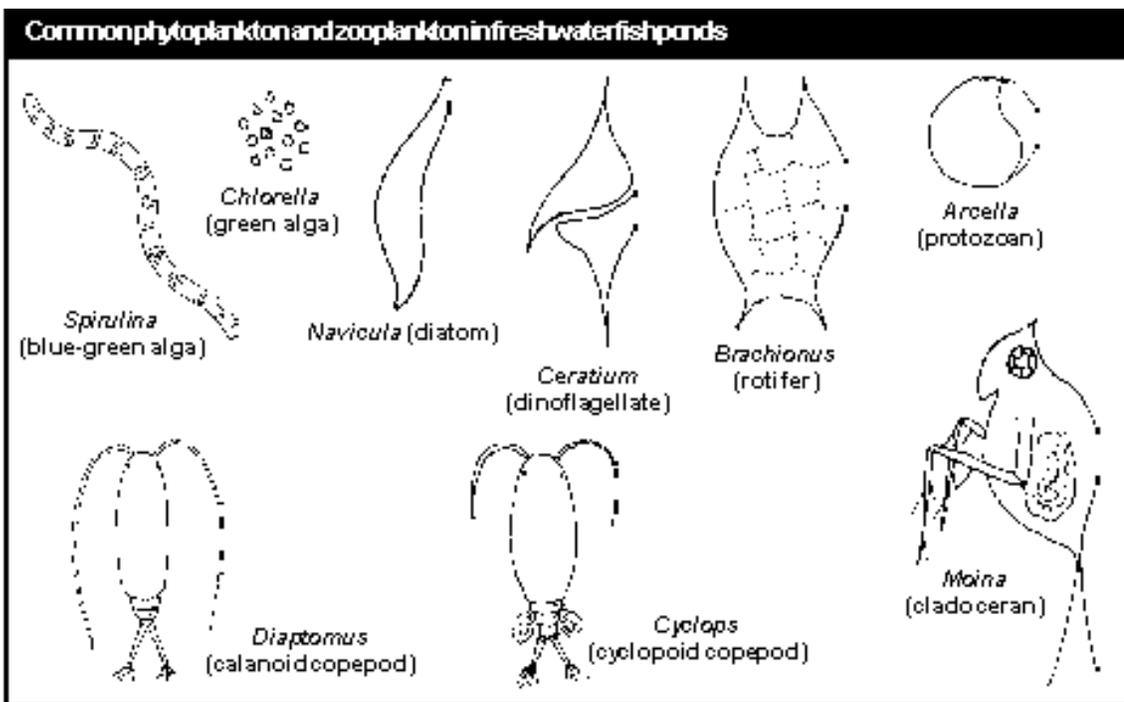
Fish food organisms are the different groups of plankton whose growth can be enhanced through the application of fertilizers. Biofertilizers are biotic agents like bacteria and algae that carry out functions like fixing atmospheric nitrogen. They can therefore substitute for chemical fertilizers.

## **Fish food in ponds**

Plankton are the basic component in the food spectrum of fish in aquaculture ponds. Phytoplankton in freshwater ponds are blue-green algae (*Cyanophyceae*), green algae (*Chlorophyceae*), diatoms (*Bacillariophyceae*) and dinoflagellates (*Dinophyceae*). The common groups of zooplankton are protozoans, rotifers, cladocerans and copepods. Most fish and shellfish species used in pond culture are filter-feeding herbivores or detritivores, depending on the abundance of plankters.

## **Culture of fish food organisms**

Fish food organisms like *Chlorella*, *Scenedesmus*, *Dunaliella*, *Brachionus*, *Moina* and *Artemia* are cultured as feed for hatchery systems. In-pond productivity enhancement measures can be undertaken, including varying proportions of organic and inorganic fertilizers, provision of periphytic substrates (polythene sheets and bamboo mats). The development of biofilm and periphyton provides additional food biomass for the fish. A 10-15% increase in fish production can be achieved through the inclusion and enhancement of fish food organisms.



Culture of high-value algae like *Spirulina*, which commands a market price of up to US\$25/kg, has become a secondary aquaculture industry, on the lines of ornamental fish culture. In India, cooperative units of *Spirulina* cultivation involving rural women have been set up. A nodal facility provides the nutrient inputs. The produce from the satellite marketing units are collected. Groups of 25-30 women undertake the lgal culture in four to six cement vats (3 m x 1.5 m x 0.6 m) using the algal starter material and the nutrient inputs that they receive from nodal facilities. Pure cultures are maintained at the central unit and are replenished whenever needed.

### ***Spirulina***

*Spirulina* (*S. platensis*, *S. fusiformis*) is a blue-green alga known for its protein level (62-71%). It is likewise known for its beta-carotene (1.7 g/kg), a precursor of vitamin A. It possesses a digestibility of 84% and net protein utilization of 61%. It is an important dietary component of valued fish and shellfish species like ornamental fish and prawns. It is also of therapeutic value to humans.

With lab-scale cultures of *Spirulina* obtained in Zarrouk's medium (having a high level of bicarbonate), the commercial cultivation is carried out in a network of cement raceways to prevent algal accumulation at the surface. The outdoor cultivation parameters are:

- raceways (length-breadth ratio 1.5:1) preferably with a mid-rib for facilitating water circulation;
- culture medium depth 15-20 cm;
- flow rate 20 cm/sec;
- temperature 25-35°C;
- pH 9-11;
- hardness 120-150 mg/l; and
- light intensity 20-30 k lux.

#### Zarrouk's medium for indoor cultures

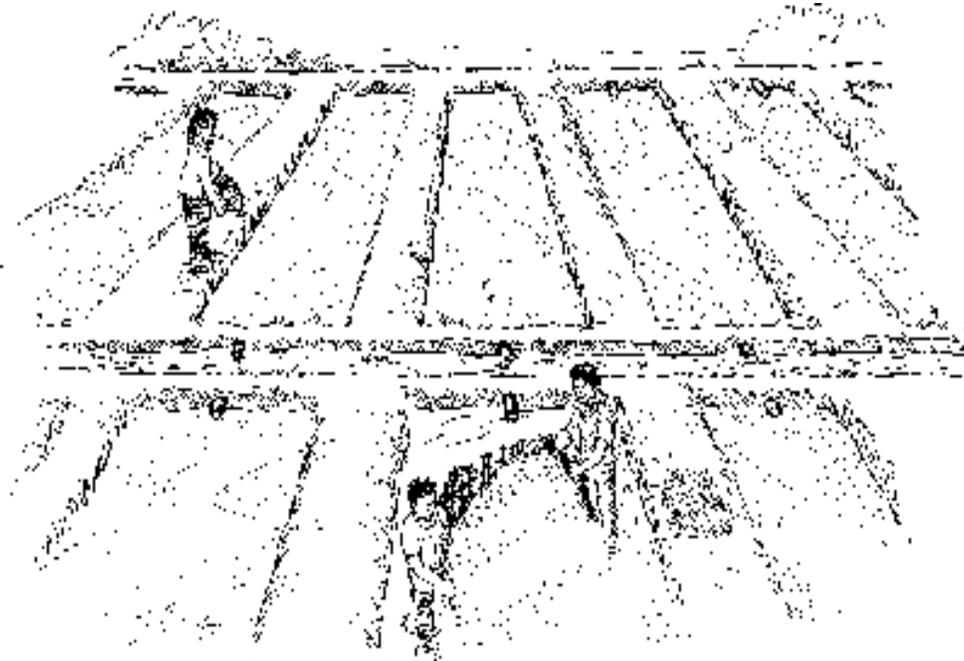
	g/l
Sodium bicarbonate	18.00
Dipotassium hydrogen phosphate	0.50
Sodium carbonate	4.00
Sodium chloride	1.00
Sodium nitrate	2.50
Magnesium sulphate	0.20
Ferrous sulphate	0.01
Potassium sulphate	1.00
Calcium chloride	0.04
EDTA	0.08

Trace quantities of manganese chloride, sodium molybdate, zinc sulphate, sodium tungstate, titanium sulphate and cobalt nitrate.



#### **Azolla as a biofertilizer in aquaculture**

The significance of biological nitrogen fixing in aquatic systems has brought out the usefulness of biofertilization. *Azolla* is a floating aquatic fern, fixing atmospheric nitrogen through the cyanobacterium, *Anabaena azollae*. Its high nitrogen-fixing capacity, rapid multiplication and decomposition rates resulting in quick release of nutrients have made it an ideal nutrient input in farming systems.



The normal doubling time of *Azolla* is three days. A kilo of phosphorus applied during its culture results in 4-5 kg of nitrogen (i.e., 1.5-2 tons of fresh biomass). With a dry weight range of 4.8-7.1% among different species, the nitrogen and carbon contents are 1.9-5.3% and 41.5-45.3%, respectively.

While *Azolla* is grown as a green manure before rice transplantation or as a

dual crop in agriculture, it can be cultivated in earthen raceways and applied periodically to fish ponds.

#### *Azolla* culture in earthen raceways

The culture system comprises a network of earthen raceways (10-15 m x 1.5-2 m x 0.3 m), with water supply and drainage facilities. The operation in each raceway consists of:

- application of *Azolla* inoculum to cover one-third the water surface (400 g/sq m);
- phosphatic fertilizer (3 g/sq m);
- maintenance of 5-10 cm of water depth; and
- harvest in a week's time.

The produce is about 1-1.5 kg/sq m in this period and, for continuous culture, a third of the biomass is left as inoculum for the next cycle.

The suggested application rate of *Azolla* to meet the nutrient requirements in carp polyculture (and substitute for chemical nitrogenous fertilizer) is 40 tons/ha/year. This requires an area of about 800 sq m, a unit that could be taken up as a subsidiary farming activity. Along with the environmental benefits, a saving of up to 30-35% over

the traditional manuring practices is estimated.

A related aspect is the cultivation of other duckweeds that do not fix atmospheric nitrogen, hence, requiring addition of both nitrogen and phosphorus as nutrient inputs. Different species of *Spirodela*, *Lemna* and *Wolffia* are candidate species, as they have high growth rates of 200-300 g/sq m/day. With high nutrient absorption rates, their doubling time is only two to three days. They are also useful in the bioremediation of effluents in both domestic and agro-based industries (e. g., dairy effluent) and serve as inputs for fish farming systems.

# Feeds in Small-Scale Aquaculture



Carp and tilapia are dominant species in freshwater fish culture in many Asian countries. Majority of carps and tilapias are produced by utilizing natural foods resulting from proper pond fertilization, often supplemented by artificial feeds to enhance fish yield and raise fish to a larger size than is possible with natural foods. Artificial feeds range from farm products such as grass and rice bran to farm-made, formulated feeds and commercial feeds. The choice of artificial feeds depends mainly on the cost and availability of resources to small-scale farmers.

## **Types and protein contents of artificial feeds**

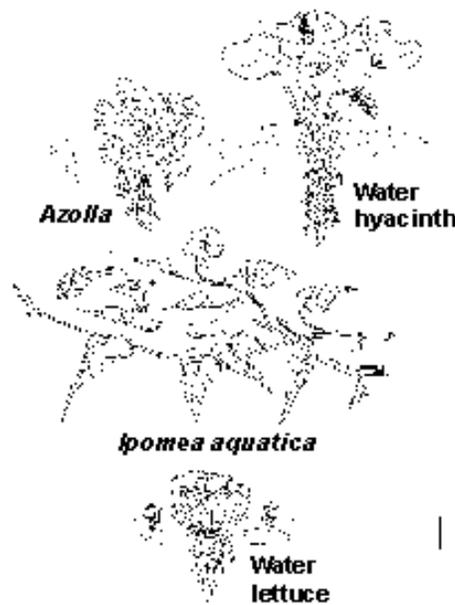
There are many types of artificial feeds for fish culture. The nutritional value of different artificial feeds depends on the palatability, digestibility and nutrient composition. The crude protein (CP) content (% of dry matter) of a specific feed varies because of many factors. Feed conversion ratio (FCR) is the wet weight (kg) of feed required to grow one kg of fish, depending upon the feed quality, moisture, cultured species, culture system and so on.

### **A. Aquatic and terrestrial plants**

Plants are one of the most widely available fish feed sources locally. They can be used fresh or dried or powdered for fish feeds.

**Commonly used aquatic plants (CP 15-35%, FCR 20-100)**

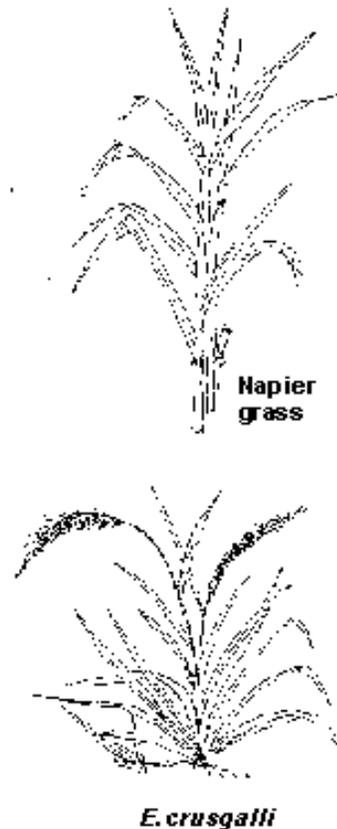
- Duckweed (*Lemna* spp.)
- Giant duckweed (*Spirodela* spp.)
- Water egg (*Wolffia* spp.)
- Aquatic fern (*Azolla* spp.)
- Water hyacinth (*Eichhornia crassipes*) – should be used in combination with other feed ingredients and should not exceed more than 10% (dry weight) by weight
- Pond weed (*Potamogeton* spp.)
- Water spinach (*Ipomea aquatica*)



- Alligator weed (*Alternanthera philoxeroides*)
- Water lettuce (*Pistia stratiotes*)
- Salvinia (*Salvinia* spp.)
- Reed-mace (*Typha latifolia*)
- Tape grass (*Vallisneria spiralis*)
- Hydrilla (*Hydrilla verticillata*)

### Commonly used terrestrial plants (CP 10-30%, FCR 20-50)

- Napier or Elephant grass (*Pennisetum* spp.)
- Ryegrass (*Lolium multiflorum*)
- English rye (*Lolium perenne*)
- Alfalfa (*Medicago sativa*)
- Red clover (*Trifolium pratense*)
- White clover (*Trifolium repens*)
- Sudan grass (*Sorghum vulgare* var. *sudanese*)
- Guinea grass (*Panicum maximum* Jacq.)
- Para grass (*Brachiaria mutica*)
- Lalang grass (*Imperata ruginacea*)
- Star grass (*Cynodon plectostachyus*)
- Barnyard grass (*Echinochloa crusgalli*)
- Sweet potato (*Ipomea batatas*)
- Wheat (*Triticum* spp.)
- Oak (*Avena sativa*)



- Barley (*Hordeum* spp.)
- Maize (*Zea mays*)
- Fresh rice straw (*Oryza sativa*)
- Sorghum (*Sorghum* spp.)
- Ramie leaves (*Boehmeria nivea*)
- Canna leaves (*Canna edulis*)
- Pumpkin vines (*Cucurbita* spp.)
- Velvet bean vines (*Mucuna* spp.)
- Cassava leave and tuber (*Manihot esculenta*)
- Bean stalk leaves and seed
- Leaves of fruit trees such as papaya (*Carica papaya*) and banana (*Musa* spp.)
- Vegetables
- Leaves and stems of leguminous plants, gourds, melons, etc.

### B. Aquatic animals and terrestrial-based live feeds (CP 40-85%, FCR 10-80)

Aquatic animal feeds and terrestrial-based live feeds are considered to be nutritionally complete. Terrestrial-based live feeds such as earthworms and maggots can be produced on-farm using various organic wastes. Some examples are:

- mollusks such as snails and clams;

- insects such as silkworm larvae (*Bombyx mori*), soldier fly larvae (*Hermetia illucens*) and termites (*Reticulo termes santonesis* and *Zootermopsis nevadensis*);
- small crustaceans such as wild small shrimp; and
- earthworms and maggot

### C. Plant processing by-products

The most common plant feeds from various agricultural by-products are listed below.

#### Deoiled cakes and meals

Deoiled cakes and meals are major sources of plant proteins (CP 20-50%, FCR 3-6).

- Beans
- Soybean
- Peanut
- Sesame
- Cashew
- Cocoa
- Coconut
- Oil palm
- Linseed
- Mustard
- Sunflower
- Cottonseed
- Rapeseed
- Cannabis
- Bran

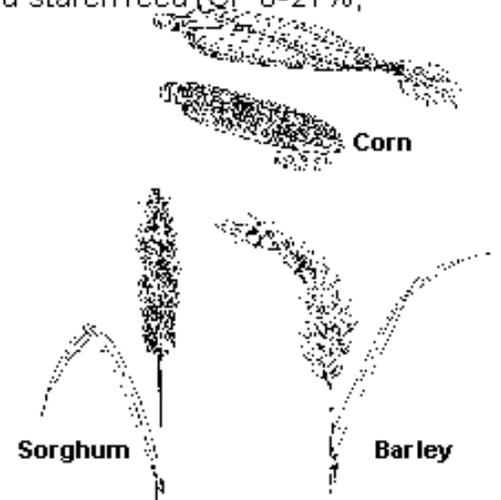
#### Beans (CP 25-36%, FCR 4-8)

- Soybean
- Broad bean
- Red bean
- Pea
- Cowpea

#### Grains and brans

Commonly used starch feed (CP 8-27%, FCR 3-4)

- Corn
- Sorghum
- Barley
- Broken rice
- Rice bran
- Wheat bran
- Wheatflour sweepings



### D. Animal processing by-products (CP 40-85%, FCR 1.5-4)

Animal feeds with high nutritional values are made from a variety of sources, such as by-products from processing factories. Major animal protein feeds include:

- Fish meal
- Bone/meat meal
- Blood meal
- Silkworm pupae meal

- Feather meal
- Food yeasts

### E. Industrial wastes

Organic waste materials from industries such as food processing, wine and beer manufacturing and water processing are widely used directly as fish feeds or as a substrate to produce living organisms for fish feeds.

### F. Formulated feeds (CP 18-50%, FCR 1.5-4.0)

Formulated feeds are composed of several materials in various proportions. The ingredients of formulated feeds complement each other and increase feeding efficiency.

### G. Commercial feeds (CP 18-40%, FCR 1.0-2.0)

Commercial feeds are nutritionally complete feeds such as pellets.

### Feed preparation

Existing techniques of on-farm feed preparation for carps and tilapias are simple.



•Most terrestrial-based live feeds are added directly to fish ponds.

•Snails and clams are crushed before being offered to the fish.

•Grass and leaves are usually chopped when fish are small or ground for rearing fry and fingerlings or grow-out fish of both filtering and omnivorous species. On the other hand, larger fish (>50 g) are fed directly.

•Water lettuce, water hyacinth and alligator weeds must be treated before being used for

feeding.

– Minced

– Fermented: Mix 100 kg plants with 3-4 kg rice bran and 0.5 kg yeast; seal in containers and store for two days at 26°C.

– Elimination of saponin: Alligator weed contains saponin, which is toxic to fish. The toxicity can

be eliminated by adding two to five percent table salt during fermentation.

– Mashed: These plants can be mashed into paste, which is an appropriate feed for fish fry because mesophyll cells in the paste are the same size as plankton.

- If dry ingredients are used, a well ground mixture maybe offered in feeding bags or simply dispersed throughout the pond.
- A reduction in feed waste can be achieved by cooking carbohydrate sources, such as cassava tubers, and mixing other ingredients with the gelatinized starch. This mixture can either be directly fed as a wet dough or pelleted by a simple extrusion process.
- Minerals and vitamins can be added when preparing feeds. For example, the addition of 2% di-calcium phosphate can increase efficiency of soy bean-based feed. It is a popular practice in China and India to use common salt in preparing feeds. The addition of vitamins can increase fish yields by 15-20% when fish stocking density is above 0.6 fish/sq m.
- On-farm prepared pellets could be sundried and stored for future use.

### Some examples of protein ingredients for producing formulated feeds, their protein contents and FCR for carps and tilapias

Protein ingredients	Protein content (%)	FCR	Species
Silkworm pupae + rice bran	25	3.0	Carp
Silkworm pupae + peanut cake + rice bran	28	3.7	Catla
Soybean meal + peanut cake + rice bran	27	3.6	
Fish meal + peanut cake + rice bran	30	2.0	
Fish meal + bean cake + silkworm pupae + peanut cake + wheat	18.2	3.6	Grass carp
Fish meal + bean cake + wheat bran + deoiled cake + wheat + barley	26.9	2.3	
Fish meal + bean cake + corn + peanut cake + wheat	24.7	1.5	
Fish meal + bean cake + wheat bran + deoiled cake	27.8	1.9	
Fish meal + bean cake + deoiled cake + rice bran + food yeasts	39.1	2.5	Black carp
Silkworm pupae + deoiled cake + barley + bone powder	26.2	2.7	
Bean cake + wheat bran + deoiled cake	30.9	2.1	
Fish meal + bean cake + silkworm pupae + com + wheat + rice bran + bone powder	39	1.8	Common carp
Fish meal + bean cake + barley	43.4	1.8	
Silkworm pupae + wheat bran + deoiled cake	30	2.5	
Fish meal + bean cake + wheat bran + barley + mussel powder	31.4	1.9	
Fish meal + cassava	30	1.5	Nile tilapia
Soybean meal + cassava	30	1.5	
Fish meal + bean cake + silkworm pupae + com + barley + tree leave	34.6	2.0	Tilapia
Bean cake + silkworm pupae + corn + mussel powder	22.6	1.9	
Fish meal + bean cake + silkworm pupae	25.5	1.8	
Fish meal + bean cake + silkworm pupae + corn	19.4	2.1	

## Feeding

The required feeding rates and feed quantity for a particular fish pond depend on certain

factors.

- Feed quality
- Cultured species
- Stocking density
- Fish size
- Nutrient inputs of manure and chemical fertilizers
- Pond history



Quantity can be calculated based on the expected net fish yield and FCR of the particular type of feed. The daily feeding rate is made equal to the percent increase in body weight of fish in the pond per day, times the existing biomass. In practical terms, these data are estimated from past years' experiences on the increase in fish biomass.

The dry matter loading rate in pond culture directly influences the morning dissolved oxygen concentrations and ammonia toxicity levels. The upper dry matter loading rate for short duration (three to six months) tilapia/carp polyculture systems is approximately 100 kg feed (dry matter)/ha/day.

In well fertilized ponds, supplemental feeding is generally needed during the last three months to fatten fish for better market prices. For Nile tilapia (*Oreochromis niloticus*), pond culture with fertilization rates of 28 kg N and 7 kg P/ha/week supplemental feeding is not needed before fish reach 150 g.

Since carps and tilapia generally have relatively low market prices, a cost-effective feeding regime depends mainly on:

- careful selection of feedstuff and ingredients;
- utilization of an optimum feed formulation;
- selection of multi-purpose equipment for feed preparation;
- optimization of feed dispersion; and
- minimizing feed waste.

For small-scale farmers with poor resources, the appropriate feeding strategy is to use available feed as supplement in fertilized systems rather than as an ingredient for formulated feeds.

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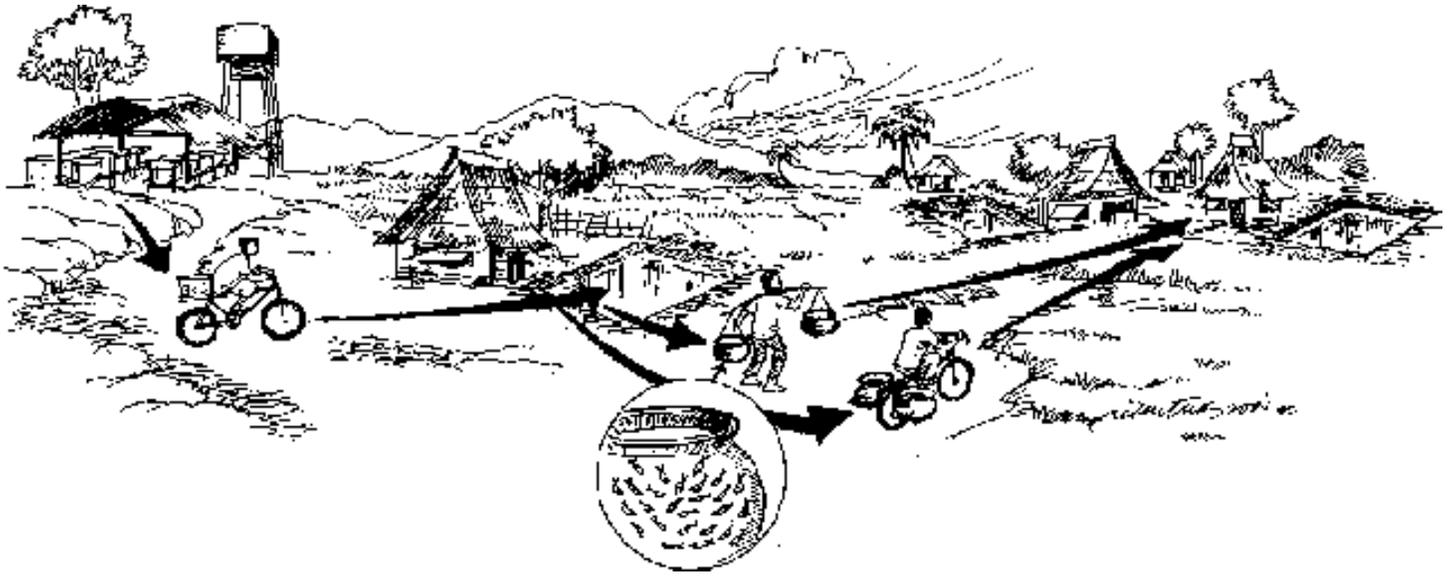
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# Decentralized Seed Production Strategy for the Development of Small-Scale Aquaculture



Good quality fish seed in the right quantity is one of the most critical inputs for aquaculture. Since most of the cultivable species do not breed naturally in confined water, aquaculture in the early days depended exclusively on seed collected from wild sources. With the popularization of aquaculture:

- the demand for seed increased multifold;
- the price of seed increased making seed collection a lucrative activity; and
- seed collection activity reached a stage where it threatened riverine fisheries.

Most of these issues were resolved when induced breeding was successfully demonstrated in Bangladesh in 1966. Taking advantage of this technology, four large regional hatcheries were established in the early 1980s.

## Centralized to decentralized production

Soon, the regional hatcheries could no longer cope with the growing demand for seed. There were also difficulties in seed distribution to different parts of the country. To ease the situation, the government established over a hundred seed production farms in areas with the greatest potential for aquaculture.

## Emergence of mini hatcheries

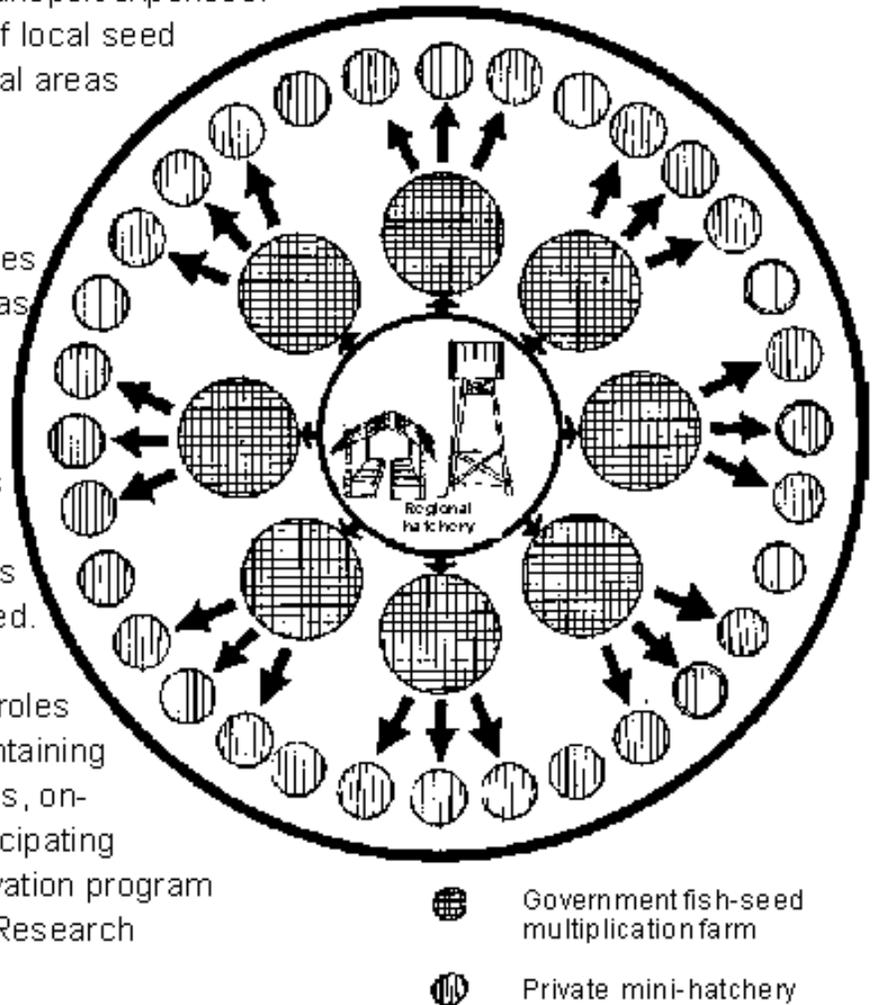
Pond aquaculture contributes over 80% of the total aquaculture production in Bangladesh. Except for community ponds, most of these are homestead ponds ranging from 0.05 - 0.25 ha, scattered throughout the country. Since the ponds are small, individual seed requirements are also small. Hence, long distance transport of seed was not only troublesome but also costly and risky. The unavailability of seed locally was a major constraint in harnessing the full potential of small-scale aquaculture. To address the problem, the government encouraged

farmers and rural entrepreneurs to establish low cost mini-hatcheries. At present, about 90% of the seeds are produced by 713 small private hatcheries, some of which are owned by NGOs. Government-owned hatcheries now account for only less than 5% of the total fry production. Most private hatcheries are small.

The establishment of small hatcheries increased seed production. Distribution across the country was impressive and now, the collection of seed from natural sources has become negligible.

### **Advantages of decentralized seed production**

- Local and year-round availability of seed.
- Low cost, due to elimination of transport expenses.
- Emergence of a large number of local seed rearers and seed vendors in rural areas creating additional livelihood opportunities.
- More options for buying seed.
- Accessibility of seeds encourages farmers to take up aquaculture as an additional livelihood.
- Reduced mortality of fry and fingerlings.
- Genetic diversity of local breeds maintained.
- Reduced dependency of farmers on big/central hatcheries for seed.
- Government seed farms able to concentrate on other important roles like serving as brood bank, maintaining genetic quality of farmed species, on-farm genetic conservation, participating in genetic improvement conservation program with the Bangladesh Fisheries Research Institute (BFRI), etc.



## Species used for breeding in mini-hatcheries

Usually major carps are widely cultured in Bangladesh and other countries of South Asia.

### Location

Most of the mini-hatcheries are located in flood-free areas where there is a high pond concentration and are accessible by road and rail.

Physical facilities required for a mini-hatchery

A small fish hatchery is composed of the following:

1. **Overhead water tank** capable of running the operation for two to three hours once it is filled. On the top of the tank, perforated trays are placed for water oxygenation.

2. A **shallow tube well** is a minimum requirement for supplying water to a hatchery. A deep tube well is used for bigger hatcheries.

3. A **circular spawning/breeding tank** 4-5 m in diameter and 1-1.25 m deep. This tank is fitted with a water inlet, outlet and egg collection facilities. Fishes are kept here for breeding purposes.

4. **Hatching jar**, which are cone-shaped cemented structures fitted with a water supply inlet at the bottom. A ball is placed at the opening of the inlet line to prevent fish eggs from entering the water supply line. An outlet exists at the top of the jar. A fine-meshed net is warped around the top of the jar to avoid losses of eggs or hatchlings. Eggs are placed in this jar at the rate of 2.5 liters. Capacity of the hatching jar is about 300-450 liters. The number of hatching jars depends upon the local demand for seed.

5. **Holding tank**, a rectangular tank 3-4 m long, 1 m wide and 1 m deep. Broods are kept here prior to injection for spawning.

## Age and size of brood fish used for breeding in the hatcheries

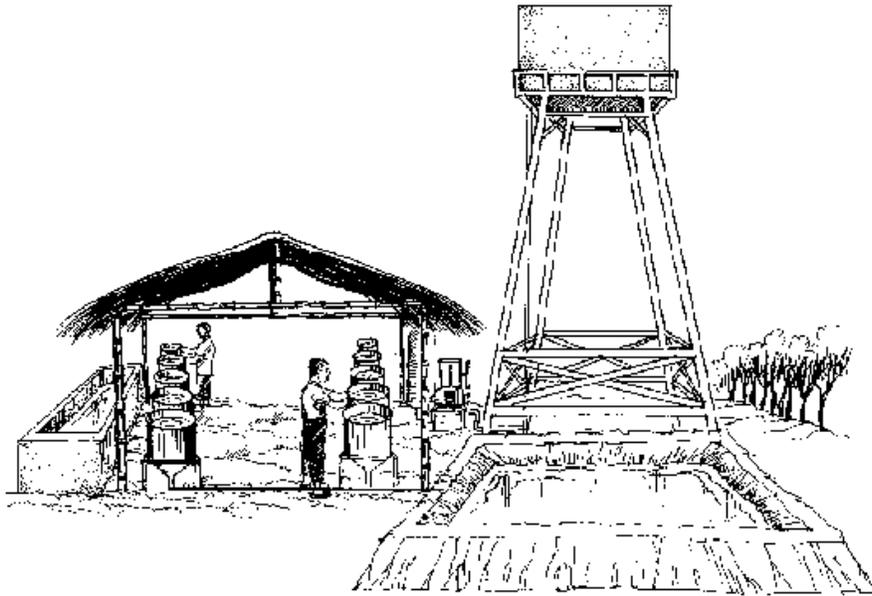
The following are usual species being used in the hatcheries including their minimum age and weight

Species	Minimum age (year)	Minimum weight (kg)
Catla ( <i>Catla catla</i> )	2+	3.0+
Rohu ( <i>Labeo rohita</i> )	2	1.5+
Mrigal ( <i>Cirrhinus mrigala</i> )	2	1.0+
Calbasu ( <i>Labeo calbasu</i> )	2	1.0+
Silver carp ( <i>Hypophthalmichthys molitrix</i> )	2+	2.5+
Grass carp ( <i>Ctenopharyngodon idella</i> )	2+	2.5+
Bighead carp ( <i>Aristichthys nobilis</i> )	2+	2.5+
Common carp [ <i>Cyprinus carpio</i> (var. <i>comunis</i> )]	1+	1.5+
Mirror carp [ <i>Cyprinus carpio</i> (var. <i>specularis</i> )]	1+	1.5+
Silver barb ( <i>Barbodes gonionotus</i> )	1	0.4+
Pangas ( <i>Pangasius eutchall</i> )	2	1.5+

## Fish seed (hatchling) production trend in Bangladesh

Year	Production		
	From natural sources (kg)	Produced in hatcheries (kg)	Contribution of private hatcheries (%)
1990	5128	13014	30
1991	6855	22170	50
1992	9342	33072	55
1993	4913	43047	65
1994	5871	49000	75
1995	9144	72000	80
1996	2399	116212	87
1997	2824	117500	87
1998	2885	118100	88
1999	2600	169000	90

1 kg of spawn counts 350,000 - 400,000 spawn (4 days old)



6. **Shed**, made of cheap material such as bamboo and straw to cover the whole structure (except the overhead tank)

7. **Brood fish** maintained in adjacent ponds owned or leased, or collected from natural sources as per the production capacity of the hatchery. Usually, existing and nearby ponds are used as brood ponds.

### Rearing of broodstock

Broods of major carp are maintained at a density of 2000-2500 kg/ha in the ponds. Usually silver carp and bighead carp are not reared along with catla to avoid food competition. Typically, hatchery owners maintain only about 10% of their total requirement of broods. They breed one female two to three times in a season. In general, the small hatchery operators need about 10-12 kg (combined weight) of broodstock (carps) to produce 1 kg of spawn (350,000 - 600,000). This includes both male and female brooders in a ratio of 2:1.

### Distribution/sale of spawn

Farmers buy the hatchlings from a small-scale hatchery and rear them up to fingerling stage for sale. In most cases, they use the homestead ponds or road side seasonal ditches to rear the seed. Ponds used to nurse the seed are either owned or leased. Large-scale hatchery owners distribute their products (hatchlings) all over the country. Large hatcheries usually maintain a good number of nursery and rearing ponds and many poor people are employed in fry rearing.

Hatchlings are sold at different prices depending on species. Catla and mrigal are highest and lowest priced species, respectively. Hatchlings are sold at rates ranging from US\$20.00 to US\$100.00/kg. Prices of spawn vary between peak and lean breeding periods: prices are high during the early part of the season and low towards the end

#### Important consideration

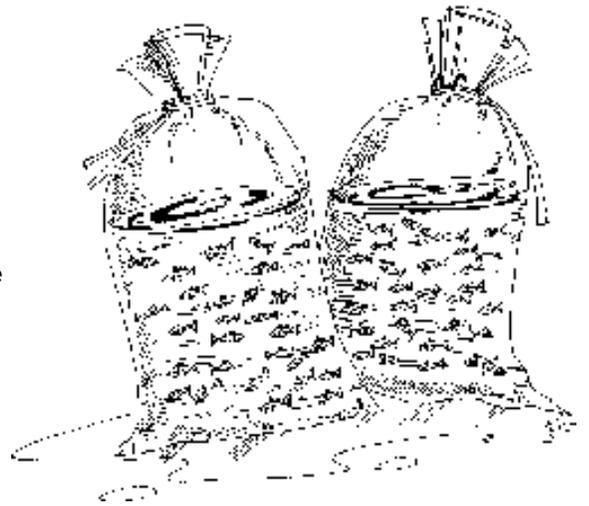
Many hatchery operators do not follow guidelines for maintaining the genetic quality of the fish resulting in instances of inbreeding. Hatchery operators should have at least half of their brood stock collected from natural sources.



of the season.

### **Seed production strategy for the development of small-holder rural aquaculture**

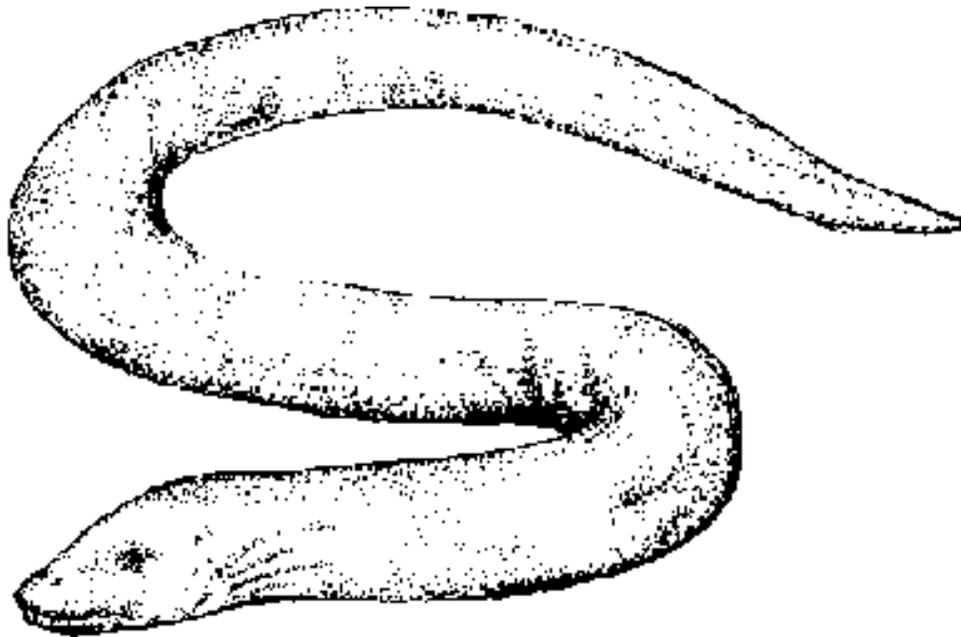
The strategy of decentralized seed production by promoting the establishment of privately-owned mini-hatcheries has created an immense impact on the development of small-scale aquaculture and culture-based fisheries. Fish seeds (spawn, fry and fingerlings) are now easily and widely available throughout the country. A large number of resource poor rural families depend on raising spawn (up to fry) and fingerlings for their livelihood while many others work as fish seed vendors.



### **Conclusion**

Accessibility of good quality seeds at the right time and in desired quantities has also contributed to the development of small-scale aquaculture and enhanced fisheries. Just as important probably, is the employment-generating potential of these seed production ventures.

# Small-Scale Eel Culture: Its Relevance for Rural Households



The eel has always been an odd subject. Many people regard it as an undesirable snake-like, mysterious animal. However, the economic importance of eels to a number of countries in the world is undisputed, at least for *Anguilla* eels.

Eel culture can be undertaken with a minimum investment, using locally available and cheap resources. Eels are long snake-like fish with a smooth, slimy, scaleless skin. There are hundreds of varieties of eels. *Monopterus albus* (rice field eel but in some literature also known as swamp

eel), which disappeared locally for unknown reasons, was reintroduced by the International Institute of Rural Reconstruction (IIRR) in late 80s in the Philippines. Many farmers are raising this species for food.

The technology described in this paper is based on several years of successful practice by farmers in Indonesia, as well as on-station and on-farm trials in the Philippines. It has also been successfully practiced in China and *Monopterus* eels, either caught from the wild or raised, are sold for a high price (US\$3-4).

The genus *Monopterus* has six species and is found only in Asia. The ricefield eel (as

**Comparative nutritive value of selected foods**

Sources	Calories	Protein (g/100g of material)
Eel	303.0	14.0
Fish (general)	125.0	18.0
Shrimp	90.0	16.0
Chickenmeat	110.0	20.0
Beef	301.0	17.5
Egg	160.0	13.5
Milk	62.5	3.5

also the swamp eel *M. cuchia*) is raised in cemented tanks. The advantages of raising this species are:

- it can be raised in small cemented tanks (there could be other innovations, but this paper deals with cemented tanks as an example);
- it can breed in captivity without using any chemical stimuli;
- it is an air-breathing species and can survive in oxygen-depleted conditions, and is, therefore, very useful in areas where water is scarce; and
- its natural foods are fish, snails, aquatic insects, invertebrates, worms, etc.

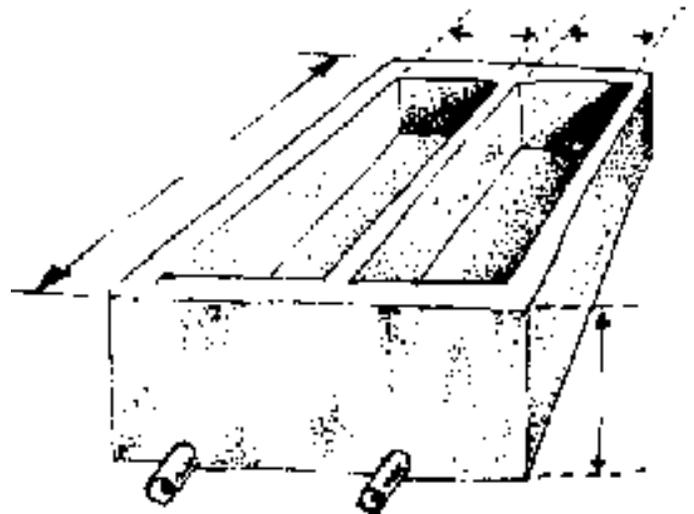
## Methods

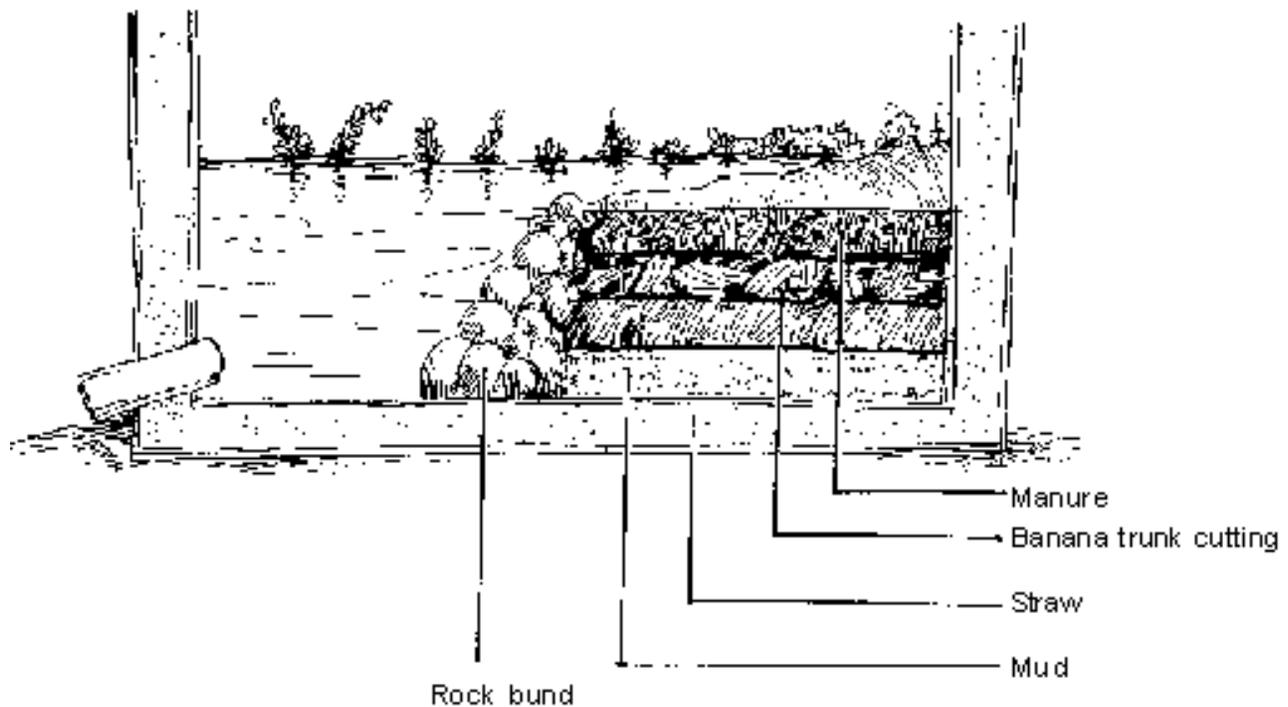
### Tank preparation and stocking

1. Construct twin tanks 1 m x 2 m x 1 m in size with a total surface area of 4 sq m. The tank should be leak-proof with an outlet at the bottom.

2. Layer half of the tank lengthwise.

- The first (bottom) should be mud (preferably from ricefields or ponds) and is 10 cm thick.
- The second is composed of straw, previously cured for about a week, and 10 cm thick.
- The third consists of finely-chopped banana trunks, which are cut a week prior to introduction and must be 10 cm thick.
- The fourth is cow manure, also 10 cm thick.
- The fifth and top layer is mud placed on a slope with one end higher than the other.





3. Ground or spring water could be used. Water from domestic faucets can also be used provided the chlorine content is not very high or can be lowered by some mechanism (spraying or holding the water in storage tanks).

4. Introduce water into the tank, 15 cm above the top layer, and allow the materials to decompose for about a week or until foam appears.

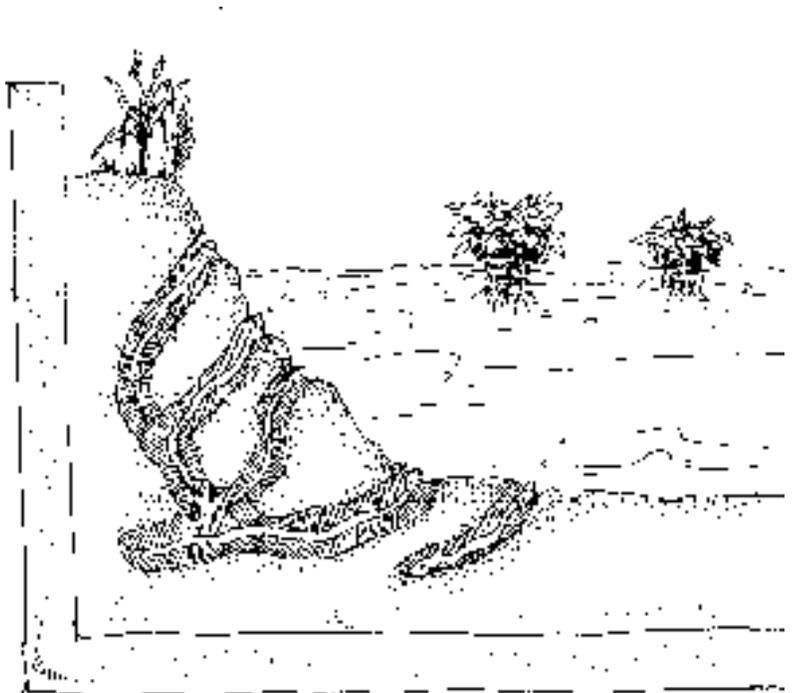
5. Drain the water and introduce fresh water again. Repeat this process every week for 20-25 days until no more froth appears.

6. Introduce *tilapia* or carp fingerlings to check if the tank is ready for culturing eels. Allow the fingerlings to stay in the tank for three days. If they do not die, that means the tank is ready for the introduction of eels. The tank, when ready, will have the same quality as a ricefield.

7. Before the introduction of eels, plant aquatic plants such as water hyacinth (*Eichhornia crassipes*) on the top soil. The plants will shelter the eels from direct sunlight and also act as a hiding place.

8. For the tank size mentioned, introduce 195 to 200 eels with a ratio of 140 females and 60 males.

9. The fecundity (egg-laying capacity) of *Monopterus* eels is low (ranging from 100-700 eggs per spawning), and, therefore, involves a very high degree of parental care.



10. The fingerlings can either be obtained from someone who is raising them or from adult eels raised in your tanks.

**Remember!**

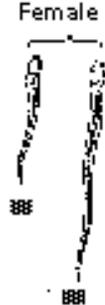
*Monopterus albus* is a protogynous (female first) species. In several species, a fish is a female as it grows and attains sexual maturity. As it grows further, however, it transforms into a male. The ones that are below 30 cm are females and those above 40 cm are males. Those whose lengths are in-between turn cannibal.



The breeding season varies from place to place although it is usually observed to take place with the onset of the rainy season.

Fingerlings, which cling to water hyacinth roots, should be segregated. Take out the weed and tap it over a net. The fingerlings will fall down. Repeat for a few days until there are no more fingerlings in the tank. Maintain in a separate tank or aquarium until they are pencil size. Then, transfer to new tanks.

Female



Male



**Note**

*M. albus* eels turn cannibal during the change from male to female because of hormonal changes.

## Feeding management

1. Maintain proper feeding levels (3 - 6% of body weight/day) throughout the culture period. Feed eels with fish fingerlings, earthworms, snails, aquatic insects, silkworm pupae, slaughterhouse wastes (cow/carabao/chicken liver, intestine, chicken skin, etc.)

### Tip

Silk-worm pupae, if available locally, are excellent foods for the eel. Live earthworms can be given directly to the fish or ground into a paste along with other fish and/or snails.

2. Use only mud from the pond or from a well-seasoned tank for nursery pond until

the hatchlings develop into fingerlings. Fingerlings can also be raised in aquarium with mud from the pond bottom.

3. Add flour or vitamin pre-mixed into the eels' natural food with the consistency of stiff paste (so the food does not dissolve in water and spoil the water quality).
4. Give food ingredients separately or in combination of two or more. A natural food, such as fingerlings of cheaper fish, is the most preferable.
5. At fingerling stage, feed eels with a lot of aquatic insects, which can be produced naturally in stagnant water bodies.
6. Collect golden apple snails from the rice fields to reduce the rice-eating snail population and feed them to the eels.
7. Consider the following factors in feeding:
  - size (length) of the fish;
  - biomass (total weight); and
  - climatic conditions, such as atmospheric temperature.

An ideal temperature for eel to feed properly would be between 20-35°C.

### **Harvesting and transporting**

1. Harvest according to the needs of the market and the growth of eels.
2. Harvest partially or completely. If you have more than one tank, harvest completely so that the next lot is ready in the new tank before harvesting.
3. Harvest during feeding time when a net can be placed under the feed.
4. Make sure not to injure the eels as it may, besides causing death, lower the market price.
5. Starve the eels in holding tanks before transporting live to the market.
6. Clean the tanks properly after harvest and sun-dry for a few days before stocking with new eels.

### **Ecological implications**

Some farmers who have introduced *Monopterus* eels in their rice fields have noticed a marked reduction in snails as these are natural feed for the fish. However, some

farmers have come across the problem of dike-boring by eels, which make it difficult to retain water in the rice fields. The ecological implications of these species in the wild are being studied. Introducing the eel into the rice field will involve additional management efforts for the dikes.

Eels, once introduced into the rice field, can serve as predator of golden apple snails, which have become a pest in some Asian countries, particularly the Philippines and Vietnam.

The introduction of eels helps enhance the biodiversity value of rice fields and neighboring swamps.

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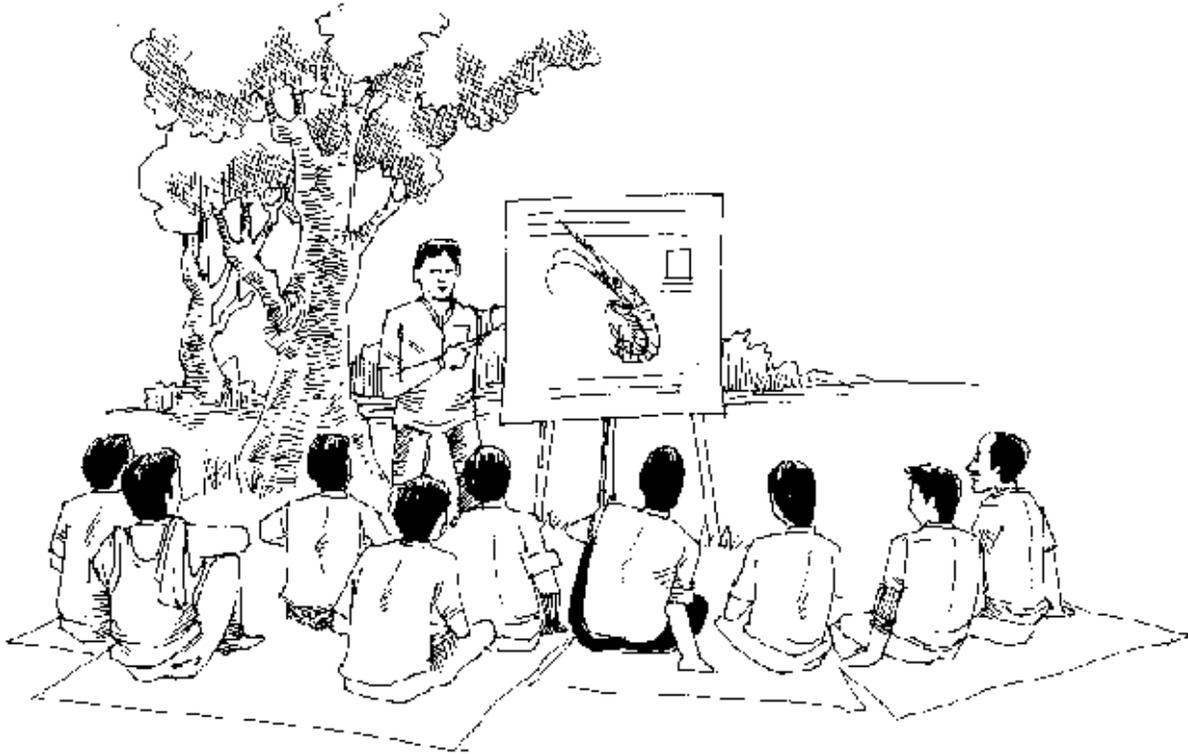
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# Small-Scale *Macrobrachium* Culture in Bangladesh



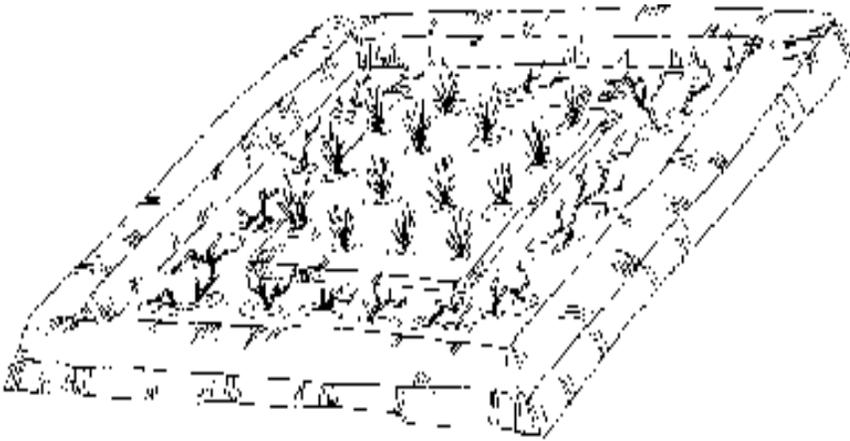
Farmers in the Southwestern (coastal zone) part of Bangladesh have developed a new method of using rice fields for cultivating both prawns and rice. The low-lying areas frequently get flooded during the monsoon season and the new high yielding varieties of rice are not appropriate. Generally, farmers are able to cultivate rice only during the boro season (dry season). During the monsoon these areas remain fallow.

The cultivation of prawn and rice in modified rice fields is called "Golda Gher". Golda is the Bangla word for the giant freshwater prawn (*Macrobrachium rosenbergii*) while Gher refers to elevation of bundhs. This type of culture is seasonal.

## **Gher construction**

- Use paddy fields located in the low-lying areas for better water holding capacity.
- Dig canals all around the paddy field to a depth of 1.5-2 m and use the excavated soil for making dikes on all four sides of the field.

- Leave the middle portion of the field unexcavated. The shapes of the canal vary depending on the location of land and interest of the farmers. Canals should cover 30-40% of the area. The rest of the area should be left as is.
- Use the canal for stocking prawns.
- In the dry season, use the un-excavated portion for growing rice. During the monsoon season the entire Gher will look like a pond, while in the dry season, a clear distinction between rice fields and the canals can be seen. The average size of the gher is about 0.2 ha.

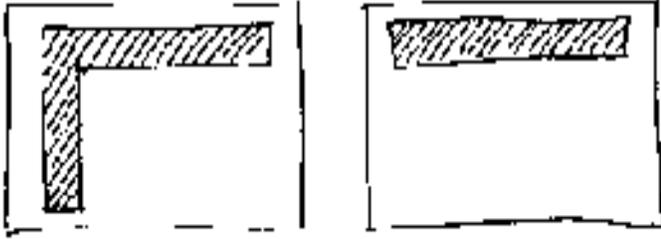


### **Gher preparation**

I Fill most of the Ghers with rainwater.

I Most farmers apply lime as a prophylactic treatment for ponds and to amend the soil pH at the rate of about 500 kg /ha. When Gher is dry lime it is applied directly but when Gher is wet

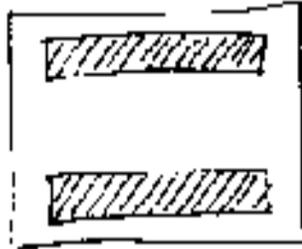
lime it is applied to the water at the same rate of 500 kg/ha. Lime is applied all over the Gher.



I Fertilize Gher water with both cow dung at the rate of 1,250 kg/ha and with inorganic fertilizers, like urea and triple super phosphate, at the rates of 25 kg/ha and 37.5 kg/ha, respectively.



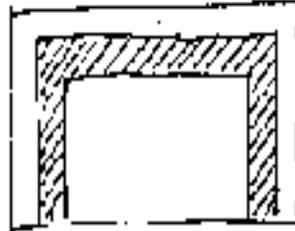
I When the water turns green, stock the Gher with prawn and fish seed. There is generally no exchange of water as it is a stagnant water culture system.



I Maintain water's green color through regular fertilization with both organic and inorganic fertilizers.



### Stocking



Most of the prawn seed required for stocking is obtained through natural collection in the coastal area. There is a good network of people actively

involved in organizing seed supplies to farmers. The post larvae procured from the wild by fishers reach the farmers through a number of intermediaries. Prawn hatcheries are developing slowly, with the decline in seed availability from the wild. The prawn post larvae are stocked at the rate of 20,000-30,000/ha, while juveniles are stocked at the rate of 10,000-15,000/ha. Along with prawn seed, farmers also stock various species of Chinese and Indian carps, mainly for regulating water quality. Stocking is usually completed between May and August. Early stocking is preferred, but due to difficulties in obtaining seed at the right time, stocking is sometimes delayed by 3-4 months.

### Feeding

Farmers maintain green water by periodic fertilization of the pond but they place a heavy emphasis on supplemental feeding of the prawns. In the early years, feeding prawns with snail meat was common but now it is being replaced by homemade feed using a variety of easily available ingredients. Women usually produce these feeds and some have undertaken feed production as an income generating activity.

Common ingredients used in feed preparation are fishmeal, ground rice, rice bran, wheat bran, molasses, mustard oil cake, etc. Farmers have developed a number of indigenous feed-making devices. Dried feed is given at the rate of 3-5% of the total biomass of prawn/fish.



Farmers adopt broadcast as well as tray feeding. Feeding is generally done in the evening to facilitate nocturnal feeding habits. Adjusting the feeding rate can easily be done by farmers as they resort to continuous harvests at periodic intervals. Snail meat is still being used as feed by the farmers because of the belief that the growth of prawns can be improved by giving them raw meat. This belief is more common among wealthier farmers.

## Harvest

Prawns are harvested several times a year and sold to local buyers. There is a good network of intermediaries involved in the regular collection of small harvests of prawns from farmers and bringing them to the processing centers. Prawns are harvested at least three to four times during the season and, depending on Gher management, harvests may reach 150-350 kg/ha.

### Caution!

It has been observed that there is a considerable degree of cannibalism among prawns, especially during the molting season.



The sizes of the harvested prawns vary. In general, the average size preferred by processing factories is 60-80 g. Harvesting is completed by November-December and the small prawns are left behind and allowed to grow for another few months up to March-June. Small farmers sell the bigger prawns in March-April and buy the required

seed for stocking in May and June.



### **Use of dikes for vegetable cultivation**

Farmers utilize the dikes for the cultivation of different vegetables, with the silt removed from the canals serving as good fertilizer. Income from vegetable growing could account for 30-40% of total income.

### **Cultivation of rice in the elevated area (Gher)**

When the water level can be easily maintained in the Gher, cultivation of two crops of paddy is undertaken: during the monsoon and dry seasons. Farmers can grow nearly enough rice to meet all the family's needs.

### **Profitability of the system**

The profitability of the system largely depends on the amount spent on seed and feed, efficient utilization of the dikes for vegetable cultivation and the size of the central un-excavated area for rice cultivation. In some cases, farmers have focused too heavily on prawns thereby increasing their risks. Alternative options are suggested to reduce these risks and to increase profitability.

Using the "Golda Gher" method, farmers have been able to derive cost benefit ratios of up to 1:4. Such a high profitability has encouraged many small farmers to adopt the system. However, these small farmers get trapped in debt, especially if they do not get any technical advice. Emphasis is placed on understanding the ecosystem and developing a scheme that is appropriate to his/her economy and farming system.

### **Constraints encountered**

- **Exploitation by money lenders.** Many institutions lend money to farmers, but very few organizations advise farmers on the wise use of credit.
- **Unplanned expansion of ghers.** Due to the profitability of the system, there is

unplanned expansion, which often blocks waterways and results in water logging.

- | **Heavy usage of snail meat.** Rich farmers continue to exploit snails for prawn feeding and this may strain the ecosystem.
- | **Prawn seed.** Almost all the seed required is currently collected from coastal areas. In the process of collection, seed of many other species are damaged. Already there are signs of a gradual decline in seed availability from the wild.
- | **Focus on prawns.** Due to the high price of prawns, farmers tend to focus too much on prawns and invest too much on seed and feed, thereby increasing risks of losses and failures.

### **Strategies to address these constraints**

- Farmers acquiring credit facilities are trained on financial management.
- Credit systems that meet the needs of farmers and help them establish self-help groups are promoted.
- Mass education using drama and posters to address unplanned expansion of ghers and to enhance the management of existing ones. An eco-village concept, which focuses on eliminating environmentally unfriendly practices, is pursued.
- Improvement of existing cultivation practices with focus on developing feeds and improving feeding strategies. Farmers have used a wide variety of strategies appropriate to their farm.
- Farmers are encouraged to develop systems that reduce risk and increase profitability through various options that are easily available. Efficient use of dikes, adequate emphasis on growing prawns with fish and growing more than one crop on paddy are some of the systems that have shown promise.

### **Conclusion**

Freshwater prawn cultivation is a potential tool in the alleviation of poverty in Bangladesh. A good network and market structure are in place. Farmers' produce is also collected, serving as a major stimulus in the development and adoption of this new system. There are opportunities to explore the adaptation of this farmer innovation in other areas, both within and outside Bangladesh.

# Culture of Chinese Mitten-Handed Crabs



Chinese mitten-handed crab (*Eriocheir sinensis*) is considered a delicacy in China and in some overseas Chinese communities. It is not a traditional species for farming, but its culture and culture-based resource enhancement in shallow freshwater lakes have become popular because of its high market value. The mitten-handed crab enjoys good domestic and foreign markets especially in Southeast Asia. Large crabs fetch a higher price than small ones.

Although the production cost for crab culture is higher than that for traditional fish farming and crab prices have recently declined, in general, crab culture still attracts farmers.

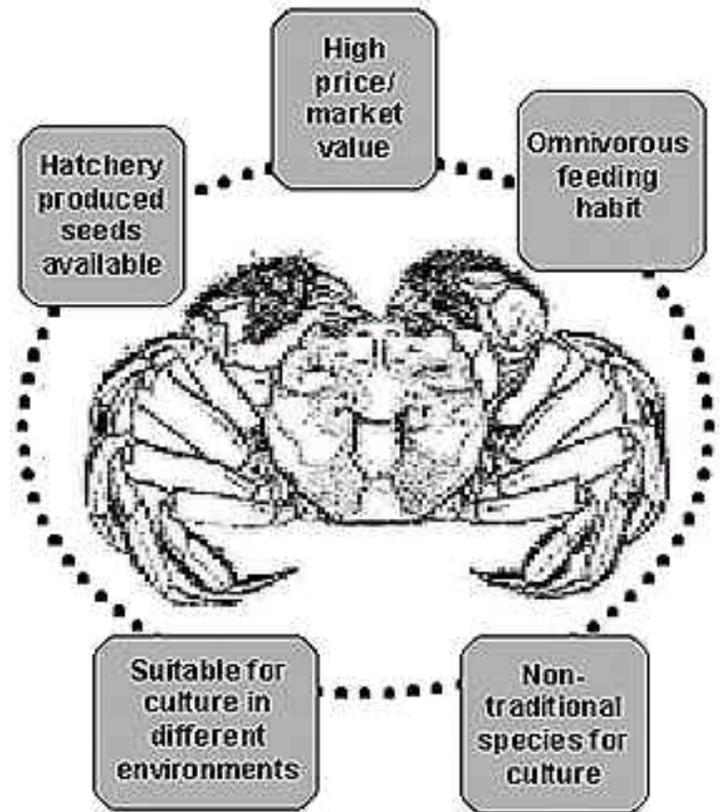
Though culture with seeds collected from the wild can be traced to three decades back, the success of artificial breeding in the 1980's boosted the rapid development of crab farming.

Retail price of female mitten-handed crabs		
Year	Small (<100 gm)	Large (>150 gm)
1996	140-160 Yuan/kg	260-360 Yuan/kg
1997	70-80 Yuan/kg	280-400 Yuan/kg

(8.28 Yuan = US\$1.0)

## Biological features

- The natural distribution ranges from sub-tropical to temperate zone in China;
- In the wild, Chinese mitten-handed crabs grow in freshwater and migrate to the sea in autumn to spawn when they reach sexual maturity. This normally takes about two years in central and eastern China.
- From juvenile to marketable size (mature), the crab molts many times. Crabs grown in the same environment do not molt at the same time. Newly molted, soft-shelled crabs are vulnerable to other crabs especially when there is not enough food.
- The mitten-handed crab is omnivorous. It exhibits a preference for food of animal origin over plants. It is nocturnal, thus it is more active at night in terms of feeding.
- Natural habitats include freshwater lakes, swamps, irrigation canals and slow moving rivers, etc. Chinese mitten-handed crabs prefer clean shallow water with loamy or clay bottom conditions. In addition, water bodies with submerged aquatic plants are preferred as shelter and because of abundant food sources.



## Stock resources and seeds

The Chinese mitten-handed crab has three different populations (called sub-species by some scholars), which are found in the south, the central and eastern regions, and northern China. The variety naturally occurring in the Yangtze River is considered the best variety for culture because of its fast growth performance and better market value.

Both hatchery-produced and naturally collected larvae are available. The availability of natural seeds, particularly in Yangtze River, is declining under excessive pressure of fishing for larvae. This has given rise to the crab hatchery industry. A complete scientific understanding of its reproductive biology is yet to be established through further in-depth research to ensure more efficient and cost-effective production of quality seed. Crab seeds of different origins are sold for farming purposes or released into open waters for stock enhancement, leading to the mixing of stocks in the wild. There is increasing evidence of poor growth and disease

resistance of the species. Hence, there is an urgent need to regulate crab seed production and marketing through appropriate mechanisms such as certification, accreditation and licensing, similar to what has been established in the field of agriculture.

Hatcheries and nursery farms grow crab larvae to "coin-size" (60-150 pcs/kg) to be sold to other farmers for grow-out culture. Some farmers purchase the larvae directly for nursing in the first year and then grow them to marketable size the following year. This crab culture system requires special skills because there is a high risk of failure.

## Culture methods

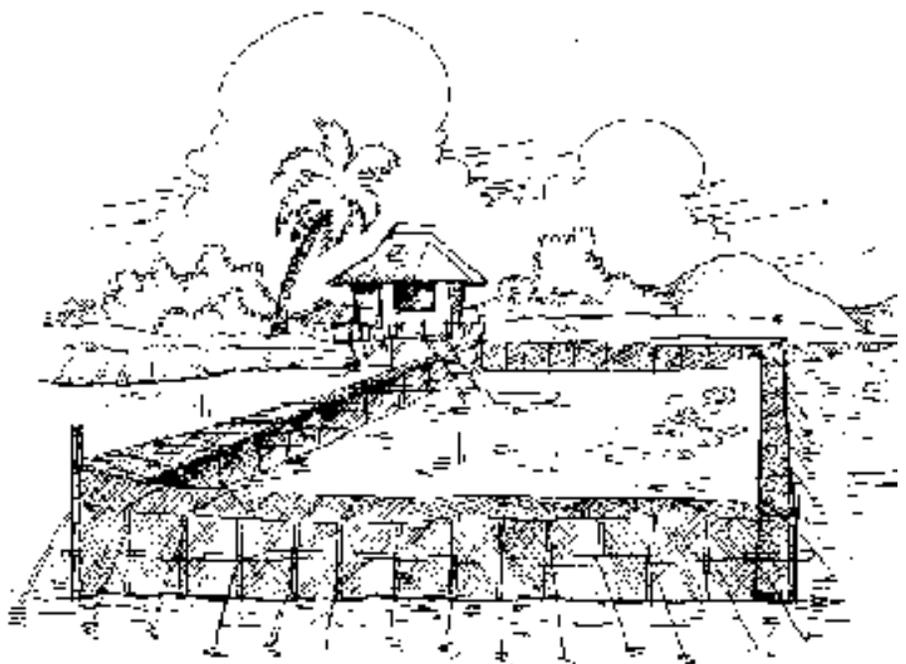
The Chinese mitten-handed crabs have been cultured in pens in shallow freshwater lakes, earthen ponds (with fence to prevent escape), fenced renovated paddy fields and covered net cages. The best results were obtained from pen culture in shallow lakes. Growth and quality (size, appearance and fatness) in pen culture are impressive, probably because pens provide crabs with an environment that is close to their natural habitat.

### Net pen culture of crabs

Culture of mitten-handed crabs in net pens is extensively practiced. Supplementary feeding is needed in addition to the natural food available in the pen. The normal yield is 300-450 kg/ha, but it could go as high as 900-1200 kg/ha with improved management skills and better levels of inputs. However, the greater yield may not always result in bigger crab size at harvest.

#### 1. Site selection

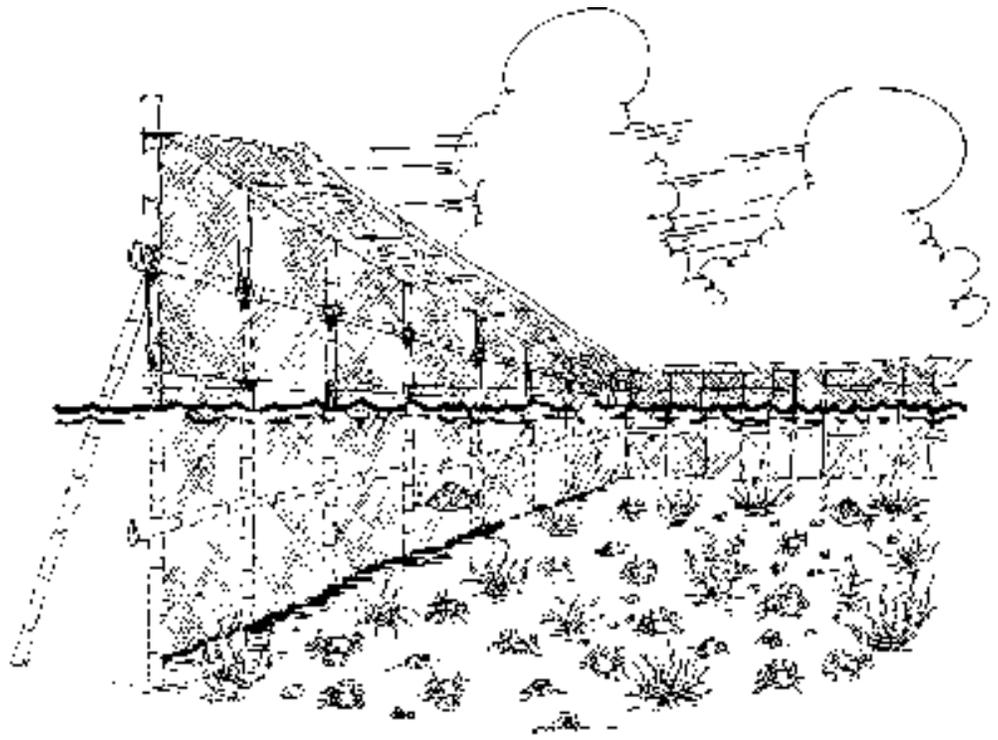
- Preferably flat with hard bottom; avoid bottom with thick silt or mud.
- Good water quality; pH 7.5-8.5; dissolved oxygen not less than 5 mg/l; free from pollution; mild flow of water (less than 5 cm/sec).
- Avoid navigation waterway/route.
- Water depth between 0.8-1.5 m, without much water level fluctuation.
- Abundant sub-merged aquatic plants



(desirable species include: *Hydrilla verticillata*, *Vallisneria spiralis*, *Potamogeton crispus*, etc.), snails, clams and aquatic insects, etc.

## 2. Net pen design and installation

- Size of net pen suitable for family operations ranges from 0.4 to 5.0 ha, depending on the farmer's available capital. The pen could be rectangular, oval or round. The shape does not matter very much as long maximum water exchange through the pen is ensured.



- Bamboo stakes or small logs and ready-made polyethylene netting can be used for the construction of the enclosure. The mesh size is 2-3 cm. Sometimes, a second outer layer of pen, made of bamboo screen or net, is built to prevent the crabs from escaping. The distance between inner and outer layers is 2-4 m.
- Bottoms of the net are sewed together to hold gravels or stones and are buried 20-30 cm deep in the bottom soil. Top of the net should be 0.8 – 1.0 m above the water, with 0.5 – 0.7 m of additional net extending horizontally from the top inwards to prevent crabs from escaping. The cross section of the net looks like an upside down "L".
- If the water and bottom conditions are favorable, the net pen for fish culture can be modified for crab culture.

## 3. Pen preparation and stocking

- Before stocking, carnivorous fish, such as snakehead, mandarin fish and catfish, should be removed from the pen because they could prey on the farmed crabs.
- Transplant aquatic plants into the pen, if there are not enough. It is recommended to cover at least 20% of the pen bottom area with submerged

vegetation of desirable species.

- Fish that graze on aquatic plants like grass carp and bottom dwellers like common carp must be removed from the pen. Grass carp and common carp could disturb the growth of crabs and compete for food. Water rats in nearby area should be killed with appropriate methods to avoid damage to the net pen and to prevent them from preying on the crabs.
- Quicklime dissolved in water should be applied by broadcasting it in the pen to disinfect the culture area.
- Crab seeds with 6-15 g/pc or 65–150 pc/kg size are desirable. The recommended stocking density is 60-150 kg/ha. The pen could be stocked starting from February to April as usually practiced in China.
- Some filter feeder fish like the silver and bighead carp could be stocked in the pen as bring-along species for culture. They help clean the water in the pen.

#### **4. Routine management**

- Supplementary feeds include aquatic plants collected from outside, vegetables, squash, sweet potatoes, boiled corn and wheat, etc.
- Animal feeds include crushed snails and clams, trash fish, slaughterhouse waste, and silkworm pupae, etc.
- Feeds are added to the pen twice a day (early morning and in the evening). The feeding rate is 3-6% of the body weight per day. About 30-40% of the daily ration is given in the morning and 60-70% in the evening. Animal protein feeds should account for 50-60% of total feed.
- Daily removal of leftover feeds (particularly in the morning) is important to keep the pen area clean.
- Daily check of the enclosure is recommended to ensure that damage to the net is repaired immediately.
- Broadcast 8-10 kg/ha of quicklime every three weeks.
- For large pens, if aquatic plants grow too much, some plants should be cut in a row (1 m wide) parallel to the water current to allow faster water exchange in the pen.

#### **5. Disease prevention and control**

- Preventive measures are more effective. A clean culture environment helps reduce the risk of diseases.
- Diseases constitute a major threat to the success of culture. In 1998, the outbreak of "shivering disease" (common term, not well defined so far) caused US\$120 M worth of losses to crab farmers nationwide.
- Basic research is lagging behind but chemicals and drugs have been developed based on preliminary research work and been commercially produced.
- Certain chemicals such as malachite green, copper sulfate, zinc sulfate, etc., commonly used for fish disease control or treatment are not suitable for crabs (different toxicology).

## 6. Harvest and conditioning

- The crabs are harvested when they reach maturity and are ready to migrate to the sea in mid-September to mid-October, when temperature drops to 12°C. Crab traps and gillnet are used for harvest.
- Crabs are kept in holding tanks or cage before marketing. Feeding of the crabs in holding tanks should continue for fattening purposes. Holding of the crab also allows the farmers to wait for a better price before selling the product.
- Crabs must be kept alive until it reaches the consumer's kitchen. Dead crabs have no market value at all.

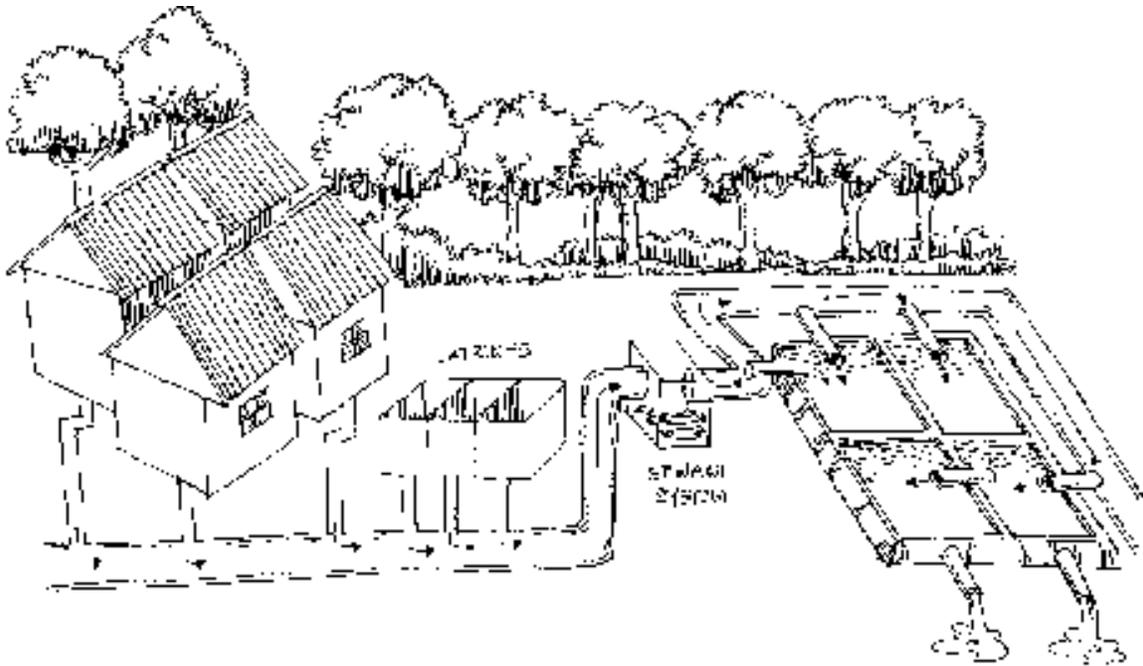
## Conclusion

Crab farming is a relatively simple aquaculture practice, suitable for both large and small scale operations. At present, the seed of crabs is still expensive and quality of seeds not consistent through years. Further development in hatchery technology and nursing techniques will help to reduce the production cost by providing cheaper seeds in the future.

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Prepared by:  
**Zhou Xiaowei**

# Aquaculture and Sewage Water Treatment



Growing population and the lack of a corresponding infrastructure for waste water treatment are growing concerns. In every country, the generation of domestic sewage escalates, often beyond the capabilities of conventional sewage treatment plants, which include oxidation/waste stabilization pond, activated sludge, trickling filter, aerated lagoons, upflow anaerobic sludge blanket process, etc. At the same time, it is increasingly being recognized that sewage is not just a pollutant, but rather a nutrient resource. Traditional practices of recycling sewage through agriculture, horticulture and aquaculture have been tried in several countries. This article discusses the role of aquaculture-related approaches for processing sewage water.

**Sewage** is a dark colored, foul-smelling fluid containing organic and inorganic solids in dissolved and suspended forms. It contains 90 to 99% water, 10-70 mg/l nitrogen, 7-20 mg/l phosphorus, 12-30 mg/l potassium.

Characteristics of sewage	Weak mg/l	Medium mg/l	Strong mg/l
<b>Total solids</b>	<b>350</b>	<b>720</b>	<b>1200</b>
Dissolved state	250	500	850
Suspended form	100	220	350
<b>Settleable condition</b>	<b>5</b>	<b>10</b>	<b>20</b>
<b>Biochemical oxygen demand (BOD) at 20°C for 5 days</b>	<b>100</b>	<b>200</b>	<b>400</b>



Fish culture with sewage as the main input for sustaining the grazing as well as the heterotrophic food chains is practiced in several countries like China, Vietnam, Cambodia, Indonesia, Laos, Germany, India, etc.

## Sewage-fed culture

Several variations from overhung latrines over the ponds to the application of primary treated sewage into fish ponds exist. The sewage-fed fish culture in Munich, Germany and sewage-fed *bheries* of West Bengal, an Eastern State of India, have been extensively studied. The practices in over 5,700 ha area in Bengal produce over 7,000 tons of fish annually.

### Normal management practices

- Fry stocking: 30-50 mm
- Fish density: 40,000 – 50,000/ha
- Sewage application: weekly or bimonthly intervals
- Field indices for pond's sewage intake: algal blooms, fish surfacing, dark color of water
- Production rate: 3-7 tons/ha/year

#### **Carp polyculture is practiced in most of these waters**

- Silver carp (*Hypophthalmichthys molitrix*)
- Common carp (*Cyprinus carpio* var. *communis*)
- Indian major carps – Catla (*Catla catla*), Rohu (*Labeo rohita*) and Mrigal (*Cirrhinus mrigala*)

#### **Other medium and minor carps**

- Bata (*Labeo bata*)
- Reba (*Cirrhinus reba*)
- Mola (*Amblypharyngodon mola*) are often used as components of fish culture in these waters

### **Problems related to sewage-fed culture systems**

- Accumulation of silt and high organic matter at pond bottom
- Incidence of parasites and fish diseases
- Possibilities of pathogens being transferred to humans

### **Solutions**

- Regulate sewage intake into the ponds
- Provide freshwater for dilution
- Use of prophylactics
- Depuration of fish in freshwater before marketing

Several modifications in the system are also being suggested to achieve greater efficiency and sustainability.

## **Sewage treatment through aquaculture**

Resource recovery from wastewater is important not only for realizing the nutrients as food, but also in ensuring that they do not contribute to the eutrophication of natural waters that are the usual receptors.

Biological treatment of sewage using algal-bacterial associations, macrophytes and fish employ both autotrophic and heterotrophic food chains, rendering the effluent nutrient-deficient and less harmful to the environment into which it is discharged.

Ponds serve as facultative receptacles for sewage treatment, and also provide oxygen input from the photosynthesizing algae and macrophytes. Ponding reduces the bacterial loads by two to three log units and bacteriophage loads by three to four log units even at the loading rates of 100 kg COD (chemical oxygen demand)/ha/day.

### **Principles of wastewater treatment models**

- Dilution
- Oxidation
- Reduction of suspended solids along with nutrient recovery in terms of biomass

## **Aquaculture-based sewage treatment plant (ASTP)**

An aquaculture-based sewage treatment plant designed in India has incorporated cultivation of duckweeds prior to application of fish ponds and post-fish culture depuration, with the objectives of refinement of sewage-fed fish culture and sewage treatment through aquaculture practices.

The ASTP consists of a set of duckweed ponds, fish ponds and depuration ponds, located at a place 250 m away from the residential area and borewells. Gravitational flow of sewage wherever feasible for sewage intake into the treatment

complex will be advantageous.

## Design and construction of a model to treat 1 mld sewage

A model for treating one million liters per day (mld) of sewage, from a population of about 20,000 is described below:

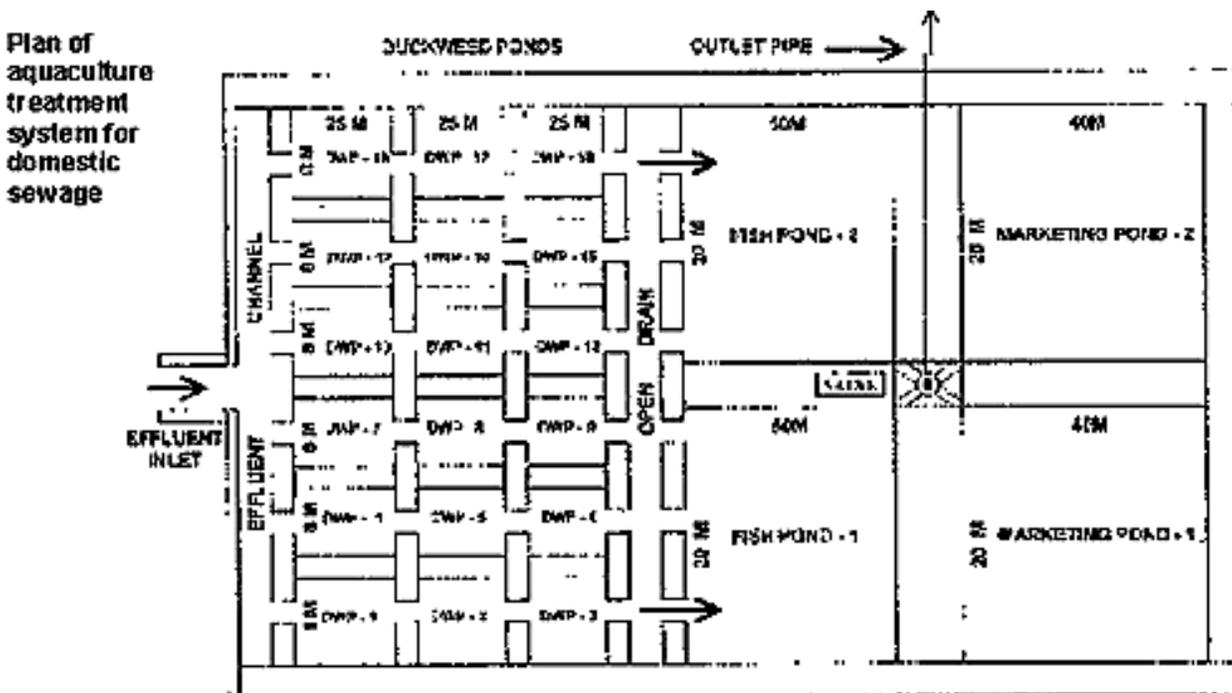
**Source:** A receiving chamber for sewage feeds the effluent to the ASTP.

**Duckweed culture complex:** It comprises 18 ponds with brick lining (25 m x 8 m x 1 m), with three series of six ponds in a row. The sewage is retained here for a period of two days, with free passage between the series.

**Fish ponds:** Two fish ponds (50 m x 20 m x 2 m) receive the treated sewage from the duckweed ponds and retain it for three days.

**Depuration ponds:** Two depuration ponds (40 m x 20 m x 2 m) with freshwater, also used as marketing ponds, provide for depuration of fish for a week before marketing. As the fish harvest is occasional, these ponds are also used for the culture of grass carp, fed with duckweeds from the system.

**Outlet:** Sewage outlet drains are provided from the fish and depuration ponds for drainage into natural waters.



Duckweeds and fern used depending on availability



*Spirodela*



*Wolffia*



*Lemna*



*Azolla*

## Duckweed culture

Duckweeds serve as nutrient pumps, reducing eutrophication effects and providing oxygen through the photosynthesis activity.

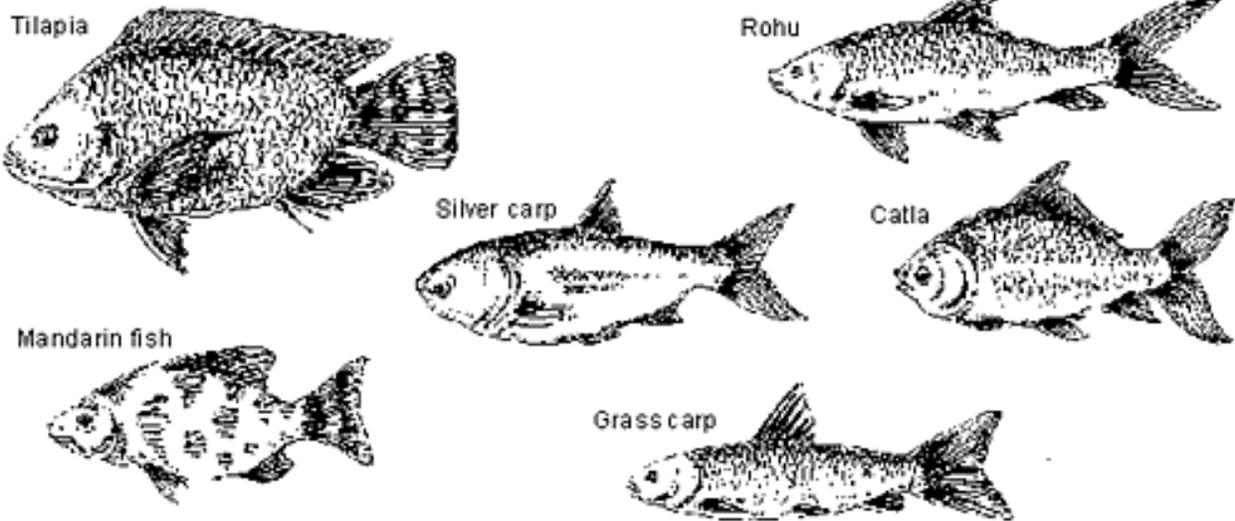
The ponds are inoculated with duckweeds to cover roughly one-third of the surface area (400 g/sq m). The approximate growth rates of individual weeds in the sewage-fed culture system are *Spirodela* 350 g/sq m/day, *Wolffia* 280 g/sq m/day, *Lemna* 275 g/sq m/day and *Azolla* 160 g/sq m/day. The harvested weeds could be used to feed grass carp in the marketing ponds or composted for application in fish ponds and horticulture fields.

## Fish culture

The ponds are stocked with Indian and Chinese carps at a density of 10 000 fingerlings/ha (Catla 40%, Rohu 40% and Silver carp 20%). Grass carp, *Ctenopharyngodon idella*, is stocked in the marketing pond and fed with duckweeds harvested from duckweed ponds. The fish stocks are checked at monthly intervals for their health

and growth through sample nettings. By monitoring of dissolved oxygen levels to maintain 3-5 mg/l, the sewage flow is regulated. Fish harvest is carried out 8-12 months after stocking, with mean individual sizes in the range of 600–800 g. About 600-700 kg of fish are harvested from the two fish ponds, working out to a production level of 3-3.5 tons/ha/year and about 400 kg of fish are harvested from the marketing ponds, representing considerable economic returns from the sewage.

### Candidate fish species for sewage-fed fish culture



Depending on the area of operation, different fish species could be used. Tilapia (*Oreochromis* spp.) and Mandarin fish (*Siniperca chautsi*) are some of the species that are cultured in sewage-fed waters in China and other countries.

The ASTP provides for retention of sewage for two days in duckweed ponds and three days in fish ponds. This achieves the desired reduction in nutrient concentrations, BOD, COD and the bacterial populations to meet the standards for discharge into natural waters. The fish produced from the system enables recovery of about 40% of the working costs.

This model has been used in several Indian villages for community sanitation and aquaculture, with modifications. Typically, a third of the pond of the size of 0.2–0.4 ha at the inlet end serves as the receptor of sewage from solid wastes from community latrines. This portion is stocked with duckweeds that multiply in the presence of organic matter and effluents that then pass into the adjacent portion of the pond stocked with fish. With a continuous flow, the organic loading is regulated in different seasons.

#### Total area required

##### Duckweed culture complex

Individual pond :	25 m x 8 m x 1 m
Total no. of ponds :	18
Area :	3600 sq m

##### Fish ponds

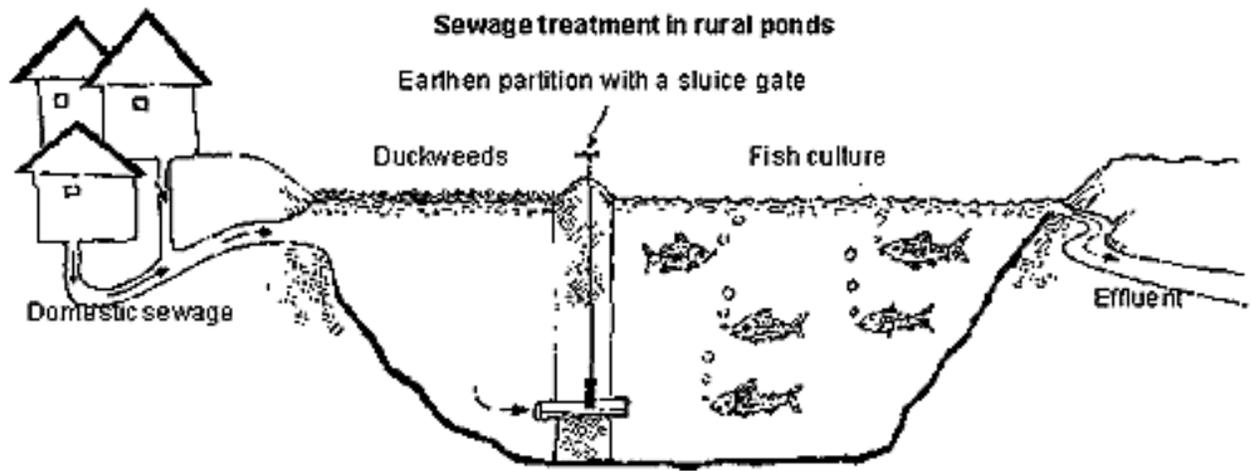
Individual pond :	50 m x 20 m x 2 m
Total no. of ponds :	2
Area :	2000 sq m

##### Depuration/Marketing ponds

Individual pond :	40 m x 20 m x 2 m
Total no. of ponds :	2
Area :	1600 sq m
Total water area :	7200 sq m

#### Wastewater reuse in Hanoi, Vietnam

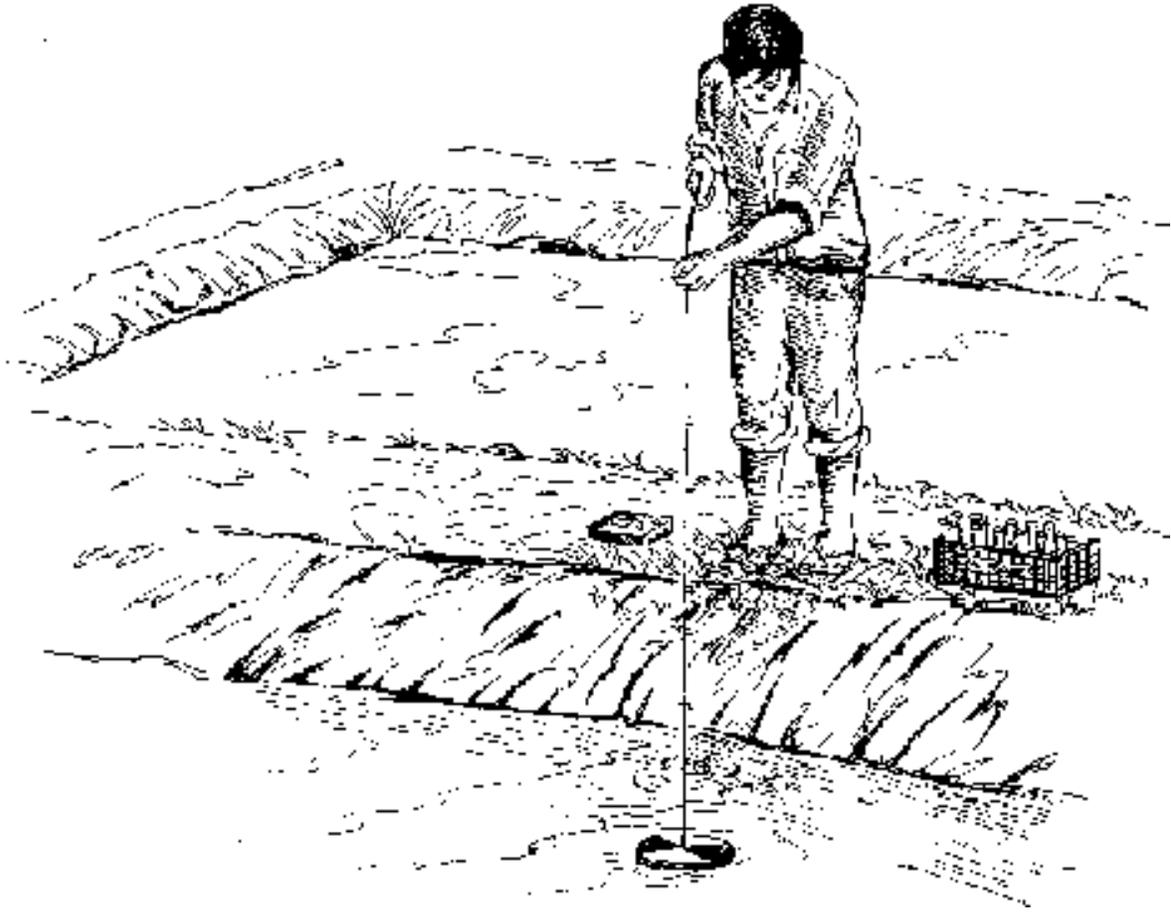
- Fish culture with silver carp, rohu and tilapia fed with wastewaters, in rural areas around Hanoi, with annual yields of 5-8 tons/ha/yr.
- Rice and fish in shallow ponds: 4-5 tons rice and 3 tons fish/ha/yr.
- Vegetable farming incorporated.
- 4,500 tons of fish from wastewater fed system, 40-50% of the total fish supply to Hanoi.
- IUCN, WHO, The World Bank and International Center for Waste Disposal recognize wastewater reuse in aquaculture as an important form of waste disposal.



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Prepared by:  
**S. Ayyapan**

# Water Quality Management for Freshwater Fish Culture



The aquatic environment governs fish life, hence, water quality should be suitable for fish culture. When environmental conditions do not conform to the optimal range for normal fish growth, then fish culture could be affected. The major concerns of fish culturist should be to deal with the aspects of water quality that may cause poor growth or death of fish. Water quality management aims to regulate environmental conditions so that they are within a desirable range for growth and survival of fish.

### Examples of variables

- Temperature
- Turbidity
- pH
- Alkalinity
- Total hardness
- Calcium
- Dissolved oxygen
- Carbon dioxide
- Ammonia
- Hydrogen sulfide
- Total gas pressure



The aquatic environment is composed of many variables. Fish culturists must know the variables that are potential sources of stress for the fish. The variables may also explain the causes of fish culture problems.

Although, these parameters can be analyzed using standard laboratory procedures and apparatuses or water quality analysis kits, there are practical indications when these parameters become risky to the fish.

## Water quality variables and their effects

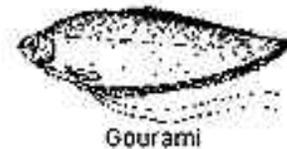
### on fish

#### Temperature

Fish are cold-blooded and dependent upon the water temperature in which they live. Every fish species has an ideal temperature range within which it grows quickly.

#### Common fishes and their optimum temperature ranges

Common name	Scientific name	Water temperature (°C)
Tilapia	Oreochromis mossambicus	25 - 35
Gourami	Osphronemus goramy	24 - 28
Tawes	Puntius javanicus	25 - 33
Common carp	Cyprinus carpio	20 - 25
Grass carp	Ctenopharyngodon idella	25 - 30
Eel	Anguilla japonica	20 - 30
Silver carp	Hypophthalmichthys molitrix	25 - 30
Rohu	Labeo rohita	25 - 30
Mrigal	Cirrhinus mrigal	25 - 30
Catla	Catla catla	25 - 30



Gourami

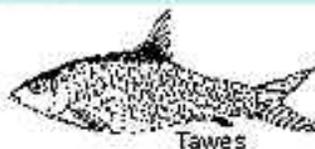


Common carp

Temperature does not act alone. If the fish show signs of distress because of hot weather, these are often caused by high temperature and low oxygen content.



Mud carp



Tawes

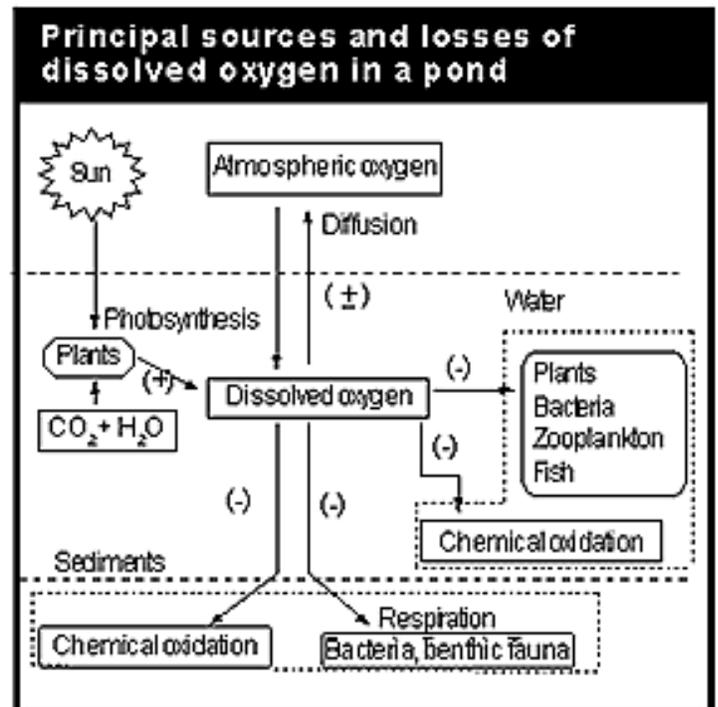


Grass carp

## Dissolved oxygen (DO)

The concentration of DO in natural water is influenced by the relative rates of diffusion to and from the atmosphere, photosynthesis by aquatic plants and respiration by the entire aquatic biological community. Oxygen is the most common limiting factor to fish life.

Aquatic fish species breathe best when DO concentrations are near saturation. As DO concentrations decrease, fish are stressed and their immune function may be compromised. DO concentration of 5 mg/l or greater should be maintained for normal fish culture.



## Common water quality problems and corresponding management techniques

### Low-alkalinity water and acid sediments

Liming can often solve problems with acid-base relationships in fishponds. Waters with alkalinity of less than 25 mg/l often need liming. Application of liming materials is not a type of fertilization. Liming may be best viewed as a remedial procedure, necessary in some ponds to permit the normal responses of fish population to fertilization and other management procedures.

Finely grounded limestone (<0.25 mm) has a high neutralizing value, thus, is the first choice for fishponds. Quicklime or slaked lime used in large quantities cause the pH to increase damaging the fine tissues coating the gills, thus causing the death of fish.

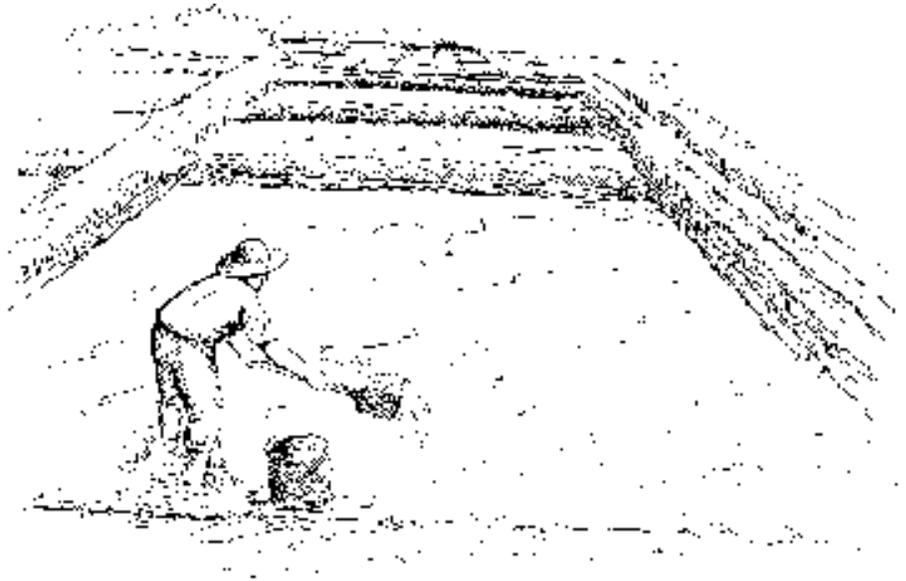
## Liming rates

Application rates for lime are based on the efficiency rating of the liming material and its neutralizing value. Lime requirement of bottom mud can also be based on pH and texture of mud.

Application rates of lime in different pH and types of soil			
Mud pH	Lime requirement (kg/ha of CaCO <sub>2</sub> )		
	Heavy loam or clay	Sandy loam	Sand
<4.0	14,320	7,160	4,475
4 - 4.5	10,740	5,370	4,475
4.6 - 5.0	8,950	4,475	3,580
5.1 - 5.5	5,370	3,580	1,790
5.6 - 6.0	3,580	1,790	895
6.1 - 6.5	1,790	1,790	0

## Liming methods

1. Broadcasting / spreading at pond surface
2. Soil incorporation
3. Pump system – for hydrated lime
4. Platform spreading
5. Piling along shallow water edges of ponds and distributed by wind action



## Effects of liming

### Desirable effects

- High pH in mud and water stimulates microbial activity and rates of organic matter and nutrient recycling increase.
- Total alkalinity increases after liming because of greater concentration of bicarbonate, carbonate and hydroxide. An increase in total alkalinity, caused mostly by bicarbonate, results in increased concentration of CO<sub>2</sub> which is available for plant use.
- Fish food organisms increase.
- Production of benthic organisms increases.

In ponds with low concentrations of organic matter, the addition of readily decomposable organic matter during the liming application will hasten the dissolution of liming materials and the stabilization of water quality. The precipitation of colloidal materials in the water (following liming) may produce turbidity and

encourage the growth of underwater weeds.

### **Undesirable effects**

- The immediate insolubility of descending lime may cause phosphorous to react with sinking lime. As a result, P is lost from the solution.
- Appreciable levels of CO<sub>2</sub> cannot exist in the water when pH rises.

## **Turbidity**

Turbidity is a term that refers to the suspended dirt and other particles in water. Two sources of water turbidity are clay particles and plankton. Clay turbidity (abiotic) usually imparts brown color into the water while plankton turbidity (biotic) gives green/yellow green/brownish/yellow green color.

### **I Clay turbidity**

Clay turbidity may come from surface runoff and the disturbance of sediments by bottom-feeding fishes. This type of turbidity can be a problem, especially in shallow ponds. The dirt and particles prevent sunlight from reaching the plankton limiting their capacity to produce oxygen. Moreover, clay particles can block fish gills, hampering respiration.

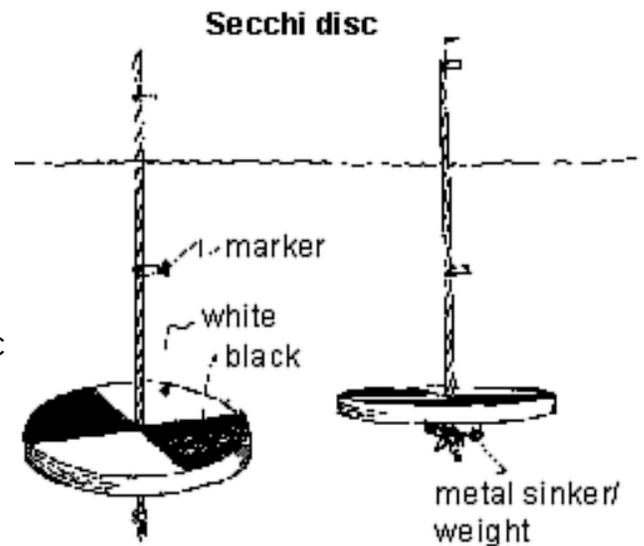
### **I Measures to control clay turbidity**

Bales of hay may be scattered to clear up the water surface. The hay will help settle the mud particles. They can be removed easily from the pond edges. However, the method should not be used in hot weather because the hay will decay very quickly and will begin to use up oxygen in water. This method applies only to small ponds.

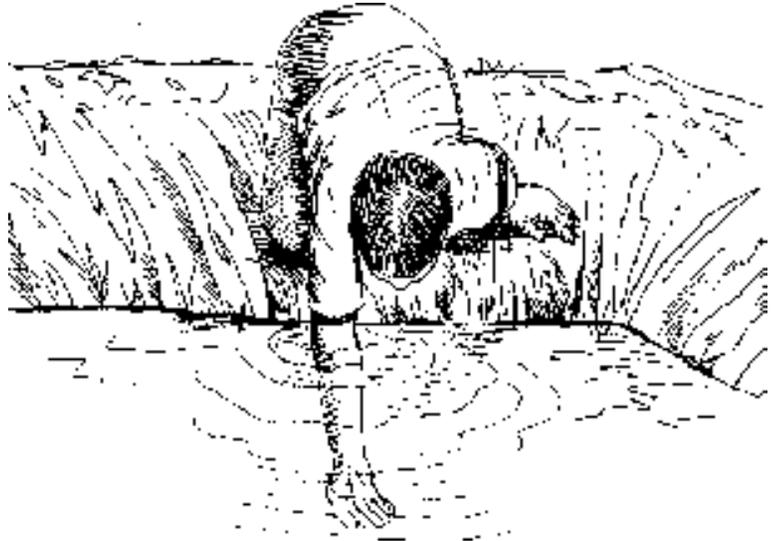
Organic manure at the rate of 2,440 kg/ha can also be used to control clay turbidity.

## Plankton turbidity as an index of natural food productivity of the pond

Plankton turbidity is measured using a device called **Secchi disc**. When the disc goes into the water, it will sink straight down and disappear from sight at some depth. If the disc disappears at 30 cm depth, the pond contains enough natural food (mainly phytoplankton). Secchi disc visibility (SDV) depth of more than 30 cm is an indicator that there is not enough natural food and that the pond needs fertilization.



Productive tilapia ponds usually has a SDV depth between 10 to 30 cm. If SDV depth is less than 10 cm, this means that there is too much phytoplankton in the pond and there is a good chance of a die-off that may lead to DO depletion.



Turbidity can also be measured without a disc, but this requires experience. The farmer stands in the pond and sticks his arm under the water. If his hand disappears then the water is not too turbid. If the arm disappears before the water reaches the elbow, the water is either turbid or very productive. If the entire arm -- from hand to shoulder -- can be seen, then the water is not too turbid nor it is very productive in phytoplankton. High biotic turbidity (phytoplankton) is an indication of very fertile water that is highly conducive to DO depletion due to high phytoplankton respiration rates and die-off.

## Poor dissolved oxygen

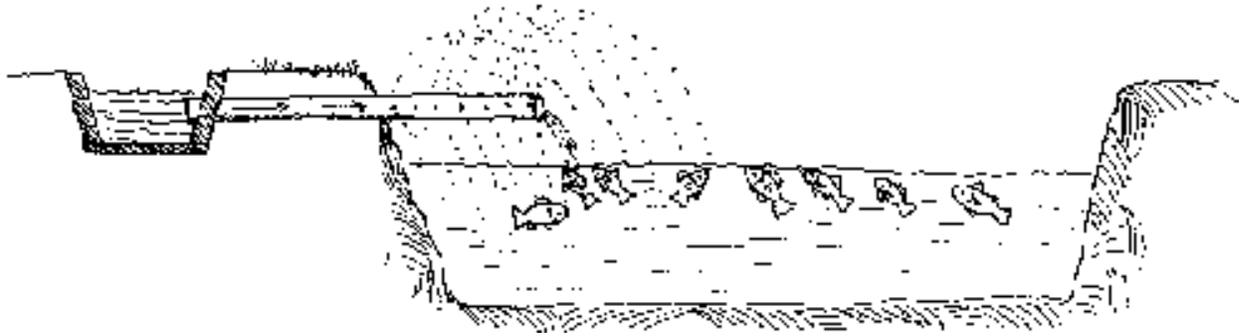
Once the DO drops to a dangerously low level, fish show signs of distress. When fish are seen gasping for air at the surface of the water, particularly in the morning, it is an indication of low DO concentration in the pond.

One of the techniques to prevent DO depletion is by aeration or circulation of pond water. By employing aeration in intensive fish culture, production can be markedly increased. The economics, however, of employing aeration in fishponds should be

considered. Some of the emergency techniques are flushing and mechanical aeration.

## Gas toxicity (Nitrogen and H

2S)



Aeration of water tends to dissipate toxic gases from the water into the atmosphere. Another management technique is to allow new water to flow into the pond in order to dilute the "old" water containing the toxic gases.

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Prepared by:  
**Arsenia G. Cagauan**

## Lake and Reservoir-Based Systems

[Pen Fish Culture in Shallow Freshwater Lakes](#)

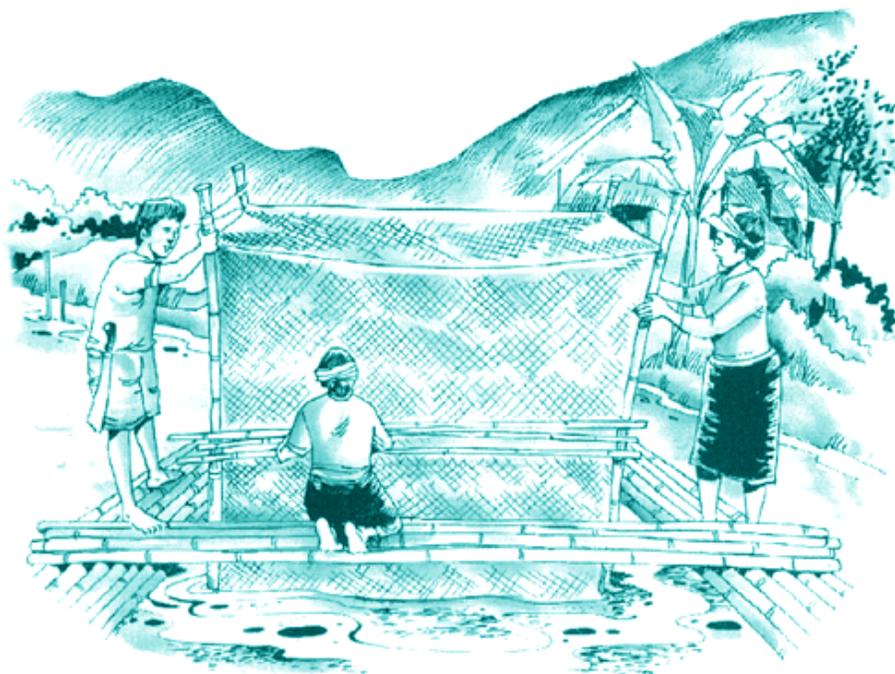
[Pen and Cage Culture in Philippine Lakes](#)

[Integrated Development of Floodplain Wetlands in India](#)

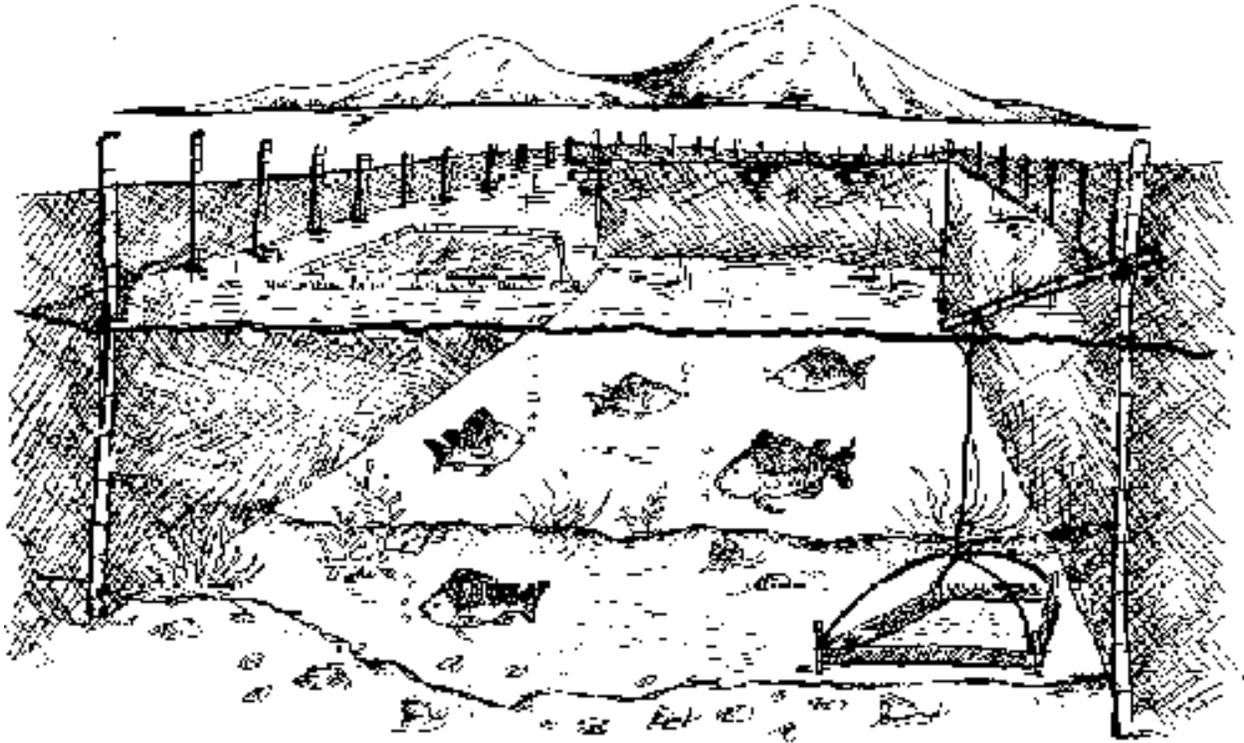
[Freshwater Cage Culture of Chinese Carps](#)

[Low-Cost Cage Culture in Upland Areas of Vietnam](#)

## Lake and Reservoir-Based Systems



# Pen Fish Culture in Shallow Freshwater Lakes



Shallow freshwater lakes are a very important resource in China. Since the mid-80s, development of fisheries in shallow freshwater lakes has attracted the interest of the government. Different kinds of resource enhancement and aquaculture approaches and techniques were tested and adopted in different types of shallow freshwater lakes, aimed at improving the income levels of fishermen and rural communities around the lakes.

Although effective increases in fish production through the protection of natural fish resources and stocking of artificially produced seeds in many inland lakes can be achieved, such approaches depend entirely on natural productivity. The fish yield is often influenced by managerial factors, especially the ability to control fishing activities in the water bodies. Moreover, these approaches become much less effective in larger natural water bodies.

## Advantages

Pen fish culture has some unique advantages when compared with other aquaculture systems and enhancement strategies.

- It can maximize the fish production in large lakes where it is difficult to raise the fish yields in the whole water body due to factors such as fisheries management or limitation of the natural environment. Annual fish production of 5-10 mt/ha can be easily attained.
- It is feasible as a family-scale operation because it requires relatively low capital investment.
- It effectively utilizes the natural food organisms, such as aquatic weeds and benthic animals.



However, pen fish culture, introduced to inland freshwater lakes in China two decades ago, has proven to be a very effective way of growing more fish in large shallow freshwater lakes. It is suitable for both large and family-scale operations. In Jiangsu province, where pen fish first started in China, fish pen area has exceeded 10,000 ha in 1999.

## Culture technology

Compared with other aquaculture systems, pen fish culture involves the

use of simple technologies. The major technical aspects are discussed below.

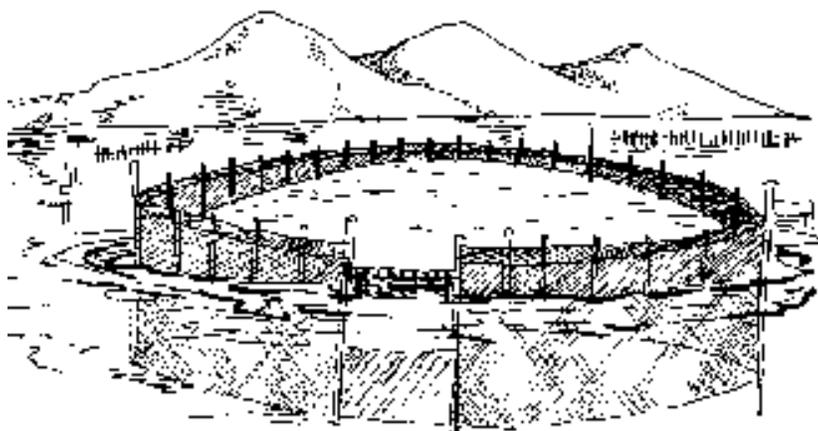
### Site selection

Selection of site for fish pen installation significantly affects the output of the operation. Among the most important factors for consideration are:

- appropriate water depth (3-5 m);
- relatively stable water level, mild current is desirable; and
- bottom with little silt and absence of emergent aquatic weeds/plants are favorable for constructing fish pen.

### Setting up fish pen

A fish pen's function is to keep the fish in a confined area to facilitate feeding and other management operations. Suitable sizes of fish pens for single-family operations are 0.3-0.5 ha.



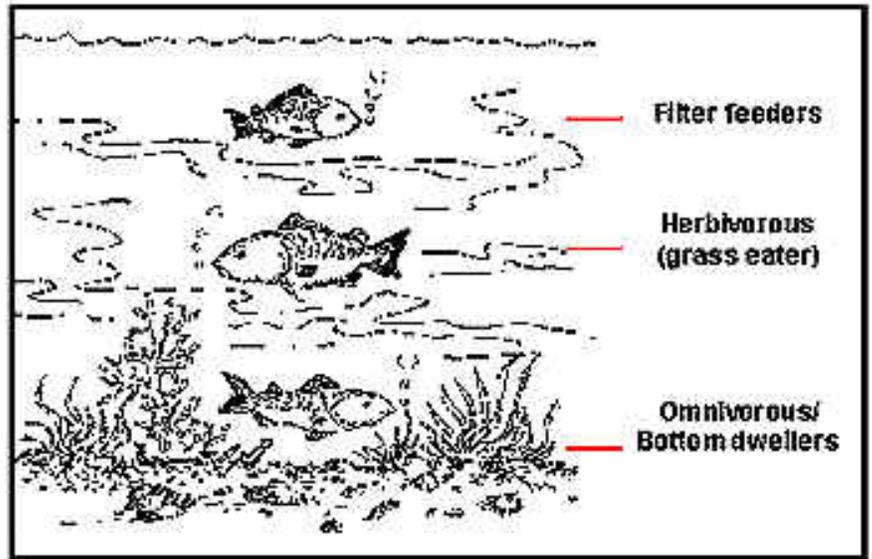
Bamboo and polyethylene netting are common materials used in building a fish pen. Ready-made netting or bamboo screen is fixed to the bamboo posts driven 0.5-1 m deep into the bottom soil to form a circular or rectangular enclosure. The mesh size of the net or bamboo screen should be small enough to prevent fish from escaping.

Round fish pens use less materials per unit area.

The top of the fish pen should be 0.5-1 m above the expected maximum water level. The bottom should be buried 20-30 cm into the soil using a weight or sinker (stone/gravel bag or iron chain sewed to the bottom of the net or screen) to prevent fish from escaping beneath the net or screen. The pen enclosure should have a gate to allow the boat to go in and out the pen for production operations.

### Suitable fish species and stocking

Polyculture is commonly practiced in fish pens. Herbivores, such as grass carp (*Ctenopharyngodon idella*) and blunt snout bream (*Megalobrama amblycephala*); omnivores, such as common carp (*Cyprinus carpio*) and crucian carp (*Carassius auratus*); and filter feeders, such as silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*) can be cultured within



one fish pen. However, the species composition should be carefully determined depending on the availability of natural food. On the average, herbivorous fish account for 60-80%; omnivores, 20-30% and filter feeders, 10-20% of the total stocking weight.

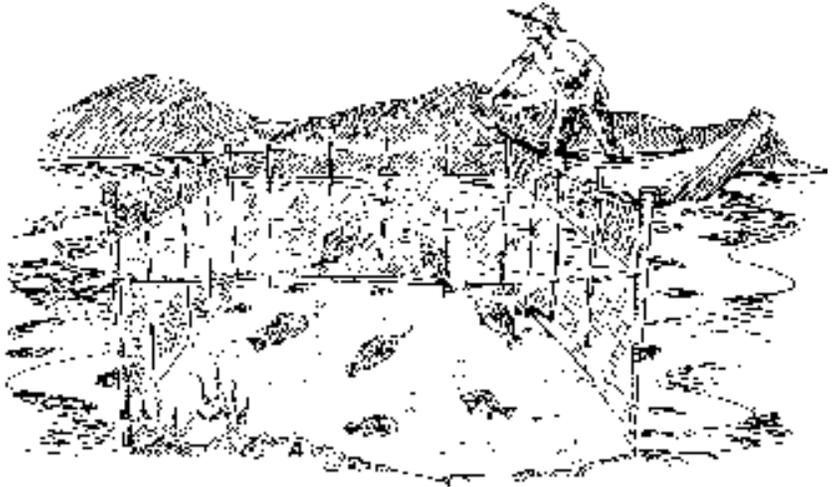
Recently, species of higher value like mandarin fish, Chinese mitten-handed crab, giant freshwater prawn (*Macrobrachium rosenbergii*) and local freshwater prawn (*M. nipponensis*) have become important species for culture in pen in some areas. The economic return is significantly higher, although it also involves higher cost in seed or feed, or both.

To achieve high survival rates and greater fish weight during the culture period, large size fingerlings are recommended for stocking in pens. The stocking size is normally 25-250 g depending on the species. On the average, fish stocked in pens gain five to ten times their body weight during the eight to ten months of culture period. The body weight gain is mainly affected by temperature and availability of feed.

The stocking time depends on the supply of seeds so it is advisable to stock early, whenever fish seeds are available.

### Feeding

Day-to-day regular feeding is very important to ensure good fish growth. A feeding frame (for floating feeds such as weeds and grasses) and a submerged feeding tray (for artificial feeds such as hard pellets) should be installed in the pen. It allows the farmers to monitor the feeding of fish and remove leftover feeds.



Farmers are advised to use locally available natural food to reduce production costs. They are encouraged to collect aquatic weeds and mollusk from the same water body to feed the fish inside the pen. When artificial feeds are used, farmers are encouraged to acquire a small pellet formation machine to make farm-made hard pellets with oil cakes, wheat bran and rice bran and other locally available raw ingredients. Pellet feed causes less pollution to the water because of reduced loss of feed when compared with the direct use of these raw materials.

The quantity of feed should be adjusted according to the temperature and weather, and increased according to the growth of the fish. During good weather and under high temperatures, more feed should be added.

## **Harvesting**

Several types of fishing gears are used for harvesting in the pen. Gill and casting nets are used in partial or selective harvesting during the culture period. In addition, seining is carried out for total harvest by the end of the production season.

## **Production and economic return**

Seeds and feeds account for the largest proportion of production cost in pen culture. In large-scale production, fish production ranges from 3,000 to 10,000 kg/ha. The annual economic return from pen culture ranges from US\$ 1,500 to 3,000/ha.

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## **Pen fish culture in Gehu Lake: A Case Study**

Gehu Lake is a typical shallow freshwater lake with abundant aquatic weeds. It is located in Jiangsu Province in the lower reach of the Yangtze River. The water surface area of the lake is approximately 16,400 ha. An integrated approach involving pen culture, protection of natural fishery resources and conservation of

environment has been carried out since 1991. Pen culture has played a major role in achieving higher fish production from the lake.

Pen fish culture in Gehu Lake employed two major stocking models. In the first model both blunt snout bream and grass carp were used as major species, whereas Chinese bream is the only major species in the second model. Stocking of filter feeders in fish pens is relatively low because the whole lake already has silver and bighead carp in the open area.

Stocking of fish in pen culture of Gehu Lake by weight (%)		
	Stocking model 1	Stocking model 2
Blunt snout bream	54-62	90-95
Grass carp	19-37	0-7
Silver carp and bighead	4-7	3-5
Common carp and crucian carp	1-9	-
Black carp	3-4	-

Favorable environmental conditions has made the practice of pen culture in Gehu Lake very successful. The rich aquatic weeds ensure good water quality and food source. The culture models used are suitable for the environmental conditions and natural resources of the lake. [Herbivorous fish -- grass carp and Chinese bream -- are the major culture species.]

Development of pen culture in Gehu Lake by 1994					
<b>Pen culture area = 3,075 ha, 18.75% of whole lake area</b> <b>Annual fish production = 9,138 tonnes, 79.8% of total fish production from the lake</b> <b>Production value = US\$ 11.55 m, 74.3% of total value of fish production from the lake</b> <b>Employment = 2,462 workers</b> <b>Fish production/worker = 4,000 kg</b> <b>Production value/worker = US\$ 4,600</b>					
Item	Quantity (kg/ha)	Cost (yuan*/ha)	Products	Quantity (kg/ha)	Value (yuan*/ha)
Fish seed					
Size I (250-1,000 g)	909	5,974	Table fish	2,721	26,637
Size II (50-100 g)	150	1,372	Fish seed	864	5,902
Size III (25)	0.3	106	Other		4,282
Pellet feed	6 300	10,100	Total	120	36,821
Weed and grass	193 590	-			
Facility depreciation		2,154	Gross profit	3,705	15,189
Management		559			(US\$
Other		1,367			1,834)
Total		21,632			

\*Exchange rate: 8.28 yuan = US\$ 1.00

## Constraints and concerns for future development

Despite the advantages of pen culture in shallow freshwater lakes, there are several constraints and concerns that should be taken into account in future development.

- Pen fish culture is operated in natural open water. It is, therefore, susceptible to some natural hazards such as floods and typhoon that might cause serious damage to the fish pen and financial losses. Good site selection and close supervision can help minimize the possibility of such damage.
- Poor planning and management of culture operations can damage the natural environment and affect the other important functions of the lake. To avoid such adverse impacts, natural food from the lake should be used. When commercial feed is used, the quality and quantity should be well controlled to minimize pollution caused by feed wastes.
- There should be a very strict control on the expansion of pen culture area according to the type and character of the lake.
- Farmers around the lake do not have the same access to lakes compared to fishpen holders. Measures should be taken to minimize or avoid conflicts between farmers involved in pen culture and those who are not.

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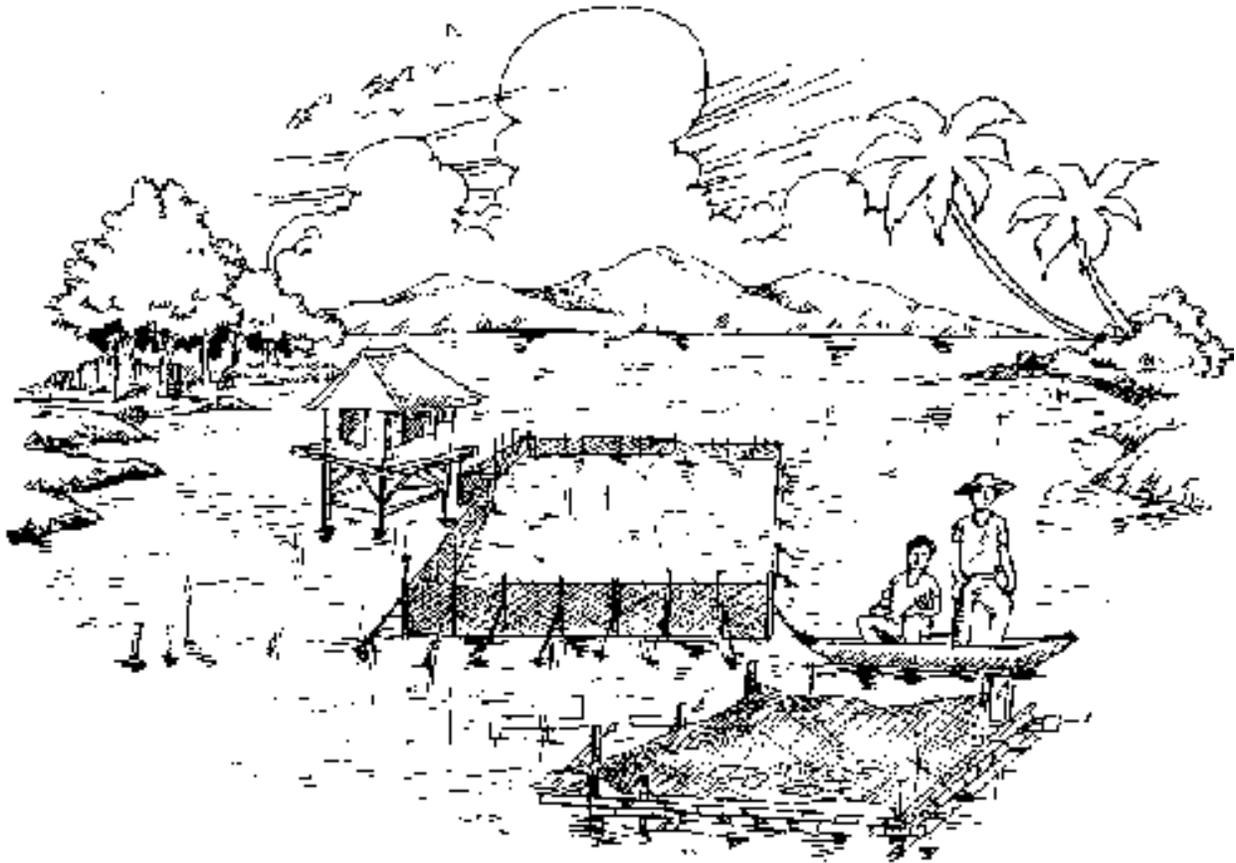
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# Pen and Cage Culture in Philippine Lakes

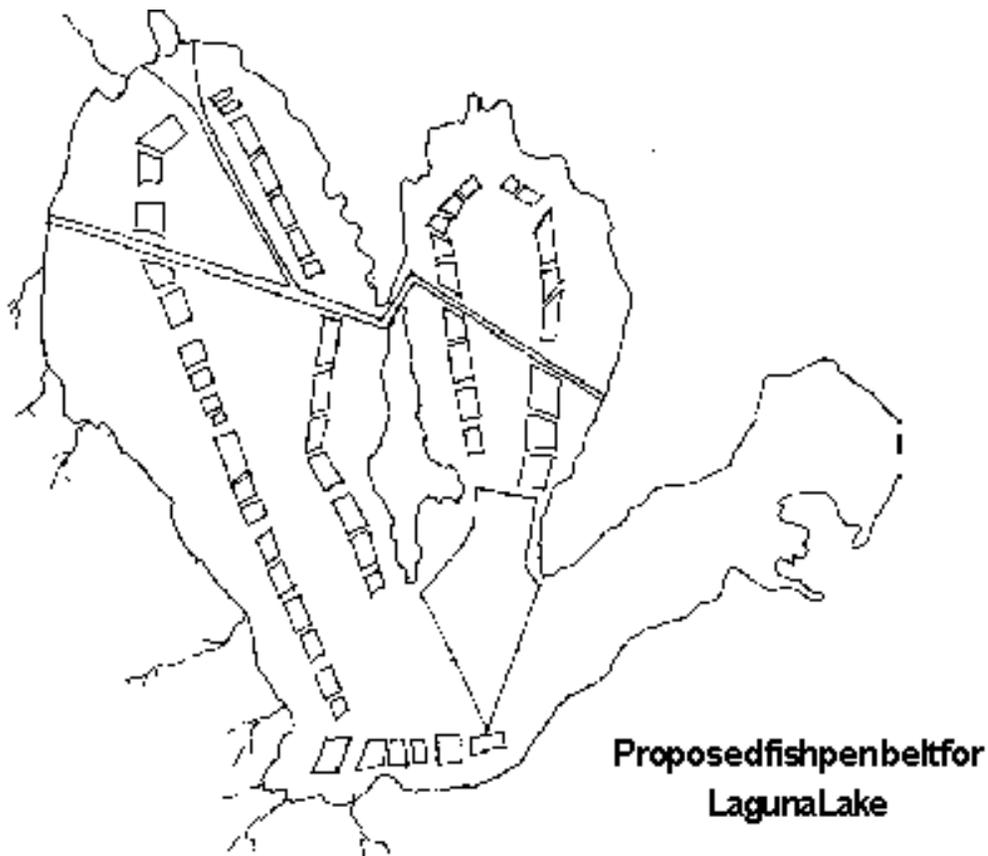
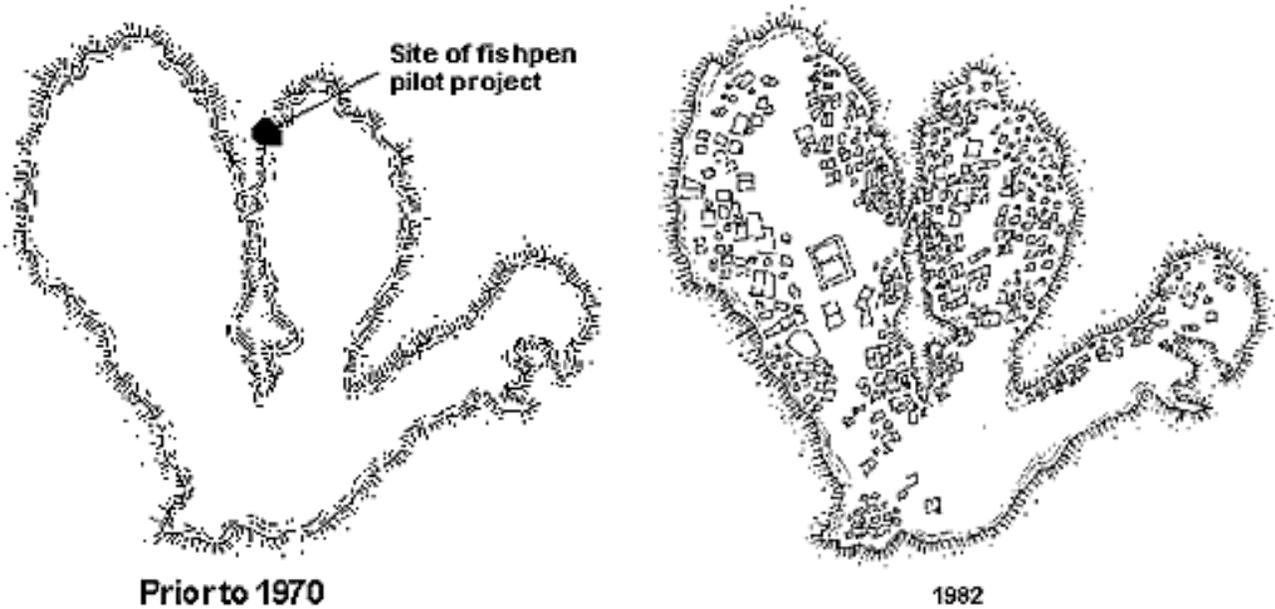


Pen and cage culture systems have existed for nearly three decades, both on commercial and small scale, in Philippine lakes particularly in Laguna de Bay and in the seven crater lakes in San Pablo City. Likewise, Taal Lake has attracted investors in cage farming. Milkfish (*bangus*) is the most popular species for pens, while Nile tilapia is most preferred species for monoculture in cages. This article discusses two cases and the lessons learned from these two sites.

## Laguna de Bay

Laguna de Bay is a shallow (3.0 m), 90,000-ha lake, the largest in the Philippines. The overall responsibility for water resources management of the lake belongs to the Laguna Lake Development Authority (LLDA). In 1970, LLDA initiated fishpen culture that proved that milkfish production could be sustained with the use of natural food (phytoplankton), which was seasonally abundant in the lake, and that fish yield could be increased 3.5 times over that in open water, a potential profitable enterprise for poor lakeshore families. LLDA offered the fishpen technology to the fishermen under a cooperative scheme but it was not readily accepted because of initial capital constraints and satisfaction with the open water catch i.e., goby (*Glossogobius giurus*), perch (*Therapon plumbeus*), carp (*Cyprinus carpio*) and catfish (*Arius manilensis*, *Clarias macrocephalus* and *Clarias batrachus*), reaching 80,000-82,000 tons in 1961-1964. This prompted businessmen, politicians, and even

ranking military officers to go into fishpen culture which then spread rapidly. Fishpen operators became a potent and very influential bloc. Under LLDA regulation, no corporation could have more than 50 ha of fishpen concession. However, influential investors managed to circumvent the regulation by putting up interlocking corporations actually controlled by the same people. The chaos was aggravated by fishpen permits issued by municipal mayors of lakeshore municipalities without coordination with or reference to LLDA's zoning or master plan. From 5,000 ha in 1973, fishpen area expanded to 31,000 ha in 1982. Stocking density ranged from 25,000 to 100,000 milkfish fingerlings/ha.



The proliferation of fishpens resulted in socio-economic problems affecting both pen operators and marginal fisherfolk. Milkfish rearing period was stretched to 8-15 months. The annual yield dropped from 4 t/ha in 1973 to 2 t/ha in 1982. Moreover, the fishpen production was 62,000 tons and, from the remaining two-thirds of the lake open to the small fishermen, 19,000 t for a total yield of 81,000 t. This was clearly equivalent to the yearly catch in 1961-1964 when there were no fishpens in the lake.



To the environmentalists, fishpen did not contribute to the total finfish production of the lake. The reduced catch not only prejudiced the more than 15,000 families of small fishermen, but also affected those engaged in snail collection and duck-raising. Congestion of fish pens blocked the movement of water hyacinth (*Eichhornia crassipes*) in navigational lanes, hindering the movement of fishing and commercial boats. Access to open waters became difficult for the small fishermen, who were accused of poaching. As a result, confrontations between the poor fisherfolk and the affluent pen operators were reported.

To assist the fisherfolk, a project funded by the Asian Development Bank, the Organization of Petroleum Exporting Countries (OPEC) and the government was launched through LLDA in 1988. The project extended sub-loans to 1,550 poor fishermen for the development of 550 fish pen modules covering 2,500 ha. The project, however, failed because of the long grow-out period for fish resulting from the lake's declining productivity. The typhoons also wiped out many fish pen modules shortly after completion. Overall, poor fishermen have not benefited yet but the loans must be repaid.

## Lessons learned

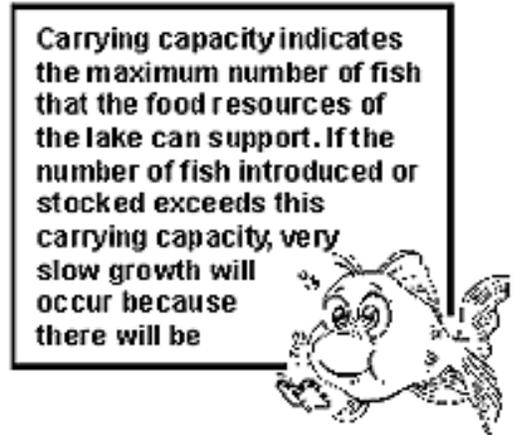
### 1. Proper management and political will

The conflict of jurisdiction over the lake between the lakeshore municipalities and LLDA was resolved by the Supreme Court in favor of LLDA. In 1996, a new master plan for a fish pen belt was approved by former President Fidel Ramos, which effectively reduced the area for pens to 10,000 ha and provided more open area for fishermen. Fish pens outside the belt were demolished or relocated. Under the

new administration, the implementation of the fishpen belt has yet to be evaluated.

## **2. The carrying capacity of lakes should be considered in aquaculture planning**

One of the mistakes in the past was to attribute fish yields (tons per hectare) to the water areas covered by the pens and cages. It was not taken into account that water circulates in and out of fish pen and, hence, fish production was a result of a wider feeding area beyond the enclosures. In a 1991 evaluation, a hectare of fishpen stocked with 60,000 milkfish fingerlings required a food supply area of about 12 ha. Therefore, the reported yield of 4 t/ha actually meant 4 t/12 ha of lake area. Adding more fishpens, therefore, meant exceeding the carrying capacity of the lake.



## **3. Stakeholders' awareness of the ecological events of the lake is important**

Laguna de Bay undergoes two important limnological behaviors, which affect fisheries. First, is the regular occurrence of high turbidity due to strong winds and second, seawater intrusion when lake level recedes to the average low level of Manila Bay. As a consequence of high turbidity, the phytoplankton becomes scarce but as sea water backflows to the lake, settling of suspended matter and clearing followed. Phytoplankton production is stimulated and the lake turns green in color with algal bloom formation – an abundance of natural food welcomed by pen and cage operators and fishermen. The government, however, began pursuing the use of Laguna de Bay as source of domestic water supply in the new millenium. The back flow of sea water had to be prevented through the operation of a hydraulic structure endangering the food web of the lake. Strong opposition from the fishery sector forced the government to study other options to preserve the multipurpose use of the lake.

## **Sampaloc Lake**

Sampaloc Lake is 104 ha, the largest of the seven crater lakes of San Pablo City. Due to an average depth of 20 m, the lake exhibits thermal layering in summer and overturn or upwelling in the cold months of December to February.

Floating cage for tilapia culture (10 m x 10 m or 20 m x 5 m) was introduced in 1976. It expanded to 33 ha in 1991. The operators of the cages are small holders. The problem started when cage culture expanded to 6 ha (tilapia fingerlings raised to market size in about 13 months); in 1986, the fishfarmers started using commercial

feeds at a rate of 187 t/ha for three crops a year. For a collective area of 33 ha, about 6,000 t of feeds were dumped into the lake annually.

## **Lessons learned**

### **1. Cage culture with intensive feeding is a potential polluter of aquatic ecosystems**

Feed losses, fish feces and other organic wastes generated by the cage culture resulted in the progressive disappearance of dissolved oxygen, a high BOD5 load and almost lethal concentrations of ammonia and total sulphides. In 1990, unaware of what was happening in the bottom layers, the cage operators sustained their feeding by negotiating for a few million peso-loan from a bank. SEAFDEC researchers working on the lake warned the operators about the possibility of a fishkill due to a large volume of anoxic and toxic waters that had developed underneath the cages and advised them to harvest the stocks. The warning was ignored and a massive fishkill of market size tilapia occurred. Cage operators lost their investment and had to shoulder the payment of the loan.

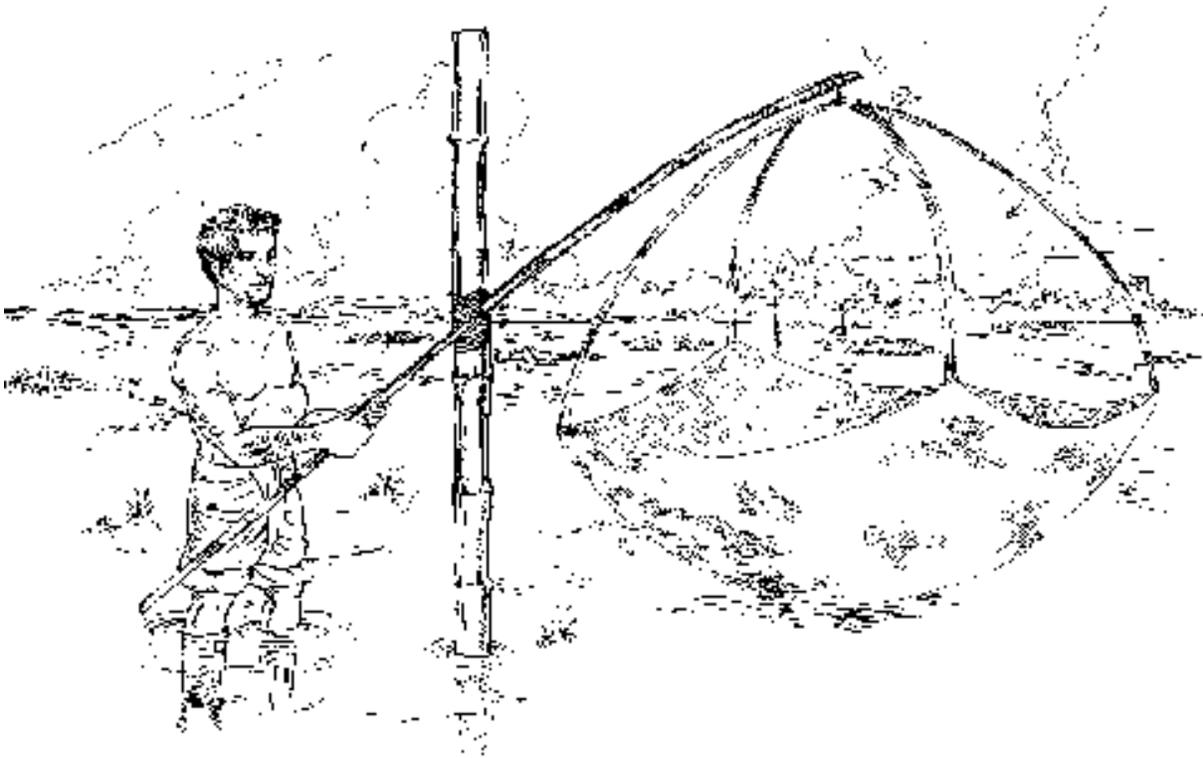
### **2. Regulate fish cage area within 10-12 ha. of the lake surface area**

A team composed of SEAFDEC researchers, the Seven Lakes Fisherfolk Federation, the Foundation for the Philippine Environment and the Nationwide Coalition of Fisherfolk for Aquatic Reform recommended to LLDA the implementation of a zoning map that will reduce cage area to only 10-12 ha. (The scientific basis for the allocated area is not clear – just a rule of thumb.)

## **Taal Lake**

Taal Lake is the third largest lake in the Philippines with a total area of 24,356 ha. It is one of the cleanest lakes with dissolved oxygen still high in deep layers. The lake has an endemic species, the freshwater sardine (*tawilis*). To date, tilapia cage culture occupies only 0.19% of the surface area of the lake. Stocking density for a 10 m x 10 m x 5 m cage is about 10,000 tilapia fingerlings. Since the lake is not eutrophic, natural food is low requiring feeding for the culture. The impact of cage culture with intensive feeding in a congested area is beginning to show through the slow disappearance of dissolved oxygen in the water column. It is hoped that we have learned from the two previously mentioned lakes. The other impact to be monitored is the effect of the escaped tilapia on the population of the endemic species. The once scenic lake viewed from Tagaytay City is affected by the increasing number of floating cages that are beginning to look like floating debris.

# Integrated Development of Floodplain Wetlands in India



Floodplain wetlands constitute a group of lentic water bodies associated with the floodplains of Indian rivers, known by different local names such as *beels*, *chairs*, *mans*, *boars*, *hoars* and *pats*. They are usually cut-off river meanders (oxbow lakes), tectonic depressions, back swamps or sloughs, covering a total surface area of more than 200,000 ha spread over the eastern and northeastern regions of the country. Floodplain wetlands in India support subsistence and commercial capture fisheries, practiced by the local fisher communities.

## **Multiple uses of wetlands and resulting conflicts**

Although fishing is the main economic activity in the floodplain wetlands, a wide range of other activities like irrigation, agriculture, duck rearing, post harvest activities, navigation and washing, are closely linked to these water bodies, making them a lifeline of rural West Bengal and Assam. Traditionally, these different activities have been carried out in harmony but in recent times, conflicts between agriculture and fisheries have become evident. Agriculturists would like to reclaim and convert as much lake area as possible into agricultural fields. A similar, though smaller, conflict exists within the fisheries segment -- among the intensive aquaculture, capture and culture-based fisheries. Attempts were made by the Central Inland Capture Fisheries Research Institute (CIFRI) to harmonize the various developmental activities by advocating an integrated approach.



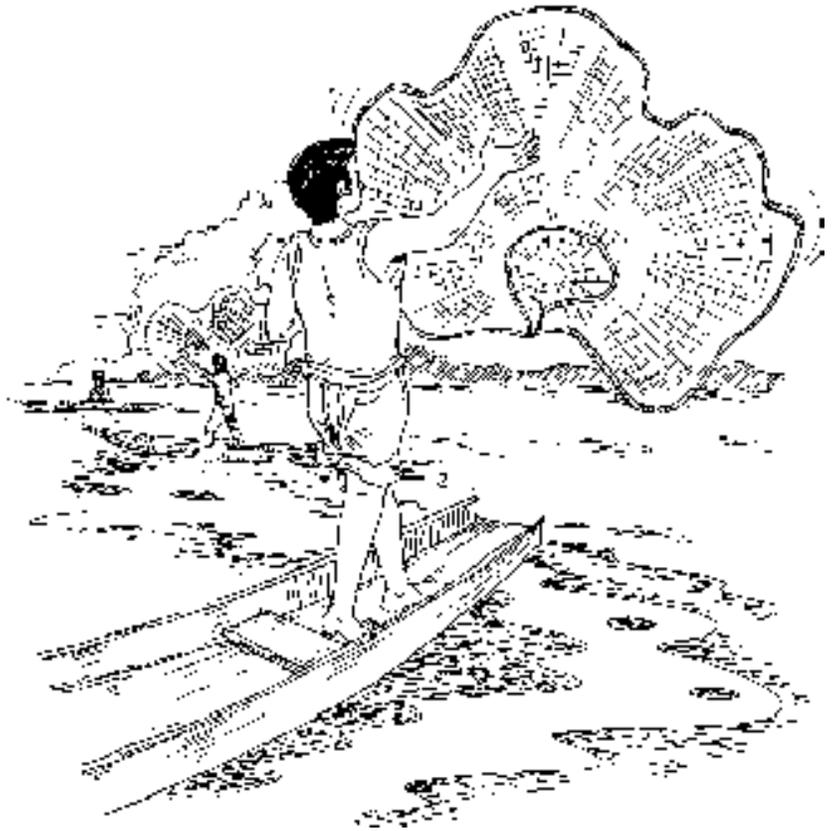
# Importance of capture fisheries in floodplain wetlands

Continuous water renewal from rivers helps maintain capture fisheries in the open lakes on a sustainable basis. Encouraging fishery based on the wild stock of fish is essential for two main reasons:

## 1. Maintaining the supply line of different species

In India, there is growing discontent among the fish consumers over the dominance of major carps in the fish market. With the steady flow of *catla* and *rohu* from large-scale aquaculture farms in the State of Andhra Pradesh, consumers have become species conscious.

Consumers seem to be bored with the once coveted Indian major carps. Today, in all the major inland fish consuming states like West Bengal and Assam, local fish species (*Anabas testudineus*, *Clarias batrachus*, *Heteropneustes fossilis*, *Gudusia chapra*, *Aspidoparia morar*, *Amblypharyngodon mola*, *Ompok pabo*, *Labeo bata*, *Puntius* spp. and *Channa* spp., to name a few) have become more expensive. It is a common complaint in these states that the local species of fish are too expensive, so it is essential to keep the supply line of these species intact by retaining the capture fishery. In this context and considering the need to address the loss of biodiversity, capture fishery of the open floodplain wetlands assumes importance.



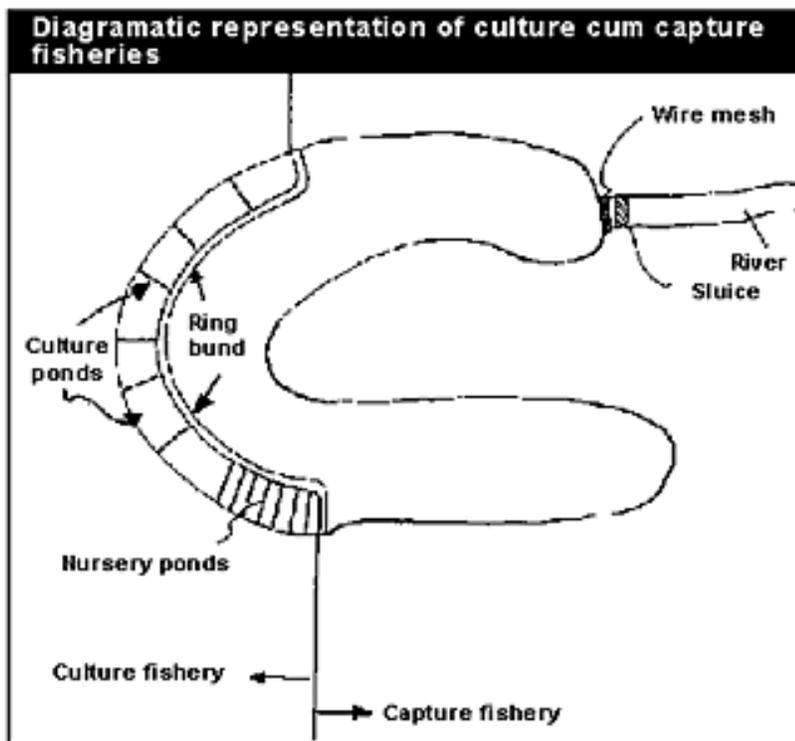
## 2. Protecting the interests of traditional fishers

Capture fishery is equally important in protecting the interests of traditional fishers who depend on fishing for livelihood. There is a growing tendency to convert the open waters into intensive aquaculture systems in coastal, mangrove and other wetland ecosystems. This is leading to many social conflicts. The traditional local fishers (often landless) are generally deprived of their right of access to common property resources. If alternative employment is not provided, their livelihood will be adversely affected and an already impoverished section will become poorer.

## Augmenting the capture fisheries

In order to increase production from the lakes, some culture practices can be easily incorporated without disturbing the existing practice of capture fisheries. A system of combining capture fishery and aquaculture has been developed by the CIFRI, which is practiced widely in the eastern and northeastern states of India.

Under this system, a series of small enclosures are created along the periphery of the lake to be leased out to entrepreneurs for aquaculture. These enclosures can be made of earthen dikes (sometimes strengthened with water hyacinth removed from the lake) or bamboo mat barricades. Some of the enclosures can act as nurseries to rear fish seed both for aquaculture and stocking. When culture-based fishery is practiced, the connecting channel should be protected with wire mesh to prevent the stocked fish from escaping.



### Caution!

- Where there is undue demand, the carrying capacity of the flood plain should be studied to avoid eutrophication. If allowed to grow unchecked, this will disturb the hydrodynamics: the water quality will be affected leading to negative impact on other water users.
- The ponds (pens) should be stocked only with indigenous species. Exotic species when introduced, can stray into the main lake and then to the rivers. This disturbs the species-balance and biodiversity.

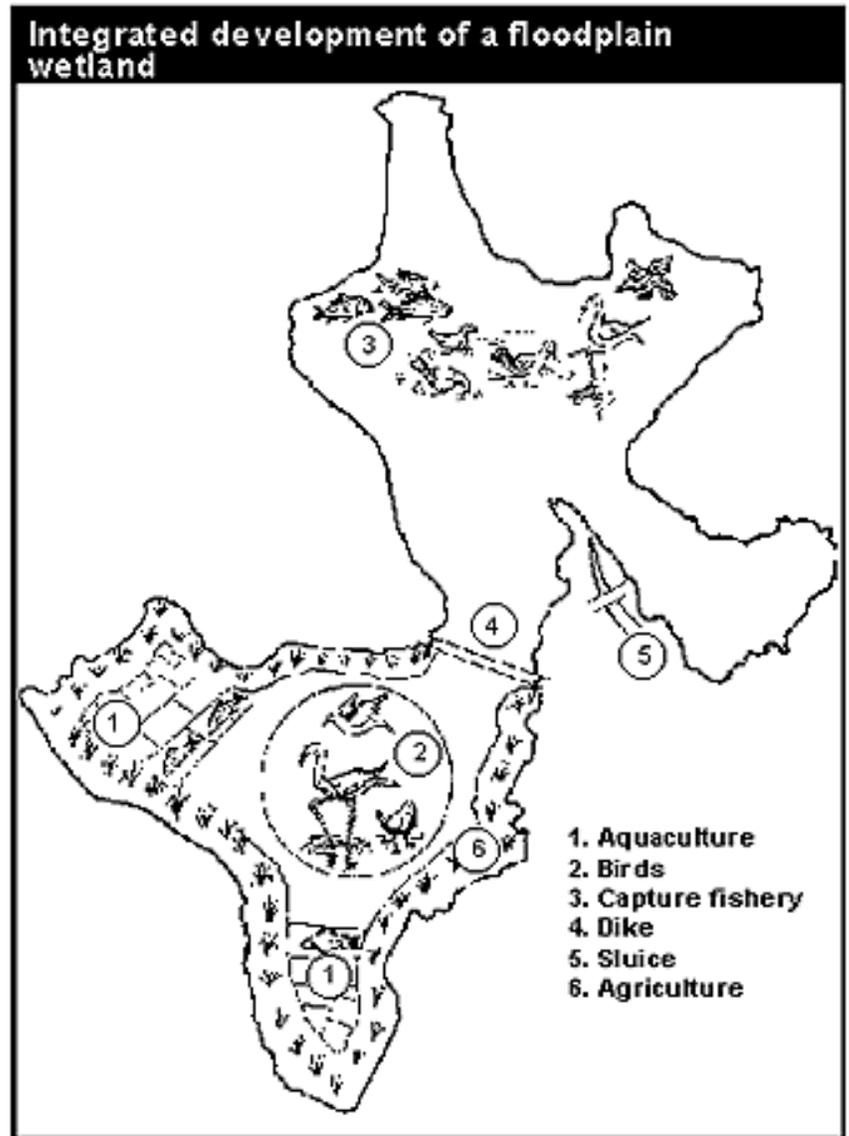


## Integrated systems

Floodplain wetlands and areas along their margins already tend to become swamps: converting these marginal areas into paddy fields is a common practice among relatively resource-rich farmers. The lake area consequently shrinks. Fishers get marginalized in the process. This is a very common cause of conflict among the various water users. As some of the lakes serve as bird sanctuaries, environmentalists are often cautious about competing uses. The floodplain wetlands are used for a variety of other purposes such as navigation, jute retting, collection of edible aquatic mollusks and plants. Each activity affects other water users.

A plan has been developed to integrate the many uses of floodplain wetlands and minimize conflicts. The current example refers to a plan drawn for a floodplain wetland in West Bengal, India, which has a swampy southern portion and a relatively deep northern portion, where the river connection exists.

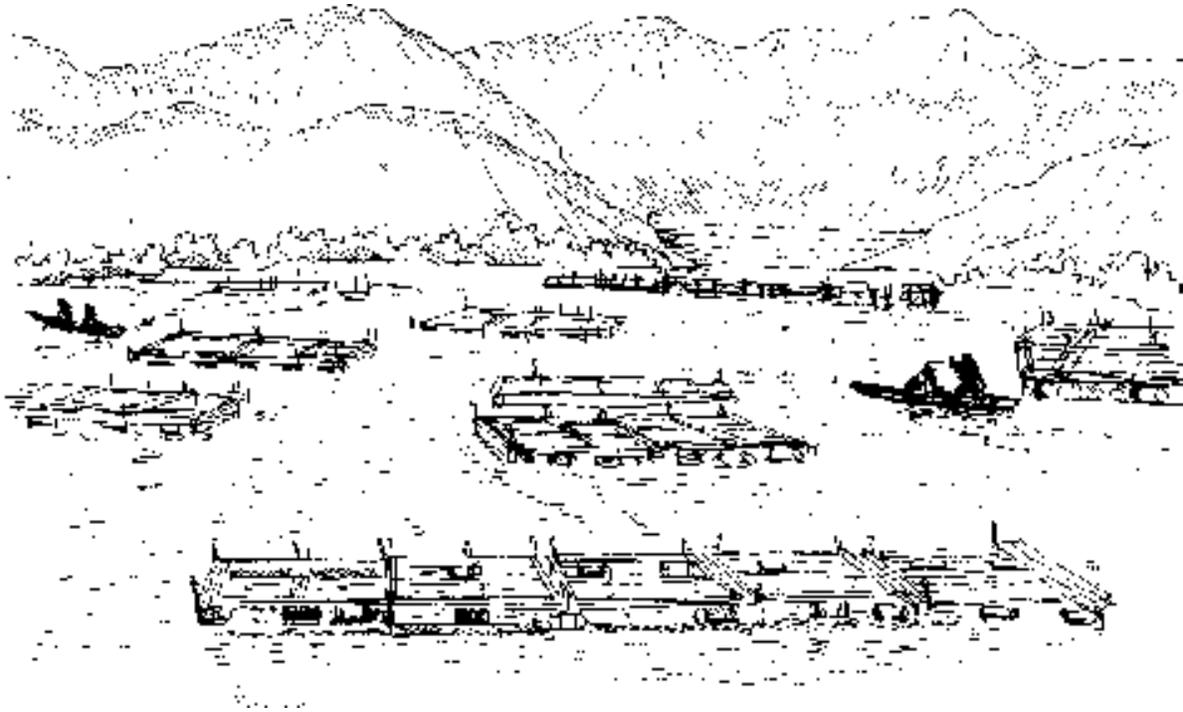
The integration plan envisages developing agriculture and aquaculture in the southern portion, while leaving the northern part for capture and culture-based fisheries. There will be a dike separating the two segments of the lake and water flow to the agriculture and aquaculture activities in the southern segment will be regulated through small canals. A central marshy portion of the southern segment will be left to attract the migratory and local birds, which frequent the place. However, the long-term effects of this type of development on the hydrodynamics and natural biological productivity of the lake are not adequately assessed.



## Conclusion

- Capture fishery should be maintained in as many open lakes as possible to keep up the supply line of different fish species into the market, conserve fish biodiversity and ensure the security of livelihood of traditional fishers.
- Fish production in the beels can be increased to meet growing demands by carefully incorporating some culture methods.
- Conflicts that arise among various water users in the floodplain wetlands can be resolved to some extent by planning various activities through an integrated approach.

# Freshwater Cage Culture of Chinese Carps



Modern cage culture was introduced in China more than two decades ago. The techniques have spread widely across the country with varying degrees of adaptation to local conditions. Gradually, cage culture became one of the major aquaculture systems in the country. It has contributed remarkably to the improvement of living standards, ensuring food security, generating higher income and creating additional jobs. Cage culture of carps retains its importance in socio-economically disadvantaged areas in particular.

Cage culture is very suitable to a wide range of open freshwater bodies, especially reservoirs. It may involve some risks of loss (fish escape, typhoon and flood, etc.) and require moderately high quality of artificial feeds in intensive culture.

## Advantages of cages

- Properly located and installed cage provides desirable environment conditions for the growth of fish.
- It makes efficient use of water body, hence, reduces the pressure on other resources.
- It makes good use of the natural productivity of a water body (in the case of growing filter feeders).
- High stocking density and high yield are achievable (extrapolated per unit yield 10-100 times higher than earthen pond).
- Daily management and monitoring are relatively easy.



## Advantages of carps for cage culture

- Carps are native to the country.
- Local market demand is high due to a tradition of carp consumption, despite its relatively low price.
- Mature hatchery technology ensures the supply of quality seeds that are widely available at large quantities and low prices.
- Carps are low in the food chain or trophic level, thus, carp culture has less impact on the environment.
- Variations in the feeding habits of carps allow polyculture in cages with little or no competition for food between species. It gives farmers a wide range of choices regarding the level of intensity of culture. Carps accept many types of artificial or supplementary feeds.



Some non-technical aspects have to be considered in developing cage culture. Fish culture is usually not the primary or high-priority user of a water body such as a reservoir. Development of cage culture is often influenced by the primary use or purpose of the water body, such as irrigation, navigation, water passage for flood control, etc. Some open waters of sightseeing or recreational value allow the release of fingerlings only and no other aquaculture activities or inputs. Cage culture with artificial feeding is discouraged or totally prohibited in reservoirs or lakes that are primarily sources of drinking water. On the other hand, growing filter feeders like silver carp and bighead are encouraged. These could help in harvesting nutrients by feeding on the plankton.

## Water bodies suitable for cage culture

Generally, water bodies for carp culture should be suitable for cage installation: water quality should meet the general requirements set by the *National Standard of Water Quality for Fisheries*. For example, the pH value should be 7.0 – 8.5 and the dissolved oxygen should be above 5 mg/l for at least 16 consecutive hours in 24 hours of monitoring and not less than 3 mg/l for the rest of the time. Other considerations include the flow/movement of water, site accessibility, etc. Inland waters used for cage culture include reservoirs, lakes, rivers, streams and canals, etc.

## Produce from cages

### Culture of large size carp fingerlings (also called yearling) in cages

- From small fingerlings (about 3 cm) to large size fingerlings (50-100 g)
- Usually in reservoirs and lakes. Large size fingerlings are produced for stocking in cages for the following year or for release into the lake or reservoirs, depending on the nature of the operation.

## Culture of food fish in cages

- From large size fingerlings to marketable size.

## Culture of food fish and fingerlings in same cage

- Fingerlings and yearlings are stocked in cages at the same time. Marketable-sized fish are harvested for selling at the end of culture cycle. The yearling grown from fingerlings continue to be cultured the next year but with a new batch of fingerlings.

## Major carp species for cage culture in China

### Filter feeders

Silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*) are typical filter feeders. These two species feed mainly on phytoplankton and zooplankton, respectively. They are suitable for culture in relatively fertile water rich in plankton. They occupy different feeding niches and therefore, could be stocked in the same cage. Feeding is not applied in cage. Polyculture of silver carp and bighead in cages could yield up to 8 kg/sq m if the water is abundant in plankton. However, the market value is relatively low.



Silver carp



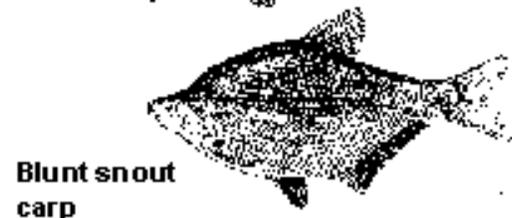
Bighead carp

### Herbivorous carps

Grass carp (*Ctenopharyngodon idella*) and blunt snout bream (*Megalobrama amblyocephala*) are foraging species. Their natural food is aquatic plants but they will also eat terrestrial grasses, vegetables and pellet feeds. Grass carp is famous for being voracious and is a fast grower. Blunt snout bream grows moderately fast but its marketable size (300-500 g) is much smaller than grass carp (1.5 kg above). The market prices of these two species are higher than those for silver carp and bighead.



Grass carp



Blunt snout carp

### Omnivorous carps

Omnivore carps include common carp (*Cyprinus carpio*) and crucian carp (*Carassius auratus*). They



Common carp

also feed on pellet feeds. Common carp can fetch a moderately high price, especially in northern China. Crucian carp is a bony fish favored by consumers in some provinces.

### Other indigenous carps

Mud carp (*Cirrhina molitrorella*) from southern China and small scale fish (*Plagiognathops microlepis*) found in central and eastern China are cultured in cages as minor species. Their feeding habits are similar: feeding on leaves of plants, filamentous algae, detritus, epiphytic diatoms and some aquatic insects, etc.



Common carp



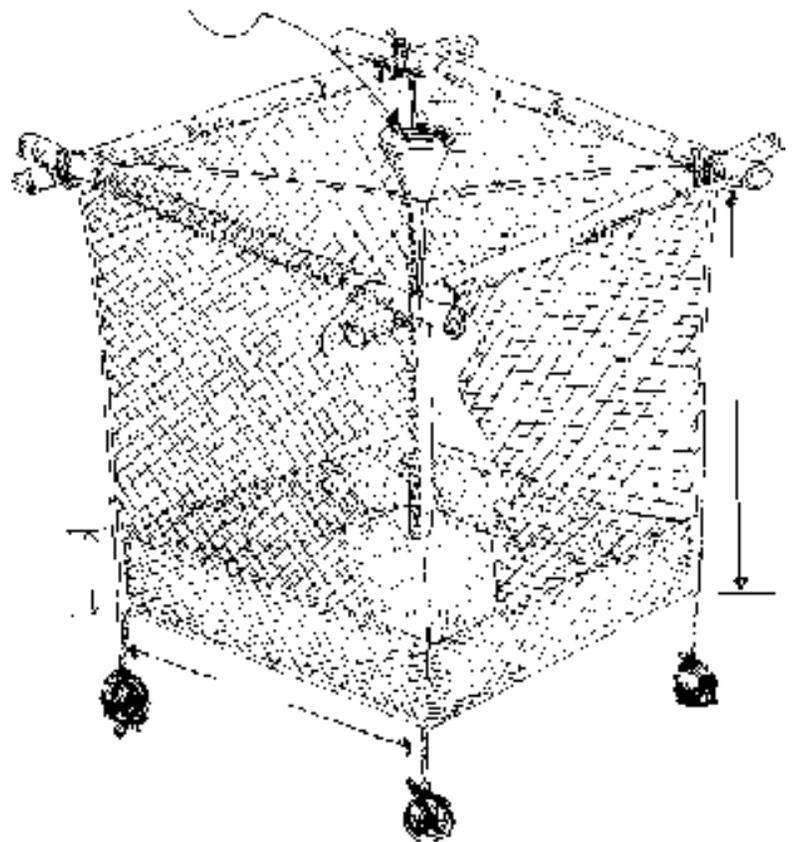
Crucian carp



Silver carp

### Types of cages used for carp culture

For freshwater fish culture, cages are designed and constructed according to the conditions of the locality and locally available materials. There is no strict standard for the type of cage to be used. The size of the cage ranges from 1 - 200 sq m, although the majority are between 1 - 30 sq m. The general trend is to use smaller cages for easy management and maintenance and better exchange of water. Individual cages are arranged in such a way that maximum water exchange is achieved. It is generally recommended that water exchange be completed in each cage within 0.5 - 1 minute.



In shallow waters, stationary cages are constructed for fish culture. On the other hand, floating cages are installed in deep lakes and reservoirs. The bottom of stationary cages should be 0.5 – 1.0 m above the bottom of the water. Depth of the cage is usually 1.5 – 2.5 m for lakes and 2 – 4 m for reservoirs.

Among locally available materials for cage construction, bamboo and ready-made polyethylene nets are commonly used. Such cages could last for three years.

Mesh size differs according to the purpose of culture. The mesh size for large carp fingerling culture is 1.0 - 1.5 cm. For grow-out culture, the mesh size depends on the size of seed to stock. An empirical equation for determining the net mesh size for cage culture of carps is widely accepted:

$$M = a \times L$$

**M** = stretched length of mesh (cm)  
**a** = factor, which differs among carp species  
**L** = total body length of fish for culture in the cage

Common carp, bighead and silver carp	a = 0.26
Grass carp	a = 0.21
Blunt snout bream	a = 0.40
Tilapia	a = 0.32

## Stocking

### Stocking for growing yearlings

Monoculture is recommended for yearling culture. Seed fish from nursery pond for culture in cages should not be less than 3 cm in length. Very fine mesh size is needed for constructing the cage if the fingerlings are too small. The stocking density (150-600 fish/sq m) depends on food availability (in the water) and targeted size of yearlings at harvest.

### Stocking for grow-out

Both monoculture and polyculture are employed for carp grow-out culture in cages in China. The smaller the cage, the higher the stocking density. With sufficient feeds available, the main factor limiting fish growth is oxygen and not fish density. Some, however, also suggest that high density of fish in the cage reduces fish movement, saving energy for growth.

Filter feeders (silver carp and bighead) of 100 g sizes are stocked at 1-3 kg/sq m. Ratio between bighead and silver carp largely depends on the composition of planktons in the water. There should be 50-60% of big head for stocking if the ratio of zooplankton to phytoplankton in the water is 1:1000. Bighead could be increased to 80% if the ratio is 2:1000.

For other carps, the culture is usually semi-intensive or intensive (in terms of feed input). A generally recommended stocking density is 5-10 kg/sq m for a cage of 20-40 sq m in size and 10-20 kg/sq m for a cage of less than 10 sq m. The uniformity of yearlings of the same species is important to achieve good results at harvest.

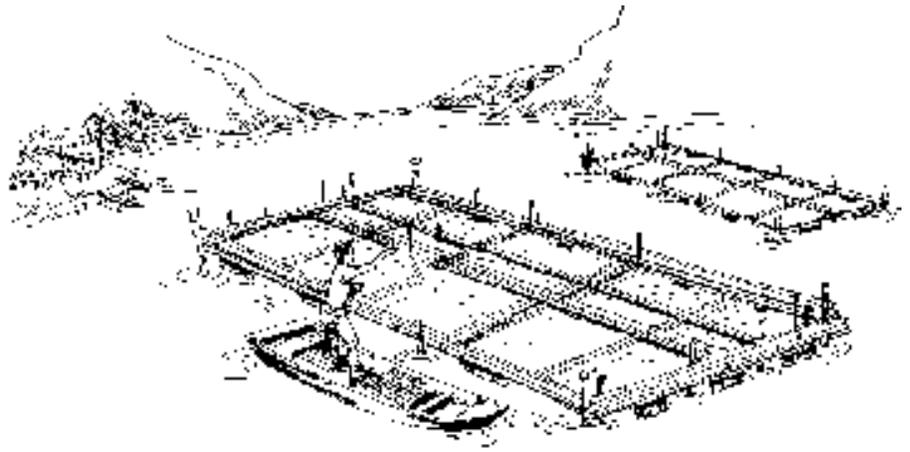
## Routine management

### Tip

Newly built cages should be left in water for about two weeks before stocking to allow the growth of some algae on the netting surface. It is considered helpful to reduce the injury of

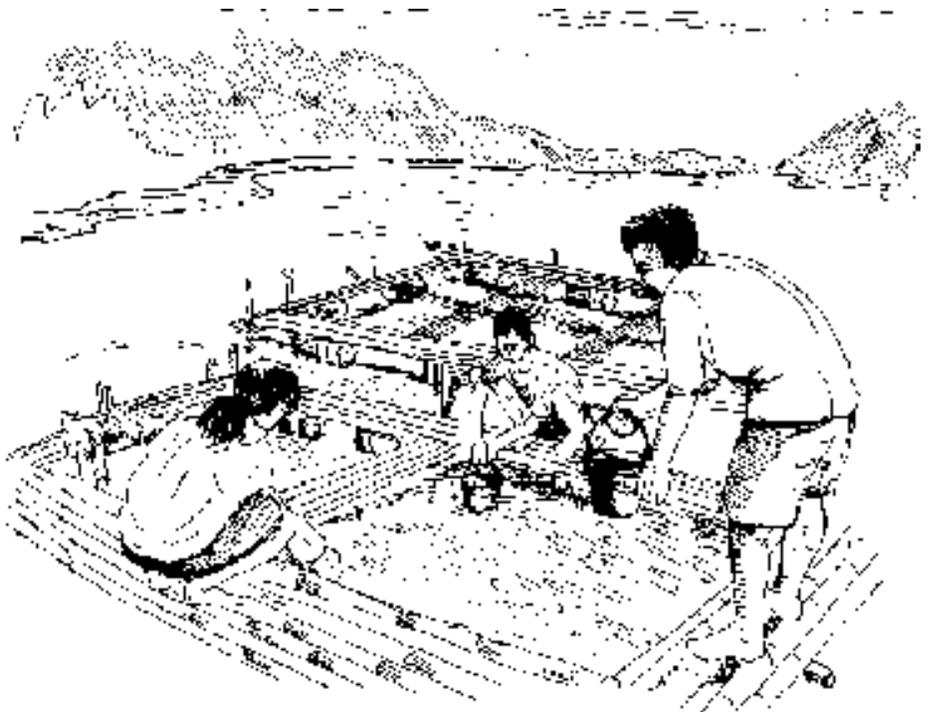


- Feeding (non-filter feeders) Constant supply of feed of good quality at reasonable cost is important to ensure technical and economic viability of carp culture in cages.
- Removal of leftover feed
- Regular inspection of cage
- Cleaning of net and removal of foul materials and organisms
- Avoiding cage damage during typhoons or floods by taking precautions
- Monitoring fish health and disease occurrence, apply medicines for disease prevention.



## Harvest and marketing

- Harvest in fish cages is relatively simple and easy.
- Careful handling is important to avoid injury to fish at harvest and during transfer to market.
- Fish wounds result in lower market prices. Dead fish fetches a lower price than live fish.
- Both partial harvest and total harvest can be applied to carp food fish culture in cages.
- Farmers or farmer groups should learn to collect supply and demand information to develop market strategies.

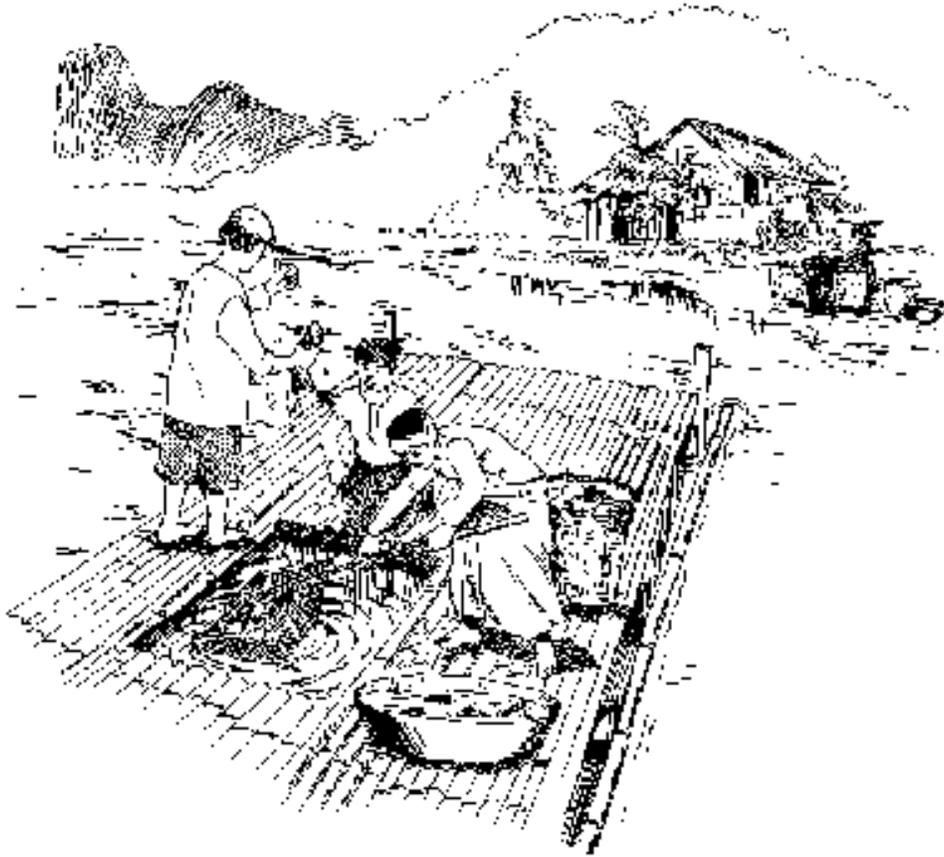


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Sifa, L. and J. Mathias (editor). 1994. Development of Aquaculture and Fisheries Sciences, 28. Freshwater Fish Culture in China: Principle and Practice. Elsevier

Prepared by:  
**Zhou Xiaowei**

# Low-Cost Cage Culture in Upland Areas of Vietnam



Cage culture is an intensive form of fish culture commonly practiced in rivers, lakes, streams, reservoirs and irrigation channels.

## Advantages

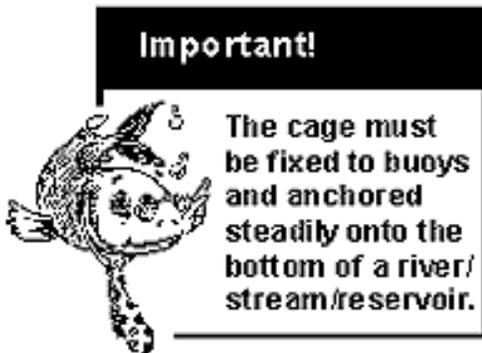
- Allows for high stocking density because of free flowing water.
- Locally available fish feed and material for making the cage.
- All members of the family can participate, including women and elders.
- Quick returns with high yields and profitability.

## Site selection

- Away from the impact of industrial wastes and other polluting agents such as domestic waste from backyard pigs.
- Away from river transportation routes.
- Velocity of water flow of the river/stream should be about 0.2 to 0.3 meters per second (mps) for best results.
- Area has clean, residual free unpolluted waste.

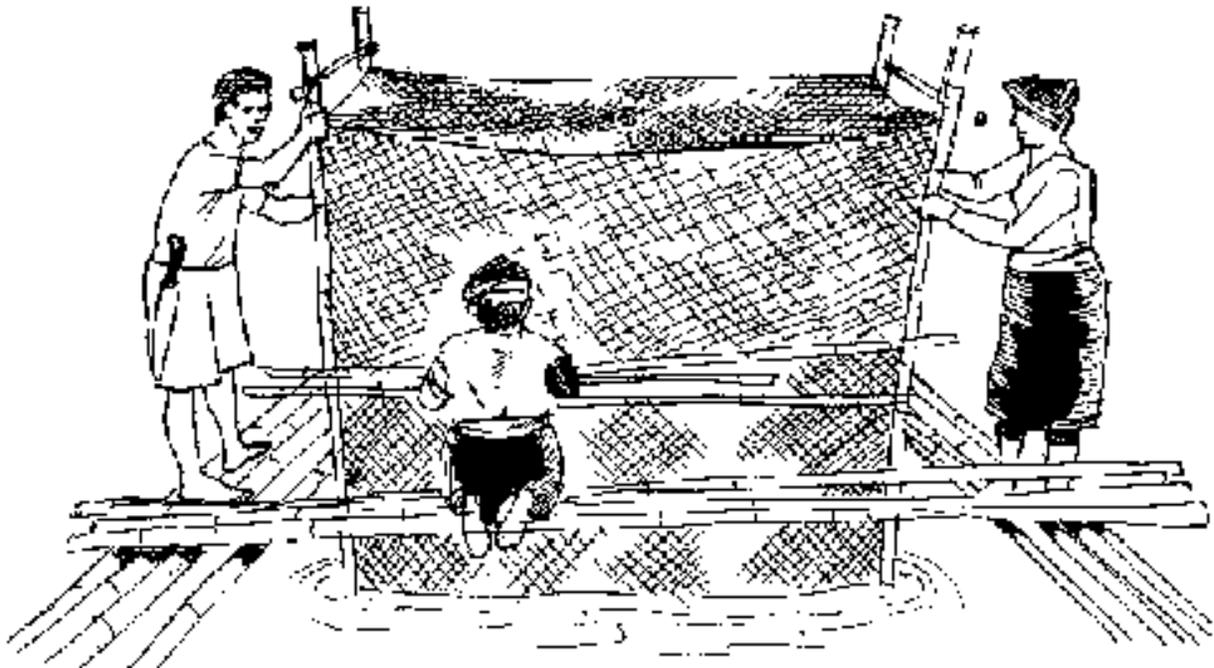
# Cage design

## Two main types



1. Nylon net cage with bamboo or wooden skeleton size 4 m length x 3 m width x 2 m height.

2. Bamboo or wooden cage size 5m length x 3m width x 1.6m height. The size of the cage depends on the water depth, velocity of water flow, materials used and capacity of the farmers.



## Placing cages

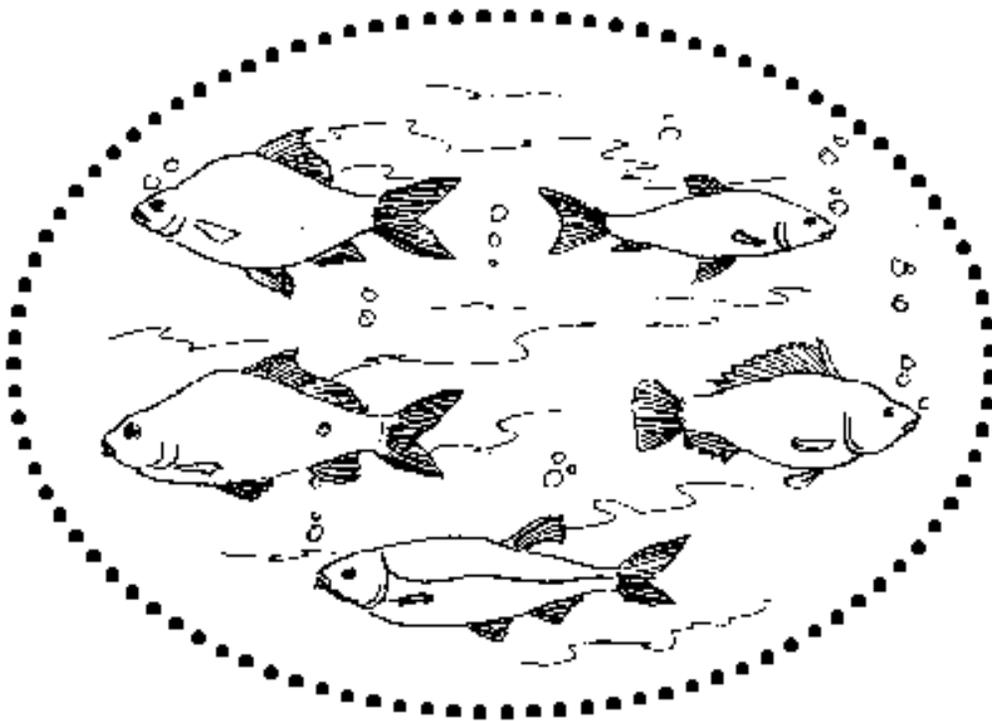
To avoid outbreaks of fish diseases, the distance between the cage bottom and sediment should be more than 0.5 m up to a distance determined by the depth of the water body.

Recommended distances between one cage and the next should not be less than 10-15 m. Distance between two groups of cages should be 150-200 m.

These recommendations have become regulations that are now enforced by government fishery advisors from the Fisheries Management Department after they discovered a fish disease problem in 1994 (due to the close proximity of cages).

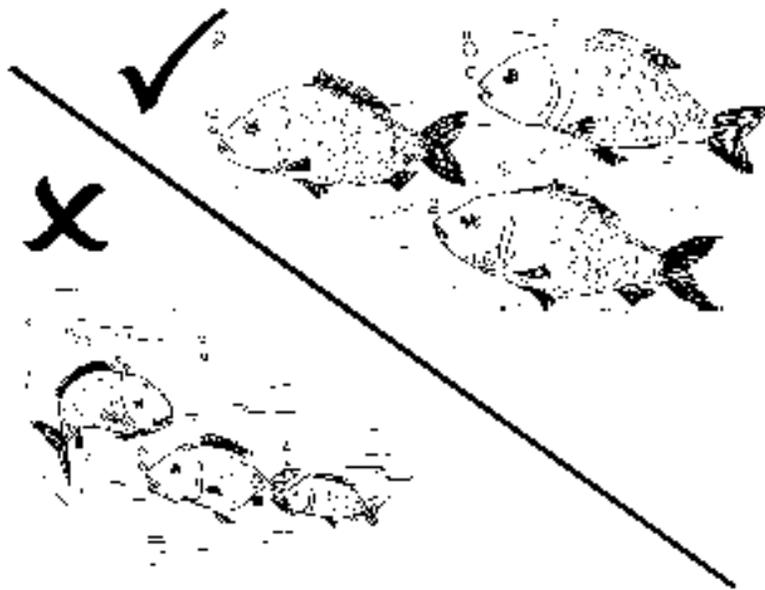
## Cultivable species

Chinese grass carp (*Ctenopharyngodon idella*), indigenous grass-eating carp (*Spinibarbythis denticulatus*), common carp and sometimes tilapia are the most popular species used for cage culture.



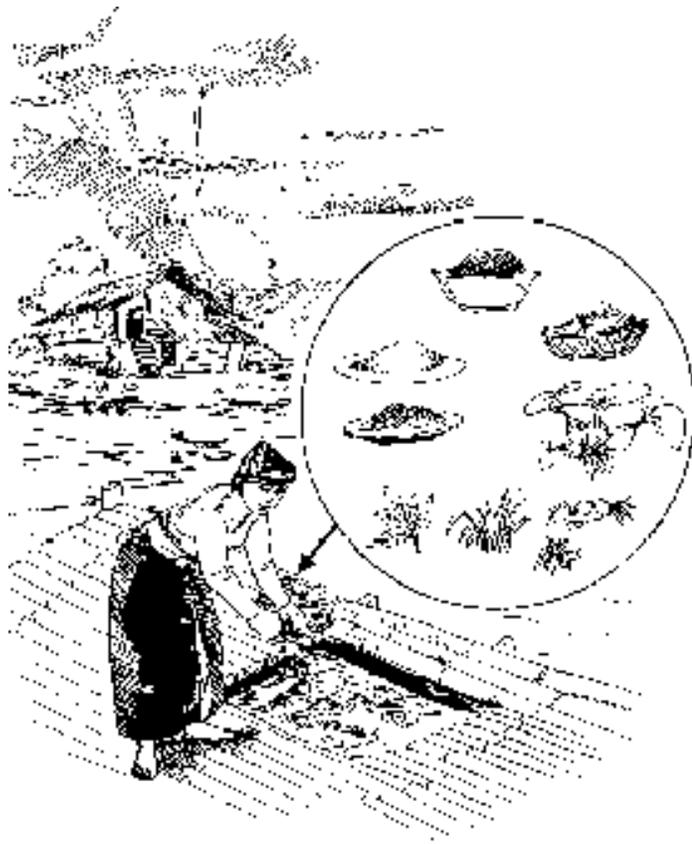
## Stocking density and size

- Vigorous and healthy seed of uniform size (150-200 g/fish) are preferred for stocking the cages.
- Stocking density is usually kept at 30-40 fish/m<sup>3</sup>



## Prophylactic treatment to prevent diseases

Before stocking, give fingerlings a bath in a 2-3% salt solution for two to three minutes to prevent outbreak of common parasitic and microbial infections.



## Care of cages

### Feeding

Feed fish with locally available grasses, vegetation and other easily available items, like garlic which contains disease prevention/control properties.

Most households produce feed as by-products of their daily activities: leaves of maize, cassava, banana, rice bran, sweet potato, duckweed, etc.

Initially, when the fish are small, chop grass and vegetation into small pieces for feeding.

*Nutrient rates:*

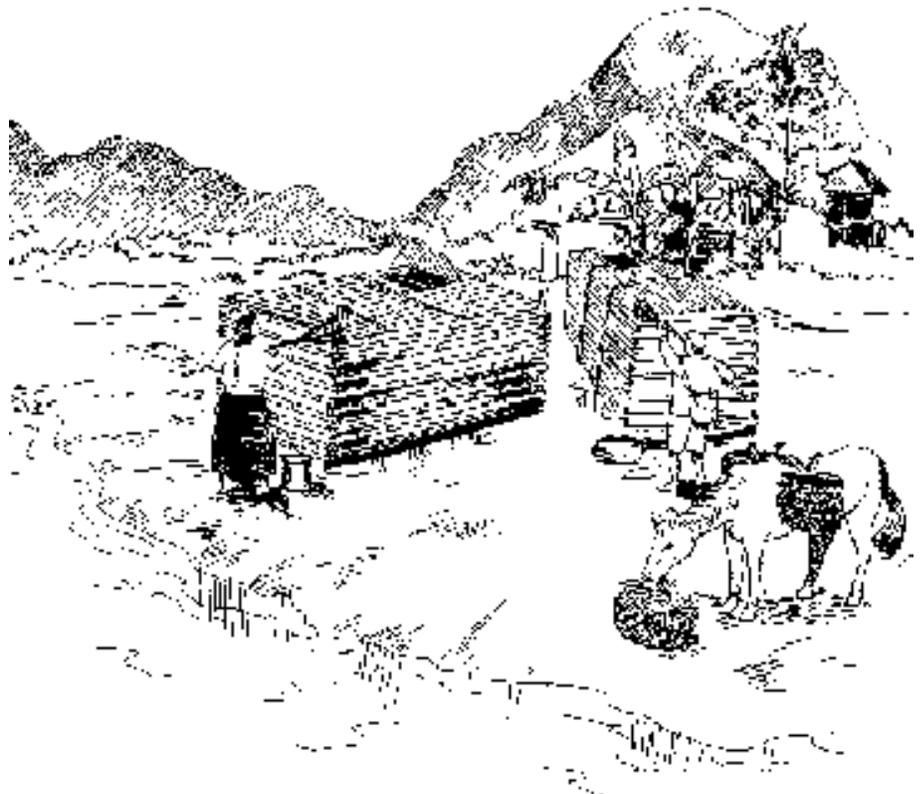
Green feed materials should be 20-25% (wet weight) and starch 1-2% of body weight per day.

### Cage cleaning

This is carried out before stocking and after harvesting.

Lift cages out of the water and brush them (in and out) using  $\text{Ca}(\text{OH})_2$  (Calcium Hydroxide) solution and leave them to dry under the sun for one to two days.

Clean the cages every week to remove all the dirt and waste stuck to the sides and bottom of the cage.



## Harvesting

After six to eight months, bigger-size fish are harvested first (3-4 kg) although depending on market price and demand, the rest can also be harvested.

Yields can be 500-800 kg/cage.

In Vietnam, during the "Tet" holidays, festivals, wedding season, consumption rises and prices increase, so it is a good practice to harvest fish then.

**Indicators of poor fish health include frequent surfacing.**

### Remember!

- Practice daily feeding.
- Never use rancid and spoiled feed.
- Monitor regularly and quickly follow up any irregularities observed. Some quick solutions include aeration (stirring to circulate and increase the flow of the water in the cage), moving infected cages 2 m away from the rest or adding feed of better quality and in adequate quantity. When the situation becomes serious, harvest the fish as soon as possible.



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Prepared by:

**Nguyen Huy Dien and Tran Van Quynh**

## **Brackishwater and Marine Systems**

[Community-Based](#)

[Rehabilitation of Mangroves](#)

[Mangrove-Based Small-Scale Shrimp Aquaculture](#)

[Estuarine Aquaculture Systems](#)

[Utilizing Coastal Wetlands for Small-Scale Aquaculture in Sri Lanka](#)

[Successful Small-Scale Mudcrab Farming Development in the Thai Binh Province, Vietnam: A Case Study](#)

[Management Practices to Improve Extensive Shrimp Aquaculture](#)

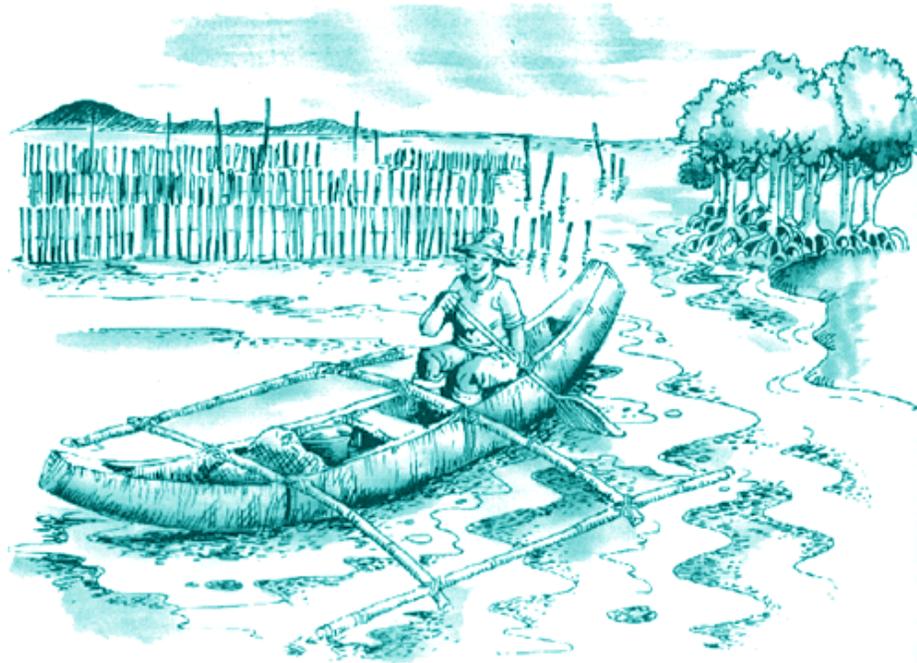
[Farmers' Methods of Oyster and Mussel Culture in the Philippines](#)

[Mud Crab Systems for Small-Scale Aquaculture](#)

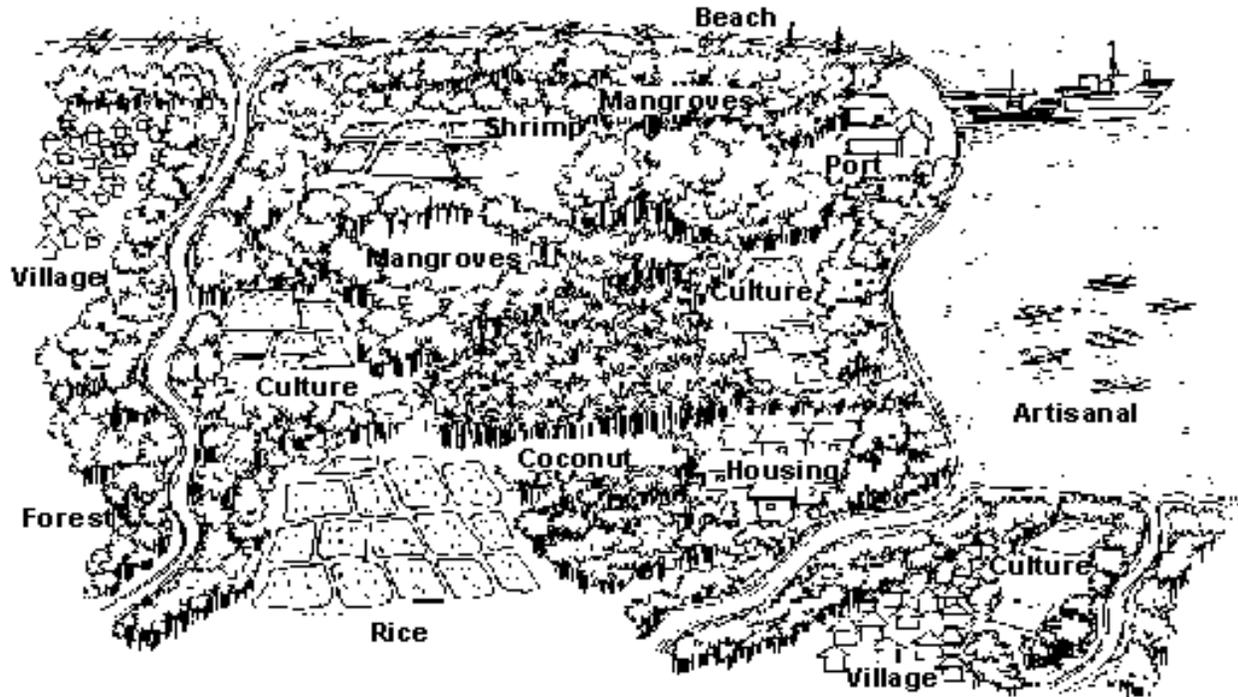
[Small-Scale Seabass Culture in Thailand](#)

[Coastal Aquaculture Options](#)

## **Brackishwater and Marine Systems**



# Community-Based Rehabilitation of Mangroves



Mangroves are intertidal communities of tropical and subtropical trees and shrubs growing in salt to brackish water and in predominantly muddy or sandy substrates, and protected coastlines. To cope with extreme conditions (of salinity, water saturation and desiccation and anoxia), mangroves have evolved a variety of coping mechanisms including prop roots, cable roots and salt glands.

## Facts

- Mangrove-associated fish contribute around 30% (1.09 million tons) of annual finfish resources (excluding fish bycatch) in the ASEAN region.
- Mangrove-dependent prawns provide almost 100% (0.4 million tons valued at US\$1.4 billion) of total prawn resources in the ASEAN region.
- A review of mangrove fisheries gives estimates of production and value (on a per ha per yr basis) respectively, of 257-900 kg and US\$475-5,330 for fish, 13-756 kg and \$91-5,292 for penaeid shrimp, 13-64 kg and \$39-352 for mud crab, and 500-979 kg and \$140-274 for mollusks.
- Conversion to shrimp/fish ponds, in addition to settlements, agriculture, salt beds, overexploitation and other factors, have led to high rates of mangrove loss ranging from 25% in Malaysia to 50% in Thailand over the last three decades.
- Shrimp pond construction in mangroves totaled 102,000 ha in Vietnam in 1983-1987 and 65,200 ha in Thailand 1961-1993; many of these farms have collapsed due to diseases. The ponds were

subsequently abandoned.

Mangroves produce both forest and fisheries resources and goods. Fisheries products include fish, shrimp, crabs, bivalve and gastropod mollusks, other invertebrates and seaweeds.

A positive correlation between nearshore fish and shrimp catches and mangrove area has been documented in many countries. Declining municipal fisheries yields parallel the reduction of Philippine mangrove areas, while brackish water pond hectareage and aquaculture production are increasing. Although total fisheries production may remain the same, municipal fisheries provides equity by supporting many more people than pond culture.



### **Several other products can be obtained from mangroves**

Aside from the products it provides, the regulatory function of the mangroves or the provision of amenities or services are equally important. These services include coastal protection, erosion control, sediment stabilization and trapping of terrestrial run-off, flood regulation, nutrient supply and regeneration, treatment of dissolved and particulate wastes, and habitat for wildlife. Total values as high as US\$10,000/ha/yr have been estimated for all these mangrove goods and services.

## Mangrove rehabilitation

Rehabilitation is the restoration of a degraded system to a more stable ecological status, which may or may not be its previous condition (Lewis, 1999).

The guiding principle in mangrove rehabilitation is the restoration of normal hydrological patterns. The community can draw on local knowledge of past hydrodynamics. Once the correct tidal elevation is restored, colonization by waterborne seedlings from adjacent stands can proceed. Planting should be undertaken only if natural mangrove recruitment does not occur, or if there is an overriding need by the local community for specific products, e.g., fishing poles from *Rhizophora*. Degraded areas with sparse mangrove cover can also benefit from enrichment planting of suitable species.

### General principles in mangrove rehabilitation

- Restore normal hydrology
- Observe natural recruitment of seedlings
- Plant seedlings only if no recruitment occurs or if the community needs specific products
- Avoid *Rhizophora* monocultures

## Mangrove plantations

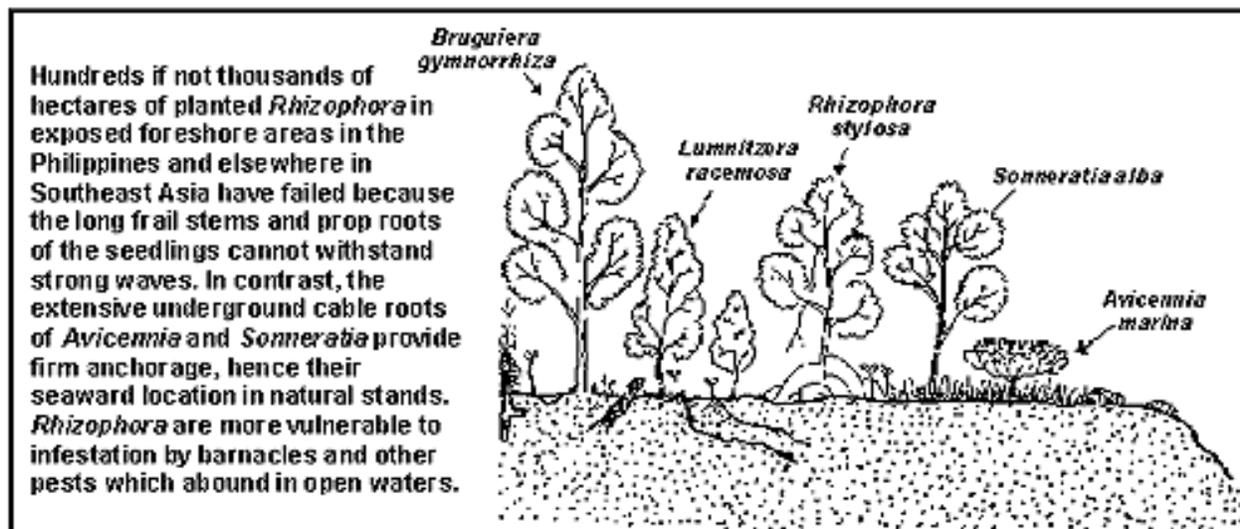
At the outset, the stakeholders or local villagers should have a consensus on their goal in rehabilitating a given area.

- Shoreline protection (pioneers *Avicennia marina* and *Sonneratia alba/Sonneratia caseolaris*)
- Forestry products: *Rhizophora* for firewood, posts and piles; *Ceriops tagal* for tanbark; *Xylocarpus granatum* and *Heritiera littoralis* for furniture; and, *Nypa fruticans* for thatch (housing material)
- Improvement of fisheries catches (by restoring habitat)

Active mangrove planting of small areas – by villagers, local officials and schoolchildren as well – for educational purposes has greater importance than the total number of hectares planted. Nevertheless, tenure over the planted area will motivate planters to regularly monitor and protect the young seedlings.

Seedlings should not be planted near strong water currents, on tidal flats that serve as feeding grounds of migratory birds and seagrass beds. Planting should coincide with the availability of propagules (in case of direct planting) and the season of least wave action and typhoons. Mangrove species to be planted will depend on biophysical conditions of substrate (*A. marina*, *S. caseolaris* in sand, *Rhizophora* in mud), wave action (*A. marina* in seaward locations, *R. mucronata*/*R. stylosa*/*R. apiculata* along rivers), salinity and tidal elevation. Species of *Rhizophora* have been favored by past and ongoing mangrove planting programs throughout Asia

because of their large propagules that are available year-round. Such monocultures have often failed.



Planting density or spacing will also depend on the objective - closely spaced clumps of three seedlings for coastal protection, higher densities of *Rhizophora* for firewood and charcoal, and lower densities for timber. Maintenance and monitoring by the community in the first months require daily check-up for barnacles, filamentous algae as well as the replacement of dead plants. As the plants become established, visits can be less frequent .

Mangrove seeds can be planted directly (e.g., the viviparous or germinated propagules of *Rhizophora*) or sowed (*Sonneratia*). Nursery-grown potted plants and hardened wildlings can also be outplanted in the field.

## Mangrove nurseries

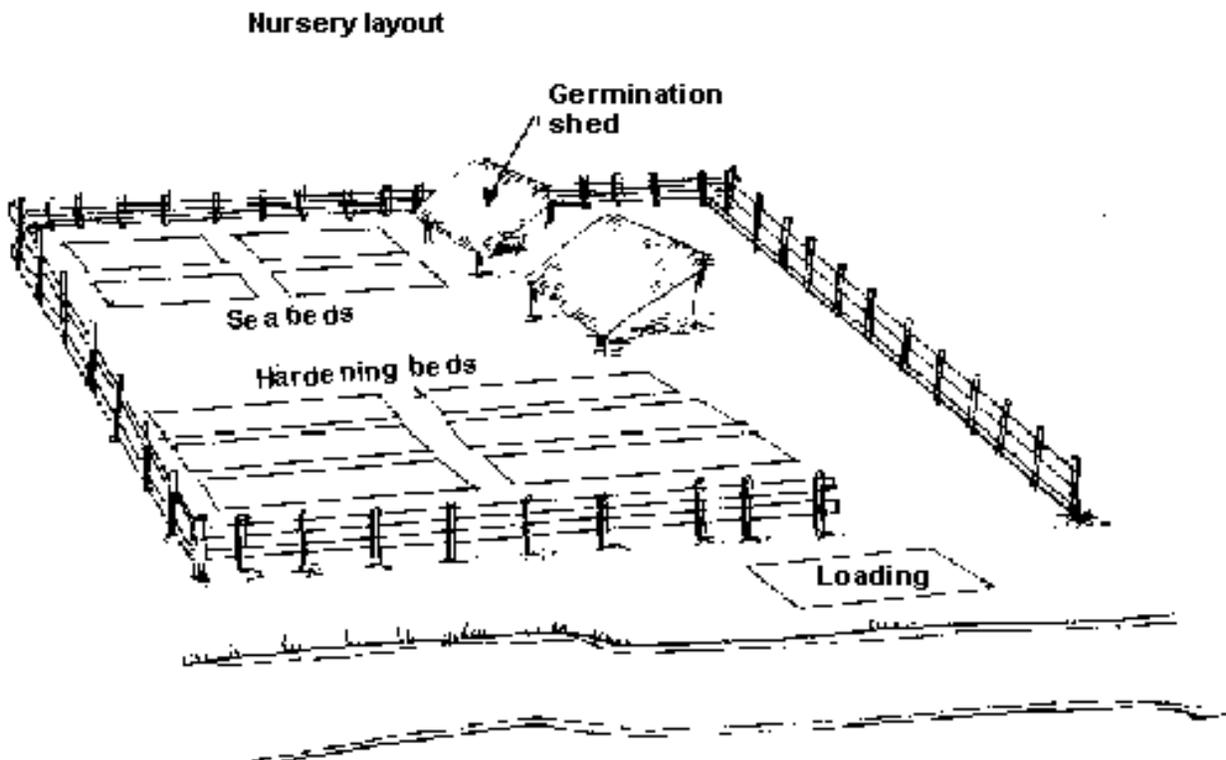
- Factors to consider in selecting a mangrove nursery site:
  - brackishwater (inundated by spring tides) and freshwater supply;
  - location close to mangrove seed sources, area for planting and village; and
  - accessibility preferably by land.
- The nursery should be built on a cleared and level area that drains well.
- Components include:
  - seed boxes (for small seeds like *Sonneratia*);
  - elevated germination beds;
  - beds for hardening of seedlings;
  - potting shed;
  - bagging shed; and

– storage shed.

- Shading by means of coconut leaves or netting material is advisable to reduce sunlight.
- The size of the nursery will depend on the number of seedlings required.

### Peak fruiting seasons

- Undamaged mature seeds may be collected from the tree or on the ground when they have just fallen.
- The growing tips of propagules should be protected during transport.
- Mature seeds of each species have their own characteristics.
- Propagules must be planted within a week after collection.
- If seeds and propagules are not sufficient, wildlings or young saplings less than 30 cm tall from mature stands may be used. Plants in newly-colonized mangroves should not be used.



### Community participation and ICZM

Since the local residents are the users, the management of coastal resources (including mangroves, sea grasses and coral reefs) should be community-based. Community involvement in the planning and implementation of coastal resource management (CRM) projects and sharing in the benefits of the interventions will contribute to the success of CRM. This may require organizing community organizations in coastal villages and leadership training under the initiative of local government bodies or non-government organizations (NGOs). Rehabilitation and

other mangrove management projects shall be in the context of a wider integrated coastal zone/area management (ICZM or ICAM) that coordinates the needs of various sectors: fisheries, aquaculture, forestry, industry, among others.

## **Socio-economic considerations in mangrove rehabilitation programs**

- Local knowledge and skills
- Social organization and institutions
- Land use and tenure

### **Tenure over mangrove areas**

In many countries, mangrove areas are open access public lands owned by the government. It is important that mangrove planters (individual families or groups) obtain tenure over their respective areas whether in the form of management/stewardship contract or lease from the government. Such mechanism ensures that they will reap the benefits of what they sow.

The successful conservation of the 300-ha Talabong Mangrove Reserve and decrease in illegal pond expansion and illegal fishing in Bais Bay, Negros, Philippines were due to the personal commitment of the mayor and local officials, community empowerment and provision of tenurial instruments. In turn, populations of various whales and dolphins that have subsequently returned to Tanon Strait outside the Bay provide opportunities for ecotourism along with mangroves, seagrasses and coral reefs in the Bay.

The successful mangrove replanting projects of Yad Fon, a local NGO, in Trang Province, southern Thailand emphasize education and community involvement in the protection, monitoring and evaluation of rehabilitated sites.

Co-management of CRM with local government units is essential because local officials are responsible for the enactment of ordinances pertaining to marine conservation and rehabilitation and their implementation. Effective enforcement of such regulations is hampered by lack of manpower and facilities, and corruption at various national and local government levels. However, the successful co-management of Bais Bay, central Philippines illustrates political will at work. Local governments also have a role to play in conflict resolution - within the community and between neighboring communities.

Aside from local government support, property rights and community involvement, other factors important in mangrove rehabilitation and CRM initiatives are effective

information dissemination/educational programs, and external technical expertise and funding, and alternative livelihood options.

Alternative short-term sources of income may be:

- cottage industries such as weaving and basket making; and
- sale of nipa thatch, seaweeds, mollusks, crabs and fish from mangrove fisheries/small-scale aquaculture.

Mangrove-friendly aquaculture includes the growing of seaweeds (*Gracilaria*), bivalve molluscs (oyster, mussel and cockle) and fish in cages/pens in mangrove waterways and tidal flats. Mudcrabs, fish and shrimp can also be cultured in pens and ponds integrated with mangrove trees inside the forest itself (called aquasilviculture or silvofisheries).

It is particularly important that the planters, i.e., the villagers (or even landless poor from neighboring areas) are allowed to harvest fish, invertebrates and other products from rehabilitated sites. Gleaning of molluscs and other invertebrates for domestic consumption in tidal flats adjoining mangroves is often done by women and children. Moreover, such small-scale fishing and gleaning in inshore areas are more species-selective, less fuel- and time-consuming, and safer than deep-water fishing.

Successful mangrove rehabilitation depends on both sound ecological principles and participation of local communities and government officials.

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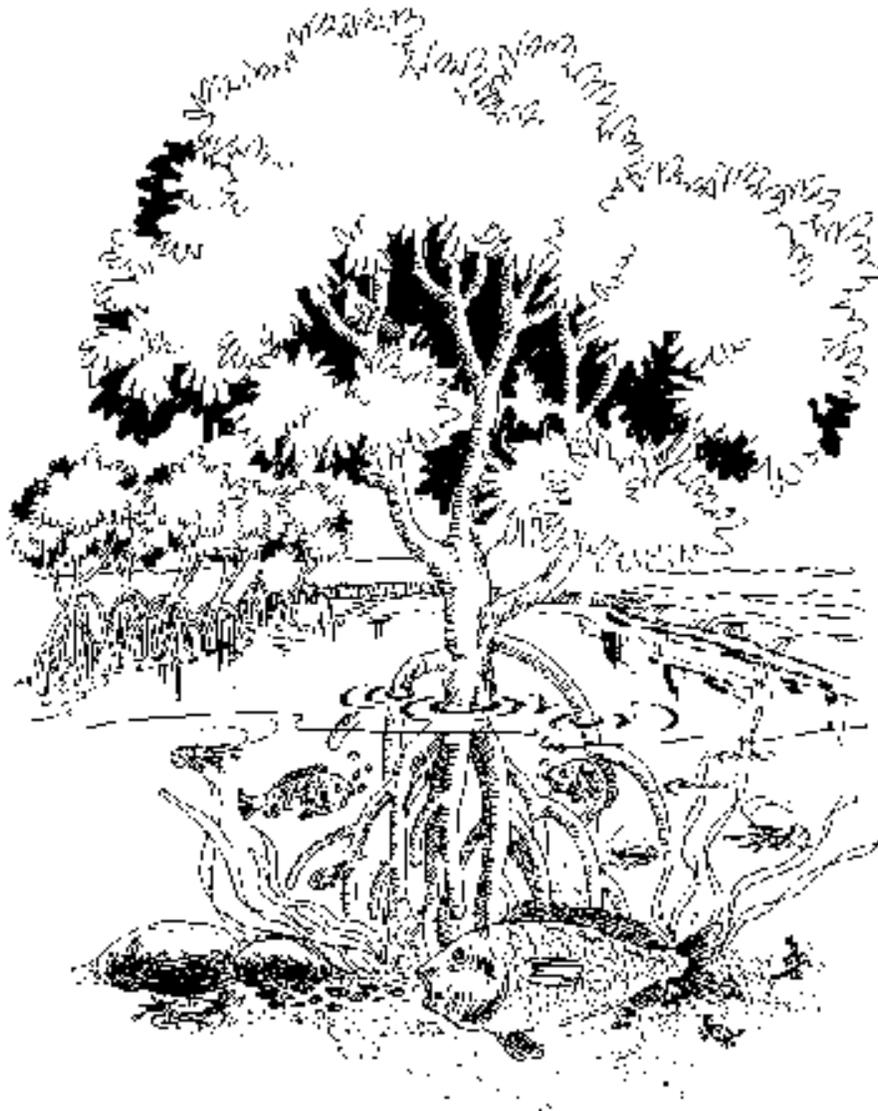
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Prepared by:  
**Jurgenne Primavera**

# Mangrove-Based Small-Scale Shrimp Aquaculture



Mangrove-based small scale aquaculture can take many forms. Some examples are:

- culture of blood cockles and other shellfish on mudflats to the seaward of mangroves;
- cage or rack culture of oysters, other shellfish and fish in mangrove estuaries;
- culture of mud crabs within mangrove areas; and
- pond culture of shrimp and fish within or adjacent to mangroves.

Mangroves are not the best site for aquaculture ponds, especially for shrimp culture, as they have potentially acidic soil. Shrimp ponds may have problems with low pH, which is bad for the health and survival of shrimp. Also, when mangroves are converted into aquaculture ponds, valuable environmental benefits are lost. In general, it is better to set up aquaculture ponds on higher land behind mangroves.

The putting up of new aquaculture ponds within mangrove areas should be discouraged. However, brackishwater shrimp ponds have already been built in many areas.

### **Some environmental and economic benefits of mangroves**

- Help protect coasts and river banks from erosion
- Help protect coastal dwellers from storms and storm surges
- Help reduce peaks of nutrient and sediment discharges from coastal rivers
- Help trap sediment and build new land
- Help reduce atmospheric CO<sub>2</sub> levels by fixing and storing carbon
- Produce leaf litter and other detritus that support coastal food chains
- Provide nursery and feeding ground for fauna, including commercially valuable fish, shrimp, crab, gastropods and bivalve species
- Provide timber and fuelwood for coastal dwellers
- Provide other products like honey and medicinal drugs
- Enhance biodiversity
- Provide aesthetic and recreational values
- Provide scientific, educational and cultural values

In 1986, the Provincial Government of Ca Mau, the southernmost province of Vietnam, established 22 mixed shrimp farming-mangrove forestry enterprises (SFFE) in the brackish water, coastal lowlands of Ngoc Hien and Dam Doi districts where Vietnam's largest remaining mangroves are found. It aims to provide income for small-scale landholders while managing the remaining mangrove resources for timber/fuelwood production and for environmental reasons.

Under the SFFEs, farming households are allocated 6-10 ha of land on a 20-year lease. At least 70% of the land is for mangrove forestry and the rest for aquaculture and domestic use. Shrimp culture is the primary livelihood for most households, although income from extensive wild shrimp culture remains low. This is partly due to unreliable wild seed stocks, particularly of species with high commercial value like *P. merguensis* and *P. indicus* (low value *Metapenaeids* now represent about 80% of the harvest). Extensive culture of hatchery-reared seed of black tiger prawn (*P. monodon*) is also practiced widely, but yields and economic benefits have been highly variable because of low survival (commonly less than 1%) due to poor pond design and water and seed quality; bad farm management practices, farmer inexperience and disease outbreaks.

### **Some general characteristics of shrimp farming forestry enterprises (SFFEs)**

- Flat with an elevation of less than 1 m above highest tide.
- Much of the area is tidally flooded from 150 to 365 days per year.
- Pronounced wet (May to November) and dry (December to April) monsoonal climate.

## **Small-scale improved extensive and semi-intensive shrimp culture**

Increasing the stocking density (up to, but not more than, 10 per meter) and the survival rate of *P. monodon* in the pond can improve the contribution of shrimp farming to the livelihood of small-scale farmers in coastal areas. This can be achieved through modest intensification, together with better pond design, good quality seed and improved farm management practices. A range of options for improvement require different levels of investment. It is necessary to show farmers a sequence of steps they could take to increase their income. These steps depend on the condition of the farm, individual financial circumstances and experience.

### **The three main requirements**

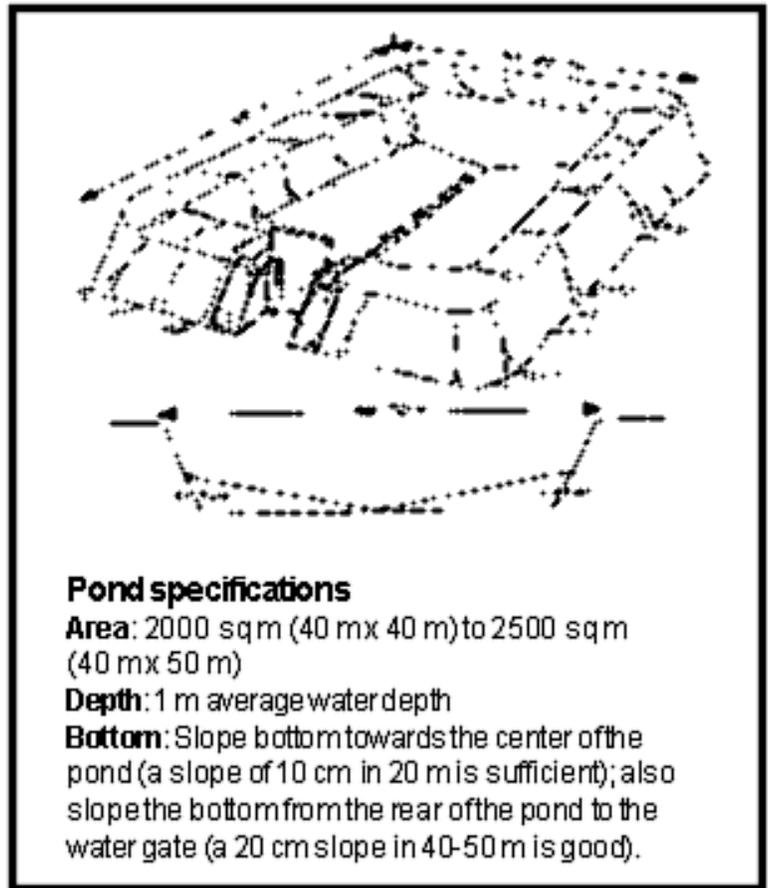
1. A good pond
2. Strong, high quality and disease-free seed
3. Good nursery care during the first 20-25 days of stocking

### **Two types of farming systems commonly used in Ca Mau Province**

1. Separate farms where shrimps are cultured in ponds without mangroves. Mangroves are grown in a separate area of the farm, sometimes in combination with shrimp culture, like mixed farms.
2. Mixed farms where mangroves are grown entirely within the pond, much like the tambac aquaculture system used in Indonesia for centuries.

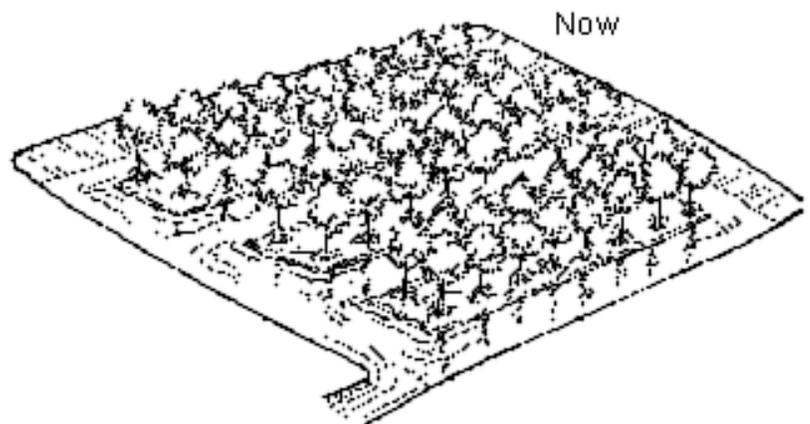
## Some general suggestions on farm layout

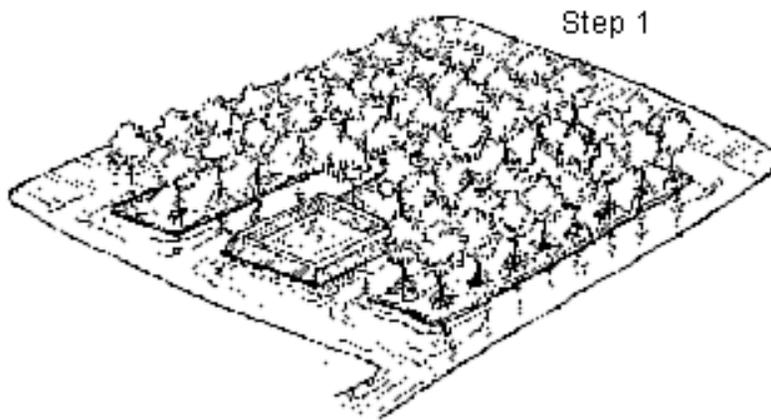
- Remember that coastal mangrove systems are highly dynamic and their characteristics often change. What is seen now may not be the same in 10-20 years time. Try to anticipate future changes and make plans with these in mind. This will help avoid future problems that might be costly to fix.
- Try to keep a 20-30 m wide belt of mangroves along the waterfront to reduce erosion and provide a nursery for wild aquatic species.
- Try to maximize the benefit of mangroves by arranging the location to allow incoming or outgoing water to pass through the trees.



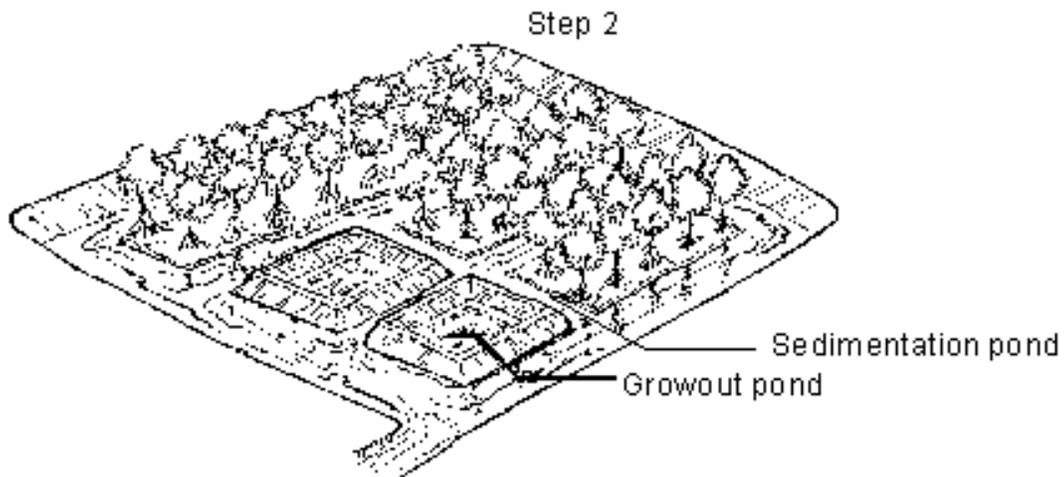
## Pond design

A small pond with a water area of about 2000 or 2500 sq m is better than a much larger pond. Big ponds are more difficult to manage. Start with one pond, then add another as capital becomes available. This will help reduce the risk of losing shrimp through disease. No more than three ponds of this design should be built. See suggested sequence for the two main farming systems in the illustrations.





Step 1

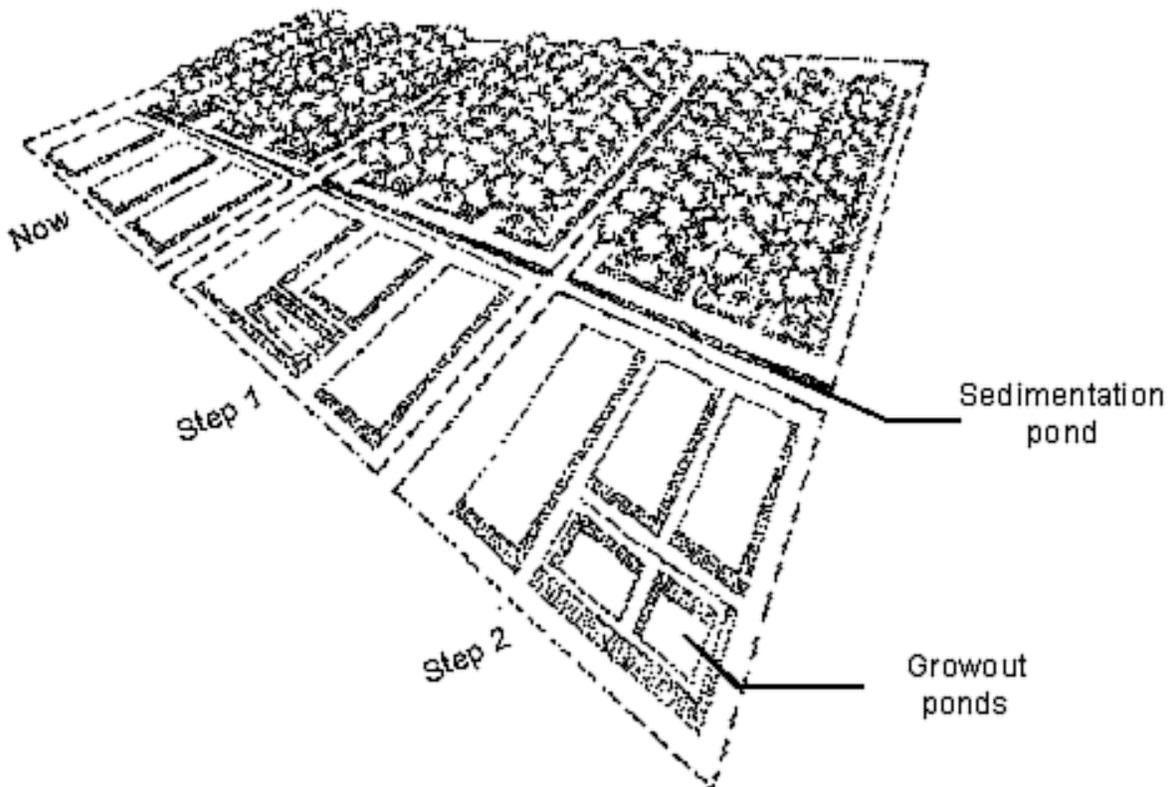


Step 2

Sedimentation pond

Growout pond

**Suggested sequence for improving mixed farming system**



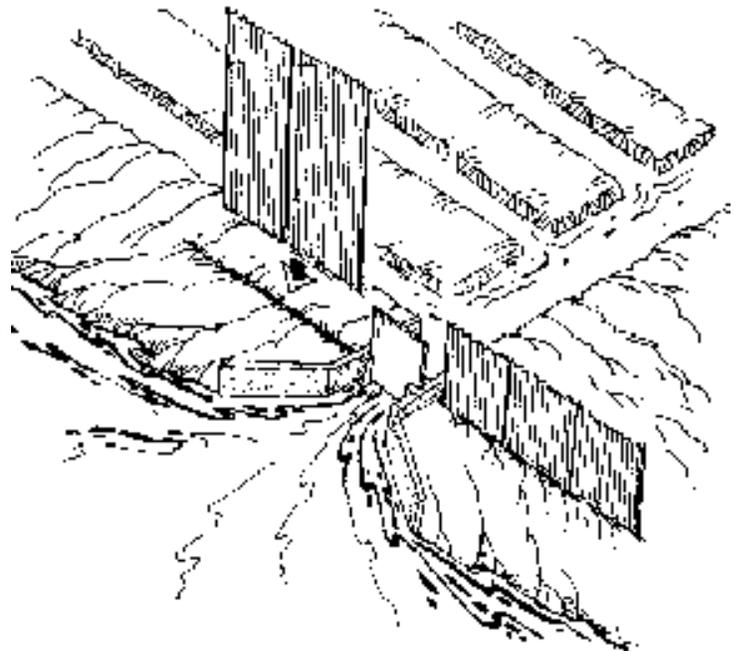
Sedimentation pond

Growout ponds

**Suggested sequence for improving the separate farming system**

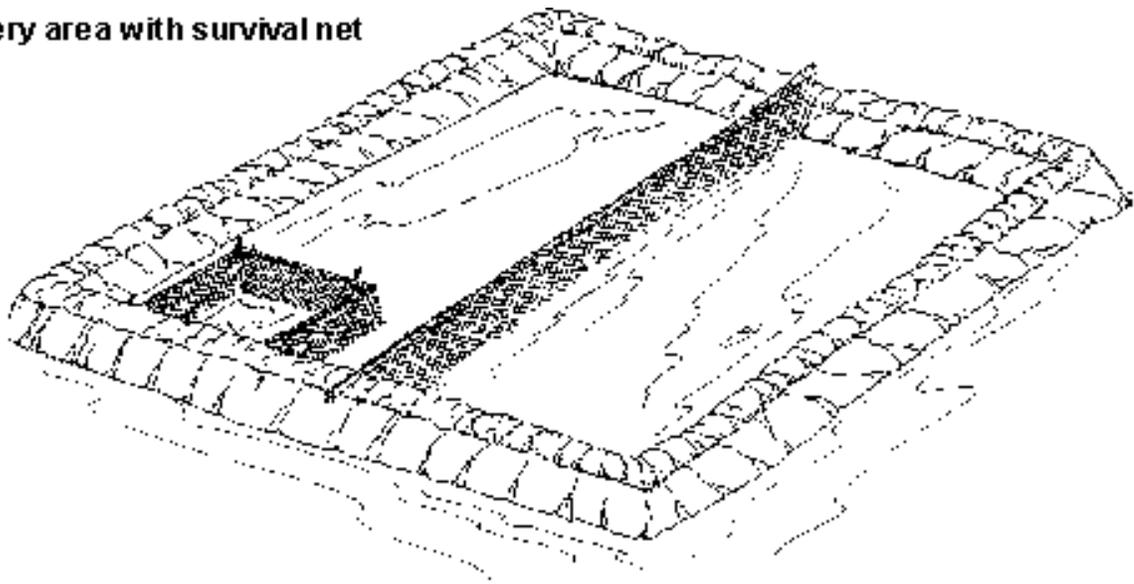
## Some useful tips on pond preparation

- Use a sedimentation pond to improve water quality if the intake water has low transparency, is polluted or otherwise of low quality. Generally the water surface area of the sedimentation pond should be at least equal to the water surface area of the growout ponds. The sedimentation pond can be stocked with *P. monodon* at a density of 1-3 per sq m or it can be used for wild shrimp culture.
- Do not dump the excavated material into the river or in mangrove areas. Use it to build an area above the tidal limit, which can be used for terrestrial crops or livestock production. Diversification can help reduce the risk to the household and provide a more stable income.
- Make sure the average pond water depth is 1 m.
- Use a cement water gate that is at least 1 m wide. If necessary, use plastic sheets or fibro-cement roofing material to prevent water leakage through crab burrows along the sides of the water gate (refer to the diagram on the right).
- Outer levees (or dikes) should be at least 4-6 m wide to reduce leakage (10 m is preferable). The levee (dike) around the pond should be at least 0.5 m higher than the highest tide to reduce the risk of shrimp being washed out of the pond by unusually high tides or storm surges.
- After constructing or after cleaning the pond, open the watergate and allow the tide to free flush the pond for at least a week. Put a net at the water gate to prevent entry of predators (e.g., fish). Avoid using chemicals to kill predators. If absolutely necessary, use only sparingly. Use Derris root or teaseed powder, both natural products, if piscicides are needed. In some areas with acidic soils, it may be necessary to apply lime (for recommendations, see paper on *Management Practices to Improve Extensive Shrimp Aquaculture*).
- Prepare a nursery area at least 1 week prior to stocking, using fine net ( $\leq 1$  mm mesh size) to cordon off the nursery from the rest of the pond. The size of the nursery area should be calculated for a stocking density of about 35-50 per sq m.



**Watergate**

## Nursery area with survival net



- Construct a survival net (mesh size  $\leq 1$  mm) within the nursery area to estimate survival after the 20-25 day nursery phase. A survival net is simply a small area (10-20 sq m) set aside inside the nursery pond. But it is important because it provides an estimate of the initial stocking rate at the beginning of grow-out period and to estimate how much feed is needed during this phase (if supplementary feeding is employed). A survival estimate is also useful to assess early mortality. If survival is low, then more post-larvae (PL) should be purchased to restock, paying greater attention to nursery practices to ensure better a survival rate next time around.

## Stocking and nursery care

The maximum stocking density (at the beginning of grow-out) should be no more than 5 per sq m without supplementary feeding during grow-out. For semi-intensive culture with feeding of *P. monodon*, stock at between 5 and 10 per sq m. Do not overstock. Stocking densities higher than 10 per sq m is not recommended.

### Stocking tips

- Select good quality seed (PL10 to PL15). Look for even-sized, actively swimming PL. If a microscope or magnifying glass is available check PL for broken or damaged appendices. Avoid the latter. If possible, shock test a sample of PL with 150 ppm formalin for 30 min. More than 80% survival is indicative of strong PL, but is not a definitive test of freedom from viral and bacterial diseases.
- Stock into a nursery area. Keep in the nursery for 20-25 days (until PL35).
- Buy enough seed to allow for 30% mortality during the nursery phase.

### **Nursery care tips**

- Feed daily, preferably with finely powdered commercially manufactured feed. Do not use crustaceans or crabs as feed.
- Feed in the nursery at the rate of 0.2 kg feed/ day/ 10,000 PL for the first 5 days, then increase to 0.5 kg feed/day/10,000 PL for the rest of the nursery phase.
- Spread the feed as evenly as possible across the whole nursery area, including survival nets.

When buying PL, allow for a 30% loss during the nursery phase. Buy extra PL to give the desired final stocking density.

Do not put more than 2,000 PL in a single bag. Transport PL from the hatchery to the farm as quickly as possible in late afternoon to avoid temperature stress. Give the PL a chance to adjust to nursery water conditions overnight. Before stocking, acclimate the PL to nursery water in large tubs or bins for 30 minutes with aeration. Gently release PL into nursery area. Do not forget to stock the survival net with the required number of PL.

At the end of the nursery phase, count the survivors in the survival net. Use this to estimate survival and the stocking density at the beginning of the grow-out phase.

## **Grow-out**

Use feeding trays to monitor feed intake. Don't overfeed as uneaten feed will only cause problems with water quality, particularly if the pond is not aerated with paddle wheels.

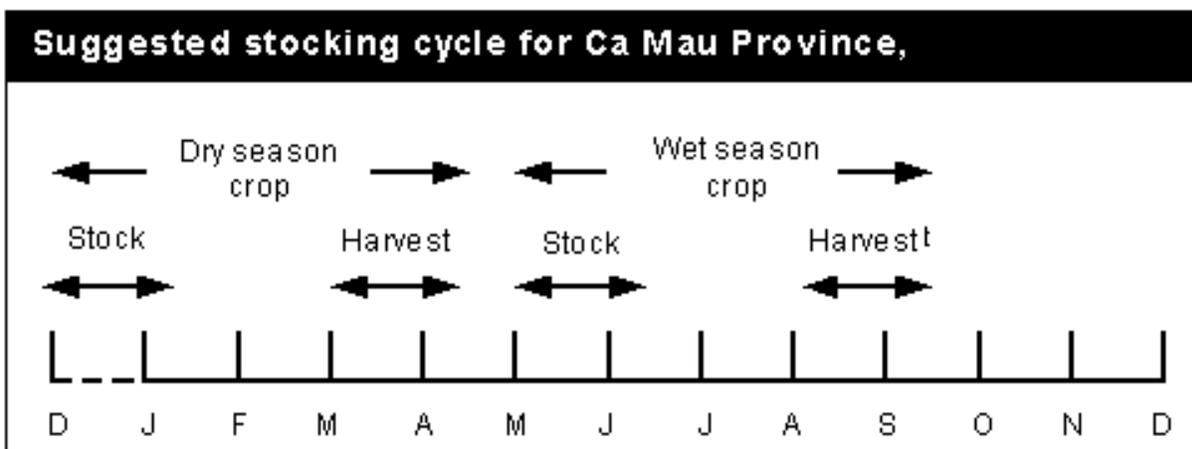
Aeration with a paddle wheel(s) is optional, but it is likely to increase survival at stocking densities up to 5 per sq m without feeding. Aeration is recommended for stocking densities of 5-10 per sq m with supplementary feeding (this will depend on the financial capability of individual farmers). Aeration is essential for stocking densities above 10 per sq m, when supplementary feeding is also necessary. Harvest in 90-120 days. Clean the bottom of the pond after each crop.

### Management during growout

- Keep the water level in the pond topped up. For stocking densities up to 10 per sq m, it may not be helpful to change water too frequently, especially if the quality of intake water is worse than that in the pond.
- Drain the surface water during heavy rain to reduce rapid changes in salinity and pH.
- Check and record the size and number of shrimp in the grow-out pond at least every seven days using a feed tray, lift net or cast net. A sharp decline in the number of shrimps may indicate a problem. If shrimps are of marketable size, then harvesting could be considered rather than risk losing most of the crop.

## Stocking cycles

Avoid stocking *P. monodon* at times when water quality may change rapidly, for example at the beginning of the wet season. A wet season crop has a greater mortality risk due to rapid changes in salinity and pH. Try to stock a wet season crop as early as possible, before heavy rains start. Drain and clean the pond bottom between crops, then leave the pond dry for two to three weeks before refilling.



## Health management

Shrimp health is affected by water quality, availability and quality of feeds, and viral and bacterial diseases. For brackishwater mangrove-based shrimp culture, especially in Ca Mau, Vietnam, low oxygen levels and pH are likely to be the main water quality parameters influencing shrimp health. Low oxygen can be a more serious threat when the ponds are overstocked or if shrimps are overfed. In the wet season, rapid changes in salinity may also affect shrimp health adversely. These problems can be minimized by careful water quality management.

Viral and bacterial diseases are more difficult to manage. Using disease-free seed is the first step that farmers can take to reduce the risk of diseases. However, viral and bacterial pathogens are probably present in most wild shrimp populations, so that there is always a risk that disease can be transferred from wild to cultured shrimps that were initially healthy. Crabs can also be vectors of some shrimp diseases. Hence, it would be best to exclude wild shrimp and crabs from the grow-out pond. Shrimps, like all animals including humans, are more likely to contract a disease if they are weak or stressed. Good pond and water quality management practices that keep shrimps strong and healthy will also help reduce the risk of death from viral and bacterial diseases.

## **Mangrove silviculture**

The most common mangrove species used for silviculture (cultivation of timber trees) is *Rhizophora apiculata*, which is very suitable for poles, fuelwood and charcoal. For optimum growth, this species should be propagated in areas that are flooded for a period of 10 to 25 days per month.

It is also best to plant this species with an inter-tree spacing of 1 to 1.25 m (8,000 to 10,000 trees per ha) for silviculture. Specific thinning plans will depend on site conditions and the growth rate. For Ca Mau Province in Southern Vietnam, this species should be thinned to 5,000 trees per ha at eight years. If the trees are farmed on a 20-year rotation, a second thinning to 2,000 or 2,500 trees per ha should be carried out at 14 years. *Rhizophora* forests should not be thinned after 20 years of age.

## **Benefits from integrating mangroves with aquaculture**

There are direct economic and environmental benefits from integrating mangroves with coastal aquaculture:

- mangroves can be used to process and clean up intake and outflow water in aquaculture ponds. To do this efficiently, farm layouts should be designed with this in mind;
- mangroves provide protection from storms and may prevent the loss of land from erosion, especially along the waterfront;
- generate income from the sale of wood products;
- provide fuel and materials for construction of houses, footbridges and other on-farm activities; and
- honey raising can be integrated in areas where there are suitable species of mangrove.

**Barry Clough**

# Estuarine Aquaculture Systems



The estuary is the interface between the freshwater and marine ecosystems. As such it has the following characteristics:

- Highly variable salinity with the range depending on the volume of freshwater inflow
- Relatively more turbid than the open sea
- Generally nutrient rich with high primary productivity
- Generally high flushing rate
- Often a rich fishing ground

The estuary may be a whole bay or the immediate vicinity of the mouth of a river or a creek both upstream and downstream. Indeed there can never be a sharp delineation of the boundaries of an estuary. Its extent and the variability of its physical, chemical and biological characteristics depend on the tidal conditions and the weather. Thus the salinity of an estuary varies in time as well as with depth and distance. Salinity increases with depth and distance from the freshwater source.

Selection of species suitable for culture in estuarine environments

Even if purely marine or purely freshwater species are found within an estuarine area, not all species of fish and other aquatic organisms will be suitable for culture in an estuary due to its dynamic nature. Ordinarily, a swimming species will just move away from conditions not favorable to its survival. Since aquaculture entails confining the organism to a definite location, only species with the following characteristics can be considered for culture in an estuary:

- tolerant of fluctuations in salinity; and
- not sensitive to occasional high turbidity.

The continuous presence of a species in an estuary regardless of tidal conditions can be considered the best indicator of its suitability.

In addition to the biological requirements of a species, there are logistical and economic factors that have to be considered as well. These are:

- a good market and ready access to that market;
- locally available feed at low or no cost; and
- available seedstock (fry, fingerlings, spats, etc)

## Suggested species for culture

The following species are either known to have been grown or, from their distribution and occurrence, should be suitable for culture in estuaries:



### Agarophyte seaweeds (*Gracilaria* spp.)

- Viability depend on availability of market
- May be grown by planting cuttings on shallow bottoms or tied to lines or nets attached to fixed posts or afloat
- Sold fresh for direct human consumption and in dry form for processing into agar



### Oysters (*Crassostrea* spp., *Saccostrea* spp.)

- Require plankton-rich water
- Can tolerate lower ranges of salinity and higher turbidity
- Maybe raised in shallow or even intertidal areas
- Should ideally be raised in clean, uncontaminated waters



### Mussels (*Perna viridis*)

- Require plankton rich water
- Cannot tolerate prolonged exposure to low salinity ranges
- Best grown in deeper waters
- Best grown in clean, uncontaminated waters



### **Cockles (*Anadara* spp.)**

- Require plankton rich waters
- Require wide expanse of flat, shallow and soft subtidal beds
- Preferably grown in areas with low population density and far from industries



### **Penaeid shrimps (*Penaeus* spp.)**

- Of many possible species, jumbo or black tiger shrimp, *Penaeus monodon*, grows fastest and attains largest size
- Black tiger shrimp tolerant of wide ranges of salinity but grows best in brackishwater
- Maybe grown in pens
- Require fish or molluscan biomass or formulated feed.



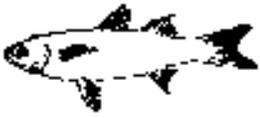
### **Mud crabs (*Scylla* spp.)**

- Tolerant of wide range of salinity
- Can be raised in bamboo pens or cages
- Use of cage usually for short-term fattening
- Require animal protein diet (fish, mollusk, poultry waste)
- Not yet bred in hatcheries so seedstock may be a problem.



### **Milkfish (*Chanos chanos*)**

- Tolerant of wide salinity range from freshwater to above seawater salinity
- Demand limited to few countries (Philippines, Indonesia)
- May be grown in cages or in pens
- May be fed rice bran but grows better with formulated feed
- Fry available seasonally but may also be produced in hatcheries



### **Mullet (*Mugil* spp.)**

- Tolerant of wide salinity range
- Demand maybe regional
- May be grown in cages or in pens
- May be fed rice bran but grows better with formulated feed
- Fry available seasonally but may also be produced in hatcheries



### **Tilapia (*Oreochromis* spp.)**

- Nile tilapia can tolerate salinities up to 15 ppt but higher salinity will require saline tolerant breeds such as *O. niloticus* + *O. mossambicus* hybrids
- May be raised in pens or cages
- May subsist on algae but high density in cage or pen requires feeding with formulated feed



### **Seabass (*Lates calcarifer*) and Mangrove snapper (*Lutjanus argentimaculatus*)**

- Tolerant of wide range of salinity but grow better in lower salinity
- Best raised in cages
- Require fish biomass
- Fry/fingerlings may be collected from natural waters, but may also be available from hatcheries.



### **Groupers**

- Cannot tolerate low salinity levels, grow best in 25 ppt or higher
- Command high price when sold live so accessibility to market very important
- Best grown in cages
- Require fish biomass as feed
- Propagation in hatcheries not yet widespread and natural so fingerlings supply can be a problem.



## Rabbitfish

- May not tolerate salinity below 15 ppt
- May be grown in pens or cages
- Can be fed vegetable wastes and/or seaweeds
- Wild fingerlings occur in abundance seasonally but may also be produced in hatcheries

## Pen versus cage

The main difference between a pen and a cage are as follow:

- **Pen** – a net and/or bamboo enclosure utilizing the natural seabed as the bottom barrier
- **Cage** – an enclosure that may be installed off-bottom (either on fixed frame or afloat) that has net material as bottom barrier

Generally, a pen would have a more adverse impact on the estuarine environment for the following reasons:

- It tends to require larger areas.
- It can only be installed in shallow areas making it more likely to obstruct access to the water body.
- It cannot be moved.
- It extends from the surface of the water all the way to the bottom impeding the flow of water more than cages, thus, has greater tendency to increase siltation rate.

## Considerations in estuarine aquaculture

- Access by other users to common resources should not be limited.
- Navigation and right of way of boats should not be blocked.
- Flow of water should not be substantially affected so as not to increase siltation rate.
- Feeding should not compete with local requirements for human nutrition.
- Culture structure should not be crowded and the natural carrying capacity of the estuary should not be exceeded.
- Installation should not result in the destruction of mangrove and wetland areas.
- Materials for construction should not be taken from endangered plant species nor treated with chemical preservatives.

## Minimizing adverse impacts

- Organize coastal communities so all stakeholders can participate in development planning and resource management.
- Work for adequate legal framework and compliance with existing laws.
- Give priority rights to local community over the use of estuary.
- Zone the estuary to provide access to all users, setting aside open areas for fishing and areas for pens, cages and other culture systems.
- Identify and use as feed species considered as pests or not usually used as human food such as golden apple snail and undersized tilapia from fishponds and shrimp ponds.

## Prospects for livelihood

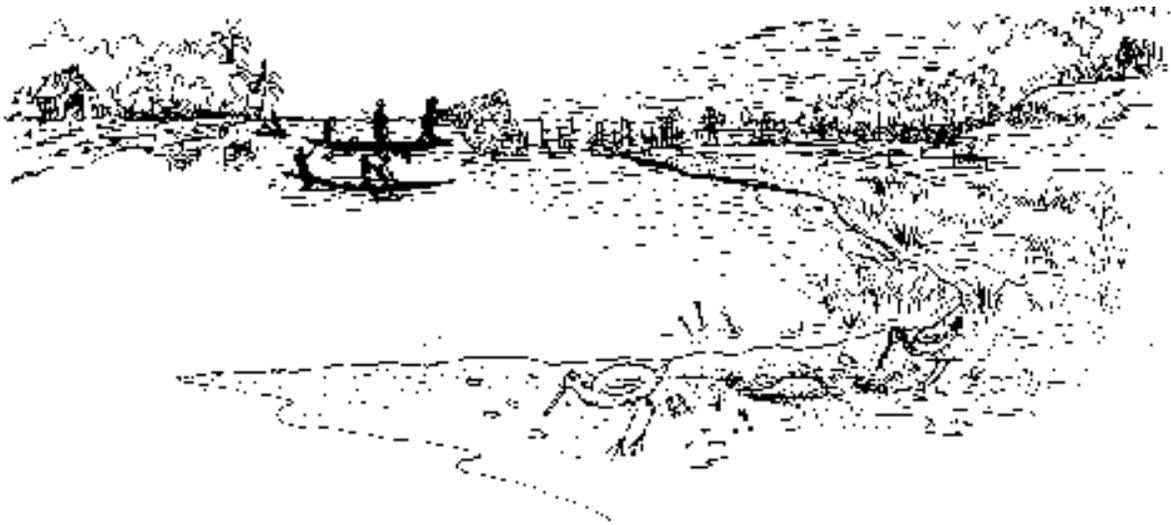
When a sound estuary development and management system is in place, the potential of estuaries in providing aquaculture-based livelihoods to the coastal poor is high. Aquaculture in an estuary has to be planned as an integral part of an estuary-wide, community-based, coastal resource management program.



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Prepared by:  
**Fred Yap**

# Utilizing Coastal Wetlands for Small-Scale Aquaculture in Sri Lanka



Wetlands are defined as areas of marsh, fen, peat land or water whether natural or temporary, with water that is static, flowing, fresh, brackish or salt. These include areas of marine waters, not exceeding six meters in depth during low tides.

According to the Ramsar convention, many parts of Sri Lanka qualify as wetland. More than 20 different types of wetland ecosystems can be identified in the country. Surface waters of Sri Lanka are divided into three main groups: freshwater, salt water and human-made.



The three types of wetlands have been further subdivided into ten general wetland types: reservoir, streams and rivers, fresh water marshes, deltas and estuaries, lagoons, marine wetlands, tanks and reservoirs, agricultural wetlands, salt pans and aquaculture ponds.

**Fresh-water**



Reservoir



Streams/river



F/W marshes

**Salt-water**



Deltas and estuaries



Lagoon

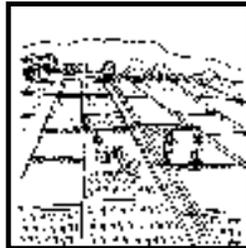


Marine marshes

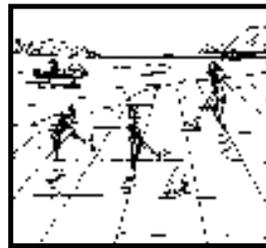
**Human-made**



Lake



Agricultural



Saltpans

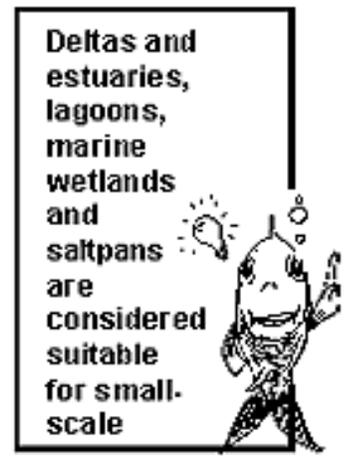


Aquaculture ponds

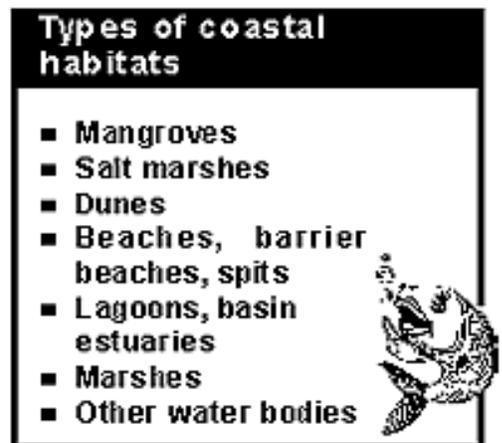
## Small-scale coastal aquaculture development in wetlands

Coastal aquaculture development has become an important activity in the country's economy. In 1998, Sri Lanka earned 6732 million Rupees (US\$1=Rs 78) from exports of fish and fishery products.

Sri Lanka has a coastline of 1585 km encompassing lagoons, estuaries, bays and fringing reefs. Lagoons and sheltered bays are common along the coast and are potential sites for aquaculture development of a variety of species. In addition, mangroves play an important role in coastal aquaculture by providing natural breeding grounds and shelter for aquatic organisms.



Most of coastal habitats suitable for small-scale aquaculture lie on the eastern and northern coasts. The western and southern coasts have little potential for aquaculture. Shrimp farmers dominate the northwestern coast. At present, only shrimp culture has been commercialized in Sri Lanka. The variety of species, which at present have the potential to be cultured, is remarkably wide. Most of the species are suitable for small-scale farming. The potential for aquaculture depends on the choice of fish species and culture system. Various criteria are used to assess



if a species is suitable for culture.

## Matrix of species

The species included in the matrix have been selected from a technical standpoint only. Although it may be technically possible to grow species in the coastal zone of Sri Lanka, the special conditions needed to develop commercial aquaculture may not be present. Following are species included in the matrix:

### Mud crab

Two species of mud crab are found in Sri Lanka waters, *Scylla serrata* and *S. oceanica*. Mud crab fattening is increasingly popular among the resource poor coastal fisher folks. A recent practice is to hold molted water crabs for two to three weeks, feeding them with fish offal. Mud crab culture in ponds is likewise, done on a limited scale. The normal culture period is six to eight months. This is well suited for small-scale operations and can be done in a way that minimizes environmental impact.



### Oyster

Field trials by National Aquatic Research Development Agency (NARA) demonstrated the feasibility of culturing systems. The most promising sites are to be found in the extensive lagoons and embayment of the east and northeast coast of the country. NARA scientists have developed appropriate methods for farming *Crassostrea madrasensis* in Sri Lanka. Weak local market demand is the major constraint in the development of oyster culture in Sri Lanka. Tourism offers opportunities provided the product could be certified as sanitary.



### Seaweed

The genus *Gracilaria* is found in sea grass beds in the lagoons and bays around the coast of the country. The work carried out by NARA on *Gracilaria* culture indicated that there was a significant potential for its development in aquaculture. Seaweeds can be used in making jelly and to extract agar, which has both domestic and export markets depending on quality.



### Hybrid tilapia

Hybrids of *Oreochromis spp* exhibit rapid growth and have high feed conversion ratios. Brackish ground water is common along the coastline of Sri Lanka and could be used to culture hybrid tilapia in small ponds. While this fish can tolerate a wide range of salinity, there should be no abrupt changes. Tilapia is also cultured in abandoned shrimp farms.



### **Sea cucumber**

Sea cucumber, also known as *trepan* or *beche de mer*, is highly priced in East Asian markets. Its habitat requirements under culture conditions are not well known. However, the species are found in muddy sand sea floors. The most valuable species are: *Holothuria scabra*, *H. nobilis* and *H. fuscogilva*.



### **Brine shrimp**

Brine shrimp or *Artemia* is widely used in the ornamental fish industry. It is vital to the shrimp and prawn hatchery business. Field trials done by NARA demonstrated the feasibility of both biomass and cyst production in the south and northwest coasts of Sri Lanka. Some commercialization has developed to supply local markets in the ornamental fish and hatchery sectors.



### **Freshwater prawn**

Freshwater prawn or *Macrobrachium rosenbergii* is used in mono and polyculture fishponds. Culture of freshwater prawn in small-scale is a profitable venture.



### **Marine finfish**

At present, marine finfish culture is limited to seabass, groupers and milkfish. Seabass and grouper are reared in cage systems. Both milkfish and seabass cultures are done in abandoned shrimp farms using seed collected from the wild. A government supported hatchery and demonstration farm could provide the necessary inputs to start an industry. Due to declining coastal fisheries and overexploited lagoon resources, there is an increasing interest in fish culture to enhance fish production, combined with aquaculture technology and community management of local fishery resources.

## Need for zoning coastal aquaculture

Haphazard development of aquaculture inevitably leads to environmental overload and conflict among user groups and serious economic losses to the industry. The uncontrolled expansion of shrimp farming in Sri Lanka is just one of many examples of the consequences of inappropriate setting, overcrowding and destruction of mangroves.

Geographical Information Systems (GIS) technology gives the planner and developer the capacity to evaluate the interaction of a wide range of environmental and social factors that affect the potential of a region for aquaculture development. The complexity of environmental and other influences is integrated through a ranking and scoring system using maps or 'layers'.

Based on the result of GIS-based zoning, aquaculture development can be targeted at suitable areas through a permit process effected by, among others, committees at the national and provincial levels. The developer and financial institution can evaluate the feasibility of projects more readily.

## The zoning matrix

Shrimp culture alone has been developed as a commercially viable technology in Sri Lanka. However, a number of other species have shown promise. Some of these have been subject to experimental farming while others have been successfully farmed in various tropical countries. Many are well suited for small-scale production and could have a positive impact on the economics of small fisher folk communities. Various criteria have been identified according to their impact on the technical feasibility of culture of the species included in the zone-matrix. Criteria are ranked according to their relative importance for each species. They are further refined by parameters which indicate the range over which a particular criterion affects the culture system.

## Matrix criteria

Certain criteria that affect or control aquaculture systems development were identified and ranked. Ranking was done on a 4-point scale, represented on layers by a monochrome shading scale. The ranking scale was set up as follows.

### Criteria

### Point

Not suitable for development

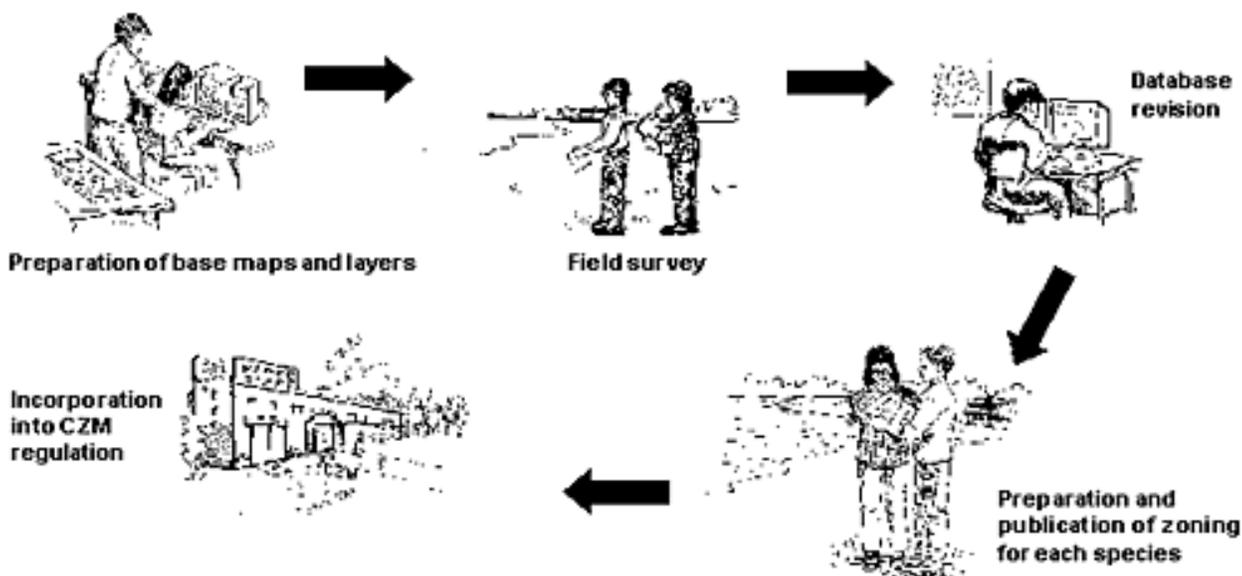
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Not optimal, affects the culture system negatively	1
Neutral, or favors the development of the culture system	2
Positive and successful development likely	3

- Parameters are ranked using the same scale applied to criteria.
- The rank score for a criterion is the product of the criterion rank by the parameter rank.
- In situations where data are insufficient to rank parameters, an approximation of the score for a criterion may be used. In this case, the score is more intuitive than objective, as it would be based on general experience.
- The score for a species within the area in question can be indicated by the sum of its criteria scores. Assigning a value of realign to a parameter is intended to remove sensitive sites from consideration.
- Subtracting their areas from the base map can do this. This will protect critical wetland habitats and direct development away from them and other unsuitable areas.

Physical, chemical and social parameters affect aquaculture development, but obviously not all parameters are applicable to every system considered. If a criterion or parameter does not apply to the species in question, its cell is left blank in the matrix.

## Zoning for coastal



## Steps for zoning coastal aquaculture

## **Preparation of base maps and layers**

- Find, collect and collate maps, reports, studies and surveys from published or unpublished literature. Digitized maps of the coastline including lagoons, bays and harbors serve as base map. Large areas of coastline fall within certain depths of some parameters like elevation.
- Construct a series of digitized layer maps of criteria relevant to each species or species group. Plots are developed from data shown on a 1:50,000 scale maps or from specialized maps of soil.
- After layers of criteria have been completed, the parameter can be ranked through the color coding scheme.

## **Field surveys**

- The survey plan is developed prior to the field survey. Sampling is based on transects perpendicular to the shoreline.
- The coordinates of the sampling station are listed for Global Positioning System (GPS) referencing in the field.

## **GIS data base revision**

- Data acquired in the field can be incorporated into corresponding layers in the GIS data base. Furthermore, data collected in on-going surveys in the context of other projects can be used to continuously update the GIS data base.

## **Publication and dissemination**

- A special publication could be produced in explaining the methodology used to establish coastal aquaculture zones. This can be done by presenting maps indicating appropriate zones for different species.

## **Incorporation into CZM regulations**

- Zoning will only be effective if it is incorporated into CZM regulations.
- When the eastern and northern coasts become accessible for development, there may be a "shrimp gold rush" to the area. When this occurs, it will be imperative to control development

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# Successful Small-Scale Mudcrab Farming Development in the Thai Binh Province, Vietnam: A Case Study



Mangrove or edible mud crabs (genus *Scylla*) are commonly found within the Indo-West Pacific region, where they inhabit tropical and sub-tropical mangrove areas. They have a high economic value due to their large adult size and high meat content. They, particularly the gravid female (also known as "egg crab") which are valuable in many countries, are fished principally for the export market.

Mud crab farming has traditionally been a small-scale activity throughout Southeast Asia, most likely originating from fishermen retaining small numbers of undersized crabs in order to increase their market value. In Vietnam, mud crab culture became established since about ten years ago.

Thai Binh Province is one of the coastal provinces on the fringe of the southern part of the Red River Delta (20°30'N; 106°34'E). Its coastline is composed of lower mud flats, mangroves, upper mud flats and small sand islands located within the river mouths.

At present, 70% of families in Thuy Hai commune (mainly former soldiers and

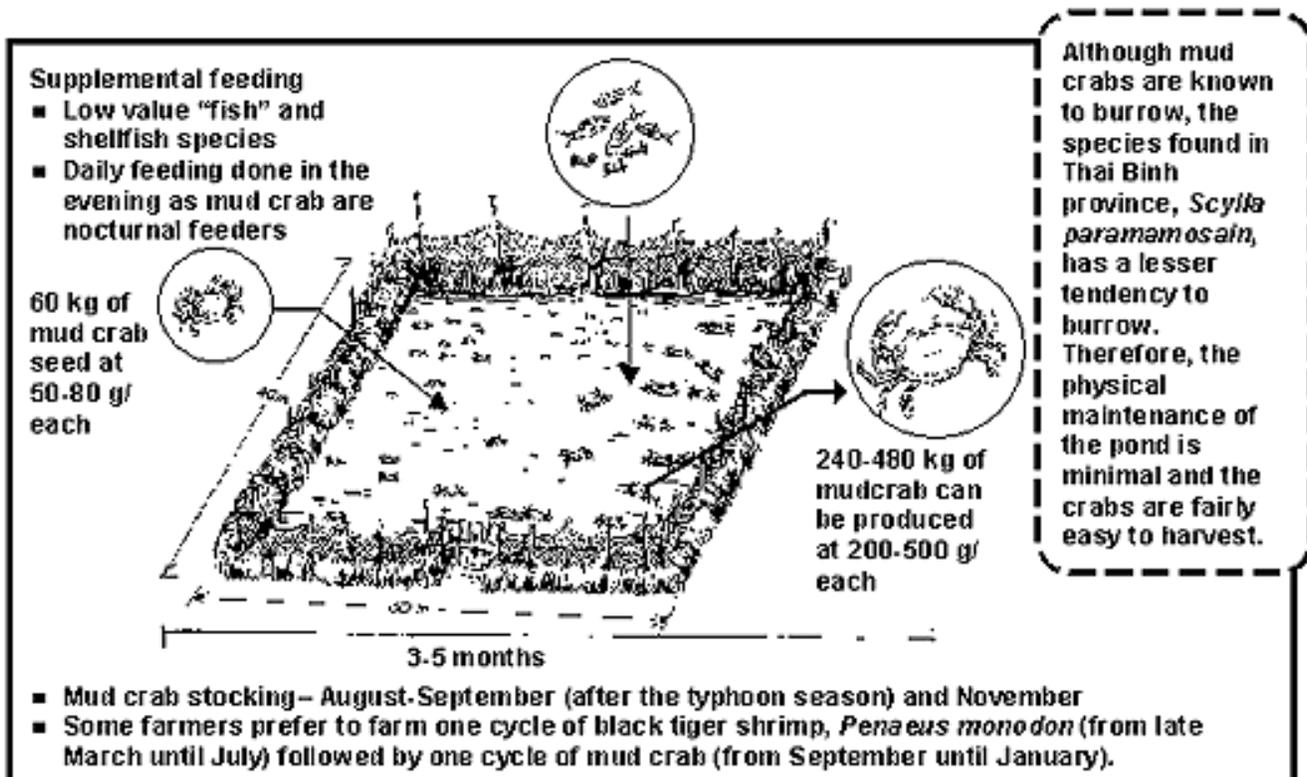
fishermen) farm mud crabs in coastal ponds in Thai Binh Province, Vietnam. Even as a spare time activity, crab farming helps boost income significantly.

## Crab farms and production cycle

Mud crabs are farmed in earthen ponds. These ponds can vary in size from as small as 1,200 m<sup>2</sup>, where the ponds are artificially stocked, to 50 hectare ponds for extensive culture where the crabs are introduced from the inflow water with some additional small crabs purchased from fishermen. These extensive ponds also trap and hold other aquatic products including wild shrimp, fish and are often 'planted' with seaweed.

Majority of aquaculture ponds are situated in front of the main sea dike but behind a recently planted area of mangrove trees (the trees are five to six years old) that act as a buffer zone against typhoons. The water quality is guaranteed to be much better in front of the sea dyke particularly since a large number of the farms rely on tidal water exchange. Over the last four years, coastal aquaculture has become more developed and formerly large extensive ponds have been subdivided into smaller, semi-intensive operations.

All ponds have a simple sluice gate for water exchange and are surrounded by some form of fencing to prevent the crabs from escaping.



## Reasons for successful development of mud crab farming in Thai Binh Province

The success of mud crab farming development in the area are due to several reasons.

### **Site suitability**

The coastal mud flats within Thai Binh Province are accreting rapidly. Every five years, about 250 to 300 ha of "new coastal land" are formed. This new land is suitable for pond construction and has good access to coastal water supply.

### **Water supply**

The freshwater input from the Red River results in brackish water conditions ideal for coastal aquaculture. Moreover, the level of local water pollution is low due to lack of urbanization and agriculture in the immediate area.

### **Accessibility**

Sea dikes not only protect local villages against storm damage, but also provide the main road system between neighbouring communities. Seed, feed and harvested aquatic products are transported without difficulty. The sea dike also serves as focal trading point where traders, farmers and fishermen can trade mud crab.

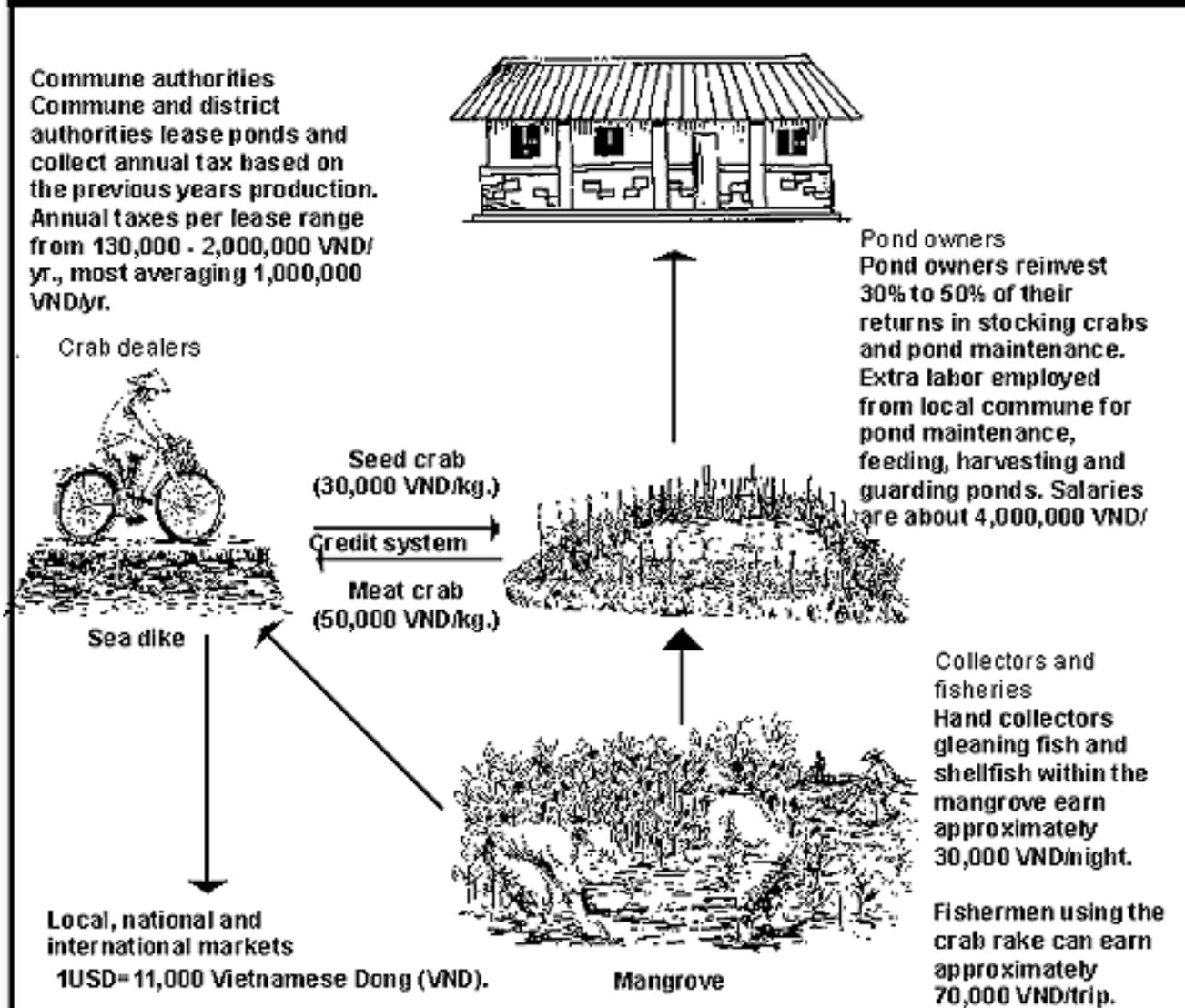
### **Seed and feed supply**

The mangrove protection belt provides the habitat for juvenile mud crab as well as other aquatic species. This has resulted in an increase in juvenile mud crab caught in stock ponds providing plentiful seed supply to support mud crab farming. Moreover, food sources for aquaculture such as low value fish species, small mangrove crab species and mollusks, are abundant in the mangrove buffer zone.

### **Socio-economic factors**

Strong community-based structure, along with the entrepreneurial spirit and hard-working attitude of the local people, has created the opportunity for many coastal communities to benefit from crab farming. The direct beneficiaries from aquaculture tend to be to the more wealthy and enterprising sectors of the community who can afford to invest in mud crab culture. However, the poorer fishers can also benefit from collecting crab seed and food materials to sell to the crab farmer and by providing labor for many aspects of pond operation: building and repairing of ponds, harvesting, guarding against poachers etc. Hand collecting of juvenile mud crab from the mangrove is carried out mainly by women and sometimes children. Both men and women, young and old, are involved in buying and selling crab, either as primary or secondary dealers. These additional activities spread the economic benefit of crab production widely within the community.

## Socio economic linkages between mud crab farming and other income generating activities within Thuy Hai commune, Thai Binh province, Vietnam



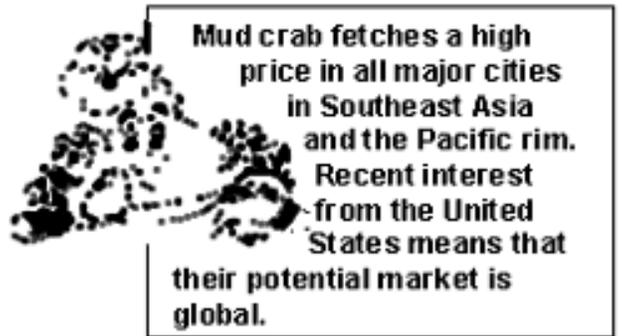
### Technical knowledge base

The combination of the knowledge gained about tidal water management from salt making and the fishers' understanding of local aquatic resources means that the progression to aquaculture was a fairly easy one. In addition, local government initiatives to promote aquaculture through technical workshops organized at the district and commune level have resulted in the training of local people in various forms of coastal aquaculture, in particular shrimp and crab farming.

### Adaptability of mud crab farming to other regions

Mud crab farming could be replicated successfully in other regions for the following reasons.

- Mud crabs are suitable for local market conditions (easy to move, store and trade) and the export market potential is excellent. It represents another high value crustacean product on the market and prices come close to those of farmed shrimp.
- Earthen ponds can be used to culture either mud crabs or shrimp depending on the economic climate, requiring little cost in modifying the culture system.
- Mud crabs are hardy animals. They can withstand salinity fluctuations and low oxygen levels within ponds. As long as they are kept in cool and moist conditions, survival out of water for two to three days is probable. Transporting individually tied mud crabs from the pond site to markets is easy and simple.



## Potential constraints associated with mud crab farming

Some limitations may affect the replication of crab farming to other areas.

- Different mud crab species may have slightly different biological requirements that may affect the way they are cultured.
- Currently, mud crab culture is still in its infancy and mud crab farming still relies on seed supply caught in the wild. For the small-scale farmer, locally caught seed supply is vital for sustainability of crab farming, although they only require a few crabs to sustain their small-scale activities. A sudden and uncontrolled increase in mud crab farming for other practices such as soft shell crab farming could have a devastating effect on wild mud crab stocks through over exploitation. Moreover, the overfishing of juveniles may eventually affect the number of adult crabs available for other fisherfolk.
- The high value of mud crabs means that they are farmed primarily as a cash crop rather than as a protein source. The increasing commercial interest in mud crab farming may result in a rapid expansion of the sector. This expansion could cause problems, like competition over land, pollution and disease due to over development and/or lack of coastal planning, as has been observed widely in the shrimp industry.
- The low-cost fish used to feed crab might be better used to provide food for the poorer sectors of the community. Other potential protein sources need to



be investigated.

## Further reading

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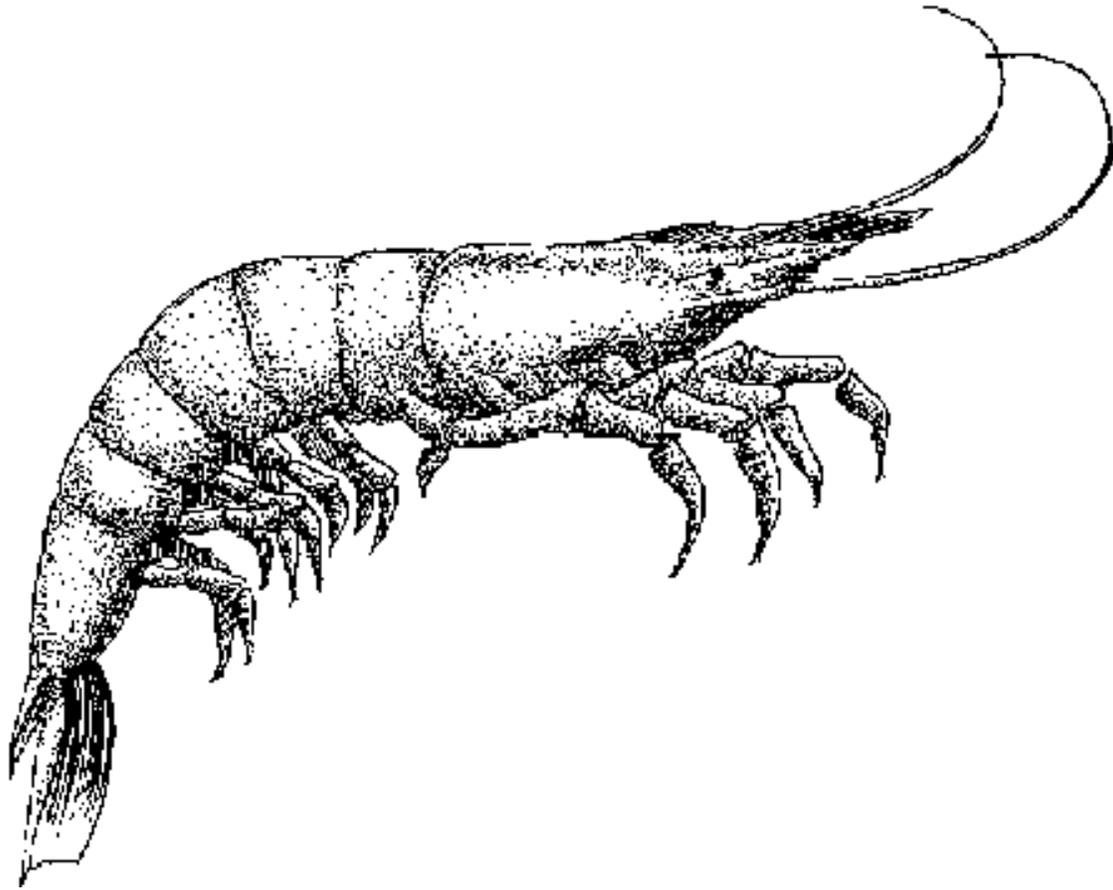
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# Management Practices to Improve Extensive Shrimp Aquaculture



Low yields due to low survival rates and frequent disease conditions are main problems encountered in extensive shrimp culture. A greater part of production losses occurs soon after stocking of post-larvae because of unsuitable conditions in the pond. The following management practices are recommended to reduce post-stock losses and increase production, particularly for black tiger prawn. These recommendations are based on the results of the project "Disease prevention and health management of coastal shrimp culture in Bangladesh".

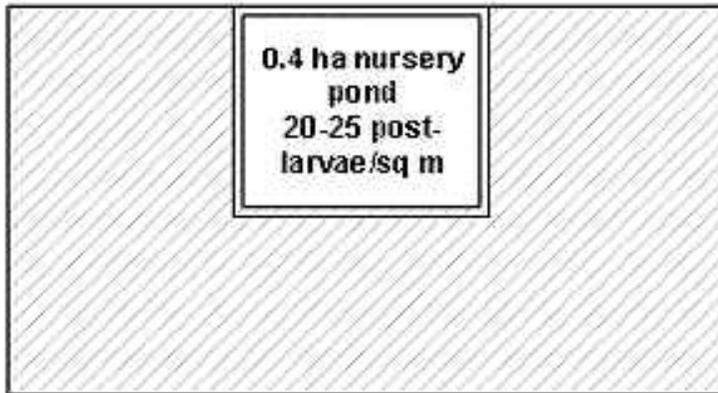
## **Select the correct season for stocking shrimp fry**

Shrimp post-larvae are sensitive to climatic changes. Low yields and disease have been experienced when shrimp post-larvae are stocked during rainy or cold months.

During cold months, temperature fluctuation in a day usually exceeds 2°C. Temperature less than 20°C causes harm to shrimp post-larvae. Other reasons for avoiding the rainy season are:

- Sudden salinity decline in water is very stressful to shrimp post-larvae.

- Low salinity affects the molting process resulting in slow growth.
- Heavy loading of silt and suspended solids increases sediment accumulation (leading to depletion of oxygen in the water).



## Establish a nursery pond

A nursery pond will provide a predator- and competitor-free environment to enhance the survival of post-larvae. Supplementary feeding of shrimp fry in the nursery will be more effective than feeding the post-larvae in the main pond.

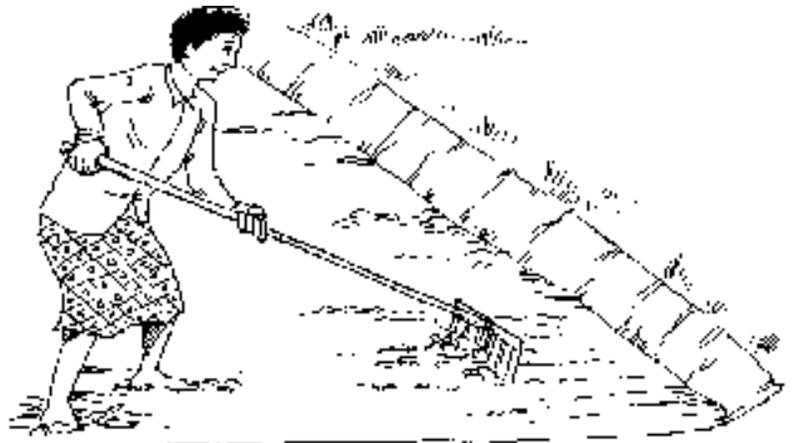
In establishing the pond, remember the following.

- A 0.4-ha nursery compartment pond should be set aside within a 6-ha pond.
- Larger ponds should have two or more nursery compartments rather than one big nursery compartment.
- Do not stock more than 20 to 25 post-larvae per square meter.

## Nursery preparation before stocking

1. Dry the pond bottom thoroughly to reduce organic waste load and remove predators and competitors that entered the pond during the previous culture. Take note of the following:

- After drying the pond, scrape the surface of the pond bottom to remove the waste. When scraping, avoid exposing the subsoil, which may contain acid sulphate layers.
- Avoid waste accumulation on pond dikes. Remove and dispose of accumulated waste away from the pond so that the rain will not wash it back into the pond.



- Dry and wash the pond bottom again after scraping and plowing.

2. Apply lime to the pond to correct the soil pH and neutralize the acidic layer in the pond bottom and dike surface. Liming will also disinfect the pond. Spread lime all over the pond bottom, applying more on areas that remain wet. Also spread along dike walls up to the top of the dike.

Agricultural lime or dolomite is better than hydrated or quick lime because of its buffering action that can regulate the pond pH. Always remember to use the right amount of lime.

### Types of lime

- Agricultural lime/limestone or crushed shell (calcium carbonate or  $\text{CaCO}_3$ ); use lime with more than 75% calcium carbonate as it does not cause a dramatic increase in pH.
- Hydrated lime [calcium hydroxide -  $\text{Ca(OH)}_2$ ] can cause a dramatic increase in pH. Do not apply this type of lime in the afternoons when pH would normally be at its highest.
- Quick lime/burned lime or burned shell lime (calcium oxide -  $\text{CaO}$ ) causes dramatic increase in pH and should not be used in ponds with shrimps. Use this to control very low soil pH during pond preparation.
- Dolomite [calcium carbonate -  $\text{CaMg}(\text{CO}_3)_2$ ] can increase pH gradually.



### Use the correct amount of lime

The correct amount of lime depends on the type of lime to be used and soil pH. Use the following table to select the type and quantity of lime.

Soil pH	Quantity of dolomite or agricultural lime (mt/ha)*	Quantity of calcium oxide (mt/ha)*
6.0 - 7.0	1.0-2.0	0.5-1.0
5.0 - 6.0	2.0-3.0	1.0-1.5
less than 5.0	3.0-5.0	1.5-2.5

\* 1 mt (metric ton) = 1,000 kg



3. After liming the pond bottom, fill the pond with 30 cm of water and add fertilizer. It is necessary to fertilize the pond water to grow natural food (plankton) in the water. Some common fertilizers used are:

- inorganic fertilizer: urea and trisuper phosphate (TSP)
- organic fertilizer: cowdung

The usual fertilization amounts are as follow.

- First application: 1 kg of urea and 1 kg of TSP or 6-10 kg of cowdung per ha.
- Before the second application, leave the pond for 3-4 days until the pond water turns green- brown in color.
- Completely fill the pond with water.
- Second application: 1 kg urea and 1 kg TSP per ha each day for 5-7 days or 6-10 kg cowdung per ha every 2-3 days for 12-15 days.
- Do not apply cowdung daily because it is slow acting; daily application might overfertilize the pond.
- Applying more fertilizers if the pond water does not turn green-brown. As a last resort, add some green water from a known pond.

4. Control the entry of predators and competitors. The practice of stocking shrimp post-larvae into ponds containing other species favors predation soon after stocking, thus, causing significant production losses. To avoid this, do the following.

- Screen the incoming water through a nylon net screen with 576 holes per square inch or 24 holes in a linear inch.
- Use two net screens: a straight net screen fixed into a frame and placed in the gate at the outer side of the pond and a filter bag net screen (2 - 3 m long) fixed into the gate at the inner side of the pond.

## **Provide supplemental food for post-larvae**

Supplemental food helps increase the survival and growth of shrimp before being released into the main pond. Large and healthy shrimp can avoid predation and withstand unfavorable conditions in the main pond.

Use the best quality feed that can be afforded. Own preparation of supplemental food would be advantageous, especially if available commercial post-larval feeds are too costly.

### **Supplemental food**

- Use chopped fish, rice bran and cooked rice or potato. Mix the ingredients, using the following percentages:

<b>Ingredient</b>	<b>Percent by weight</b>
Whole fresh fish	50-60
Rice bran	20

Cooked rice/potato

20-30

- Mash all the ingredients and rub through a sieve in small bits (2 mm in diameter). If shrimp fry are large enough, use larger pieces about 4 – 5 mm diameter.
- Sun dry the feed for six hours before using.
- Do not use shrimp, mussel, clam or cockle meat as it might transmit virus infections.

The following daily food amounts are recommended for a nursery stocked with 20-25 post-larvae/sq m:

<b>Period (days)</b>	<b>Feed per day (kg)</b>	<b>Expected survival (%)</b>
1–7	0.8-1.4	100-86
8–14	1.5-2.2	84-71
15–22	2.4-3.2	70-63
23–30	3.3-4.1	62-60

## **Feeding**

- Feed four times a day, preferably between 7-8 a.m., 11 a.m. to 12.00 noon, 4-5 p.m. and 10-11 p.m.
- Feed 25% of the daily food ration on each occasion.
- Dampen the food before adding into the pond.
- Spread the food in an area not more than 2-4 m from the slope of the dike, as this is where healthy post-larvae usually stay.

## **Perform regular health checks on shrimps**

There are two ways to perform health checks during culture:

1. observation from the dike; and
2. observation of sampled shrimp.

### **Observation from the dike**

### **Observation of sampled shrimp**

- Avoid doing the observation during hot afternoons as handling would stress the shrimp.
  - Make the observation fortnightly.
  - The following conditions would indicate that the shrimp is normal. If

anyone of them is not observed, then there might be a disease problem.

### **Characteristics of a normal and healthy shrimp**

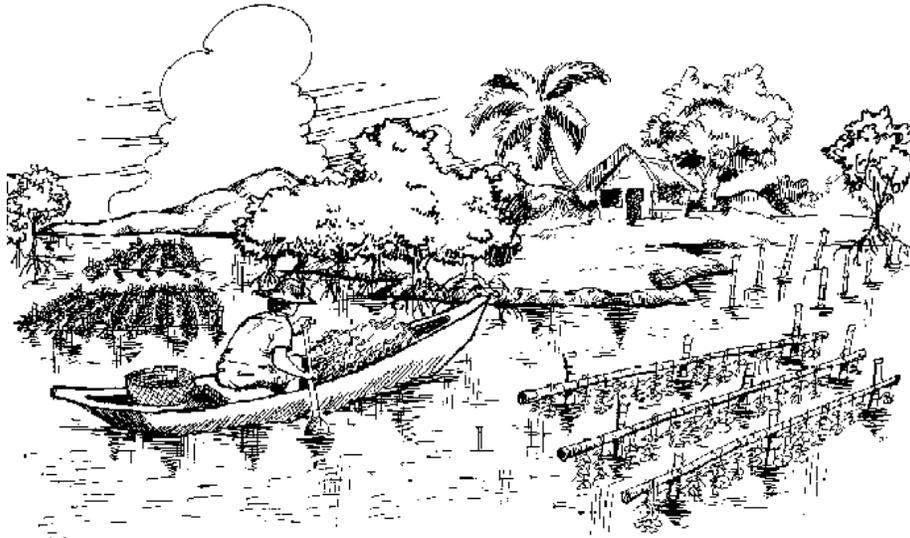
- Appendages are clean.
- No blackening of appendages.
- Tail is not swollen or eroded.
- The body color is greenish cream.
- The body is clean and shiny.
- The shell is not soft or does not crack easily.
- The gills are clean, shiny and has a cream color.
- Hepatopancreas has a yellowish green color, not shrunk or enlarged.

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# Farmers' Methods of Oyster and Mussel Culture in the Philippines



Oyster and mussel farming can be a source of livelihood for coastal communities. Though it may not be the main source, it can contribute significantly to household income and food. Women and children can also participate. Oysters and mussels are delicious and very good sources of protein, carbohydrates, vitamins and minerals, and thus have good market value.

In the Philippines, the cultured species are the slipper-shaped oyster (*Crassostrea iredalei*) and the green mussel (*Perna viridis*). Several culture methods for oyster and mussel farming have been reported but only a few deal with the farmers' methods. The culture methods described here are based on farmers' practice and are farmer-proven.

## Site selection

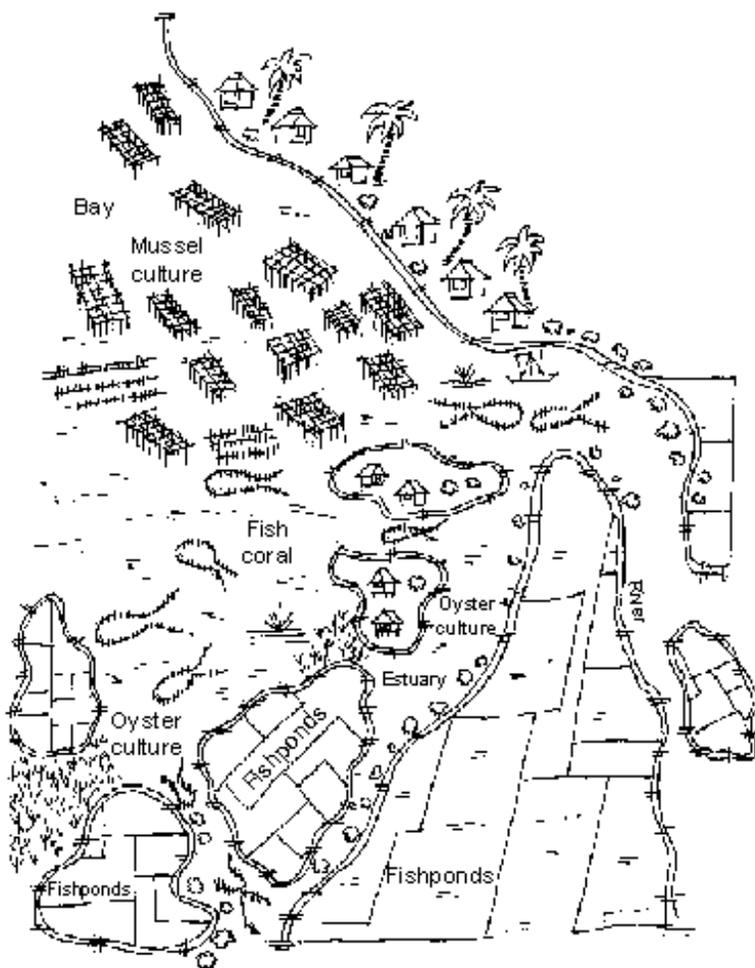
Oysters and mussels grow in brackish and salt-water areas. Specifically, oysters grow well in estuaries where salinity is lower due to the mixing of fresh and seawater. Mussels grow better in bays where salinity is higher than in estuaries. Oyster farms are generally located in shallower areas than mussel farms.

## Characteristics

Most of the information presented is based on the study of oyster and mussel farming in Western Visayas, Philippines conducted by a SEAFDEC/AQD multidisciplinary team. The Western Visayas region is a major producer of oysters and mussels in the Philippines.



*Perna viridis* is also cultured in other Asian countries. Other species of oysters are also cultured in the region.



Presence of a natural population of oysters or mussels. This makes seed collection and growing easier and inexpensive. In areas where there is no natural population, seeds may be collected from other places and transplanted for growing.

Good growth of wild or farmed oysters or mussels in the area. This indicates the abundance of natural food and the feasibility of farming oysters or mussels.

Proximity of farm site to residence for easy monitoring and guarding against poaching, a big problem among farmers.

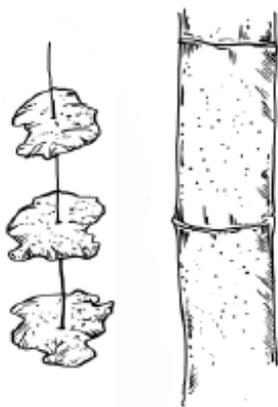
Water current for the transport of food, waste and silt.

Availability of farm site (without obstructing navigation).

Protected from strong winds and waves to avoid damage to farm structures.

Free from domestic and industrial pollution.

### Seed collection



Seeds are collected directly using substrate materials such as empty oyster shells, or the bamboo poles used in growing oysters or mussels.

By experience, farmers know the periods when seeds are abundant in the area. In Western Visayas, farmers reported using some indicators such as the presence of barnacles on the substrate materials as this would be followed by attachment of oyster or mussel seeds. The water also becomes itchy, yellowish with lots of bubbles.

These indicators are difficult to explain but they may be related to seasonal change. According to oyster farmers, the seeds are abundant when seawater mixes with freshwater in the estuary during full or new moon.

The presence of seeds is checked through ocular inspection of the substrate materials to see whether their surfaces have become rough with the presence of grain-size spots.

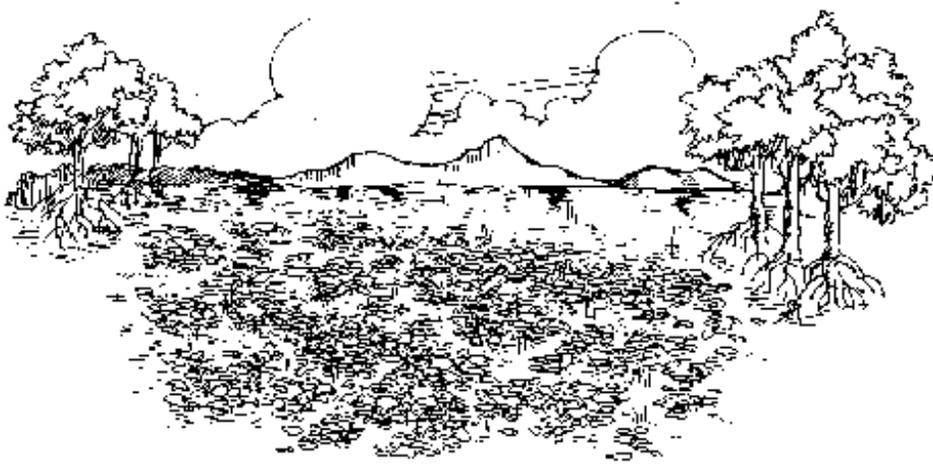
When culture is developed in a new area, a careful observation for a year or two will reveal the local seasonal pattern. Abundance of mussel seeds is pronounced during certain months of the year depending on the locality. Oyster seeds are generally available throughout the year.

### Culture methods

Most oyster farmers learned the culture methods from other farmers in their neighborhood. They imitate the culture method that has been found productive and profitable by other farmers.

## Oyster

The methods commonly used for oyster culture are bottom, stake and hanging either from a rack or raft-rack. The stake method is the most commonly used but the hanging method is the most productive followed by the stake then the bottom method. Bottom and stake methods are used in shallow (intertidal) areas, whereas the hanging method is used in deeper areas.



### Bottom

This is a natural way of growing oysters. This method is suitable for intertidal areas (exposed during low tide) or areas where structures obstructing boat navigation are not allowed.

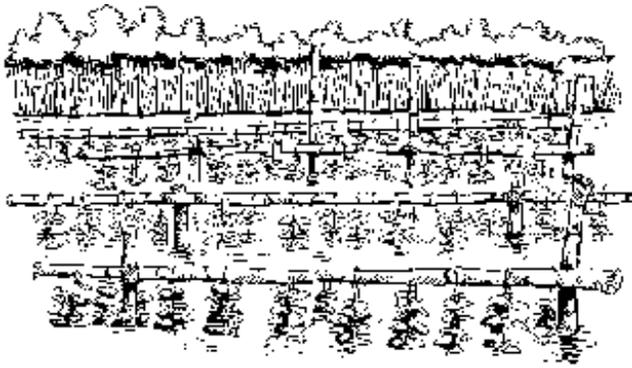
In this method, empty oyster shells are scattered or broadcast to serve as substrate for oyster seed to attach to and grow on. This method may be the least costly but mortality due to siltation and predators is very high.

### Stake

In stake method, farmers use one or a combination of different materials such as bamboo (*Bambusa* spp.), mangrove tree branches and nipa petioles.

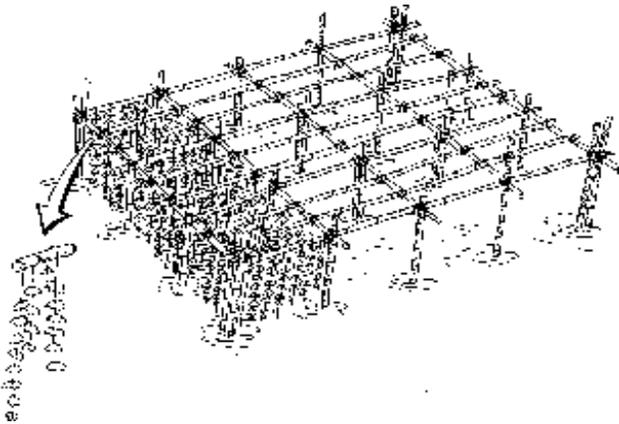


Stakes are about 2 m long with 0.6 m embedded in the bottom. They are placed 0.7 m from each other and are usually arranged in rows 0.8 m apart.



## Rack hanging

Racks are usually made of bamboo poles although some farmers use wood. Racks may be as high as 4 m and 1 m apart for easy boat navigation during monitoring and harvesting. Empty oyster shells are strung at a distance of about 20 cm from each other (1.4 m long) and hung from the rack. On a nylon string, empty shells are spaced at 14 cm from each other by knots. Some farmers use old tires (halved or whole) of motorcycle, bicycle, truck, or jeepneys as hangings.

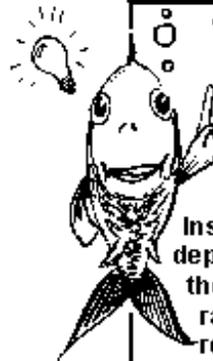


## Raft-rack hanging

Many oyster farmers do not adopt the raft method recommended in many literatures because it requires artificial floats and is, therefore, expensive. However, based on the survey, farmers use a less expensive raft made of bamboos only. Called the raft-rack method, this is a modification of the rack that floats during the early stage.

## Procedure

1. Construct a raft using bamboo poles with spacing of 20 cm.
2. Stake the bamboo poles on the four corners to set the position of the raft-rack.
3. Hang the strings of empty oyster shells from the raft at about 20 cm apart. The string of empty oyster shells should be about 1 m long, depending on the water depth at low tide. More hangings may be placed on the raft but other hangings are transferred to additional rafts in the later part of the culture period.
4. Allow the raft to float and adjust it according to water level for the first two to three months. Thereafter, when the oysters are too heavy for the raft, tie the raft to the bamboo posts at 1-3 m above the bottom, depending on the water depth.
5. Stake additional bamboo poles to further support the heavy raft.



### Tips

As oyster farms are usually located in estuaries (i.e., river mouth), the stake method is not recommended because the stakes impede water flow causing sedimentation. Instead, when possible and depending on the water depth, the hanging method -- either rack or raft-rack -- is recommended. Hangings are removed during harvest, allowing the water current to wash away the silt.

## Reasons of farmers for adopting stake, rack hanging and raft-rack hanging methods of oyster culture

Bottom	Stake	Rack hanging	Raft-rack hanging
<ul style="list-style-type: none"> <li>■ Inexpensive</li> <li>■ Good growth of oysters</li> </ul>	<ul style="list-style-type: none"> <li>■ Inexpensive and can make use of locally available materials</li> <li>■ A traditional method in their area</li> <li>■ Productive</li> <li>■ Easy to manage (less risky even during flood)</li> <li>■ Oysters not easily stolen</li> <li>■ Less laborious</li> </ul>	<ul style="list-style-type: none"> <li>■ Less expensive than raft method</li> <li>■ Productive</li> <li>■ Ease in harvest even in high tide</li> <li>■ Popular method in their area</li> <li>■ Ease in seed collection</li> <li>■ Good growth of oysters</li> <li>■ No sedimentation in the farm site</li> </ul>	<ul style="list-style-type: none"> <li>■ Productive</li> <li>■ Ease in harvesting</li> <li>■ Relatively new method that is worth trying</li> </ul>

## Mussel

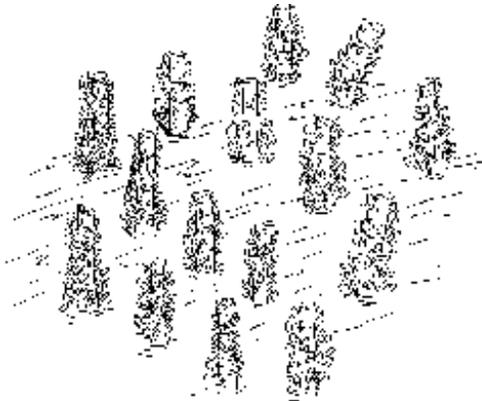
Mussels are cultured by bottom, stake or raft method. The stake and raft being off-bottom methods are used in relatively deep waters (2-4 m at low tide and 5-8 m at high tide), while the bottom method is used in shallower areas (0.60 m at low tide and 3.6 m at high tide).

### Bottom

This method of growing green mussel is not reported in other literatures but it is used by farmers in a certain locality where the seed collection site is far from their residence. Since growing the mussels in the same area could result in poaching, mussel seeds are collected from the bay using bamboo poles. After one to two months, the mussels are removed from the bamboo poles and laid at the bottom of estuary near the farmers' residence.



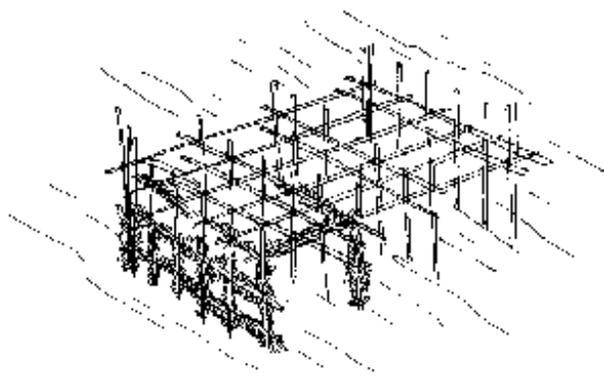
### Stake



**Mussel culture using the stake method results in higher production compared to the raft method. In the stake method, the productivity (natural food abundance) of the whole water column is maximized, while in the raft method, only near-surface productivity is utilized.**

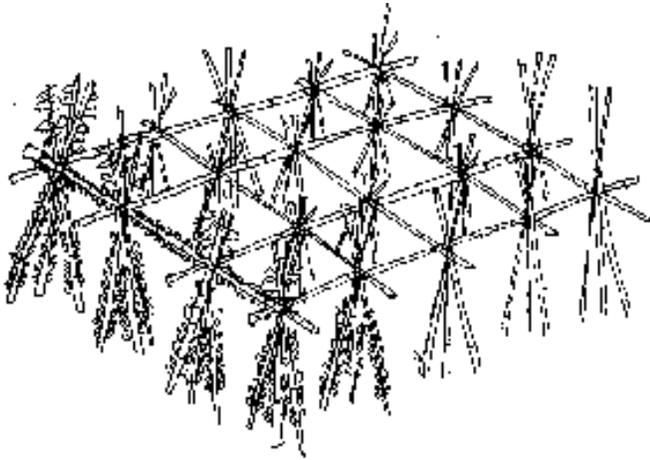


Bamboo is the most commonly used material in the stake culture of the green mussel. Some farmers use a combination of bamboos, coconut fronds and nipa petioles. Others attach old fish nets to their stakes.



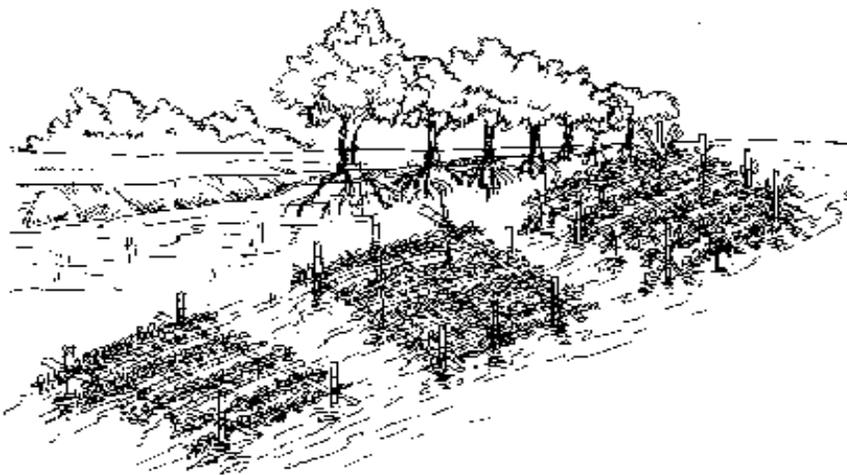
The manner of staking differs according to water depth and strength of water current in the farm site. In areas where the water current is strong and the farming area is deep, full-length bamboos (10 m) are staked 1 m apart and tied to 3-5 layers of horizontal braces. In other farming areas where water is not so deep and water current is not so strong, bamboo poles are simply staked without being tied to horizontal braces.

**Some variations of the stake method**



**Raft**

Raft culture of the green mussel differs from the usual system, which uses floats, anchors and hangings. Farmers use a different and less expensive raft made of several bamboos, which serve both as seed collector and substrate for growing, but without hangings.



The raft is allowed to float within the confines of the bamboo posts during the first two to three months. Thereafter, when the mussels become too heavy, the raft is tied to posts at a fixed position in the water. Additional posts may be added to further support the heavy raft.

**Reasons of farmers in adopting stake or raft method of mussel culture**

**Stake**

- Productive
- Popular or traditional method in the area
- Ease in harvesting particularly where stakes are nipa petioles and coconut fronds

**Raft**

- Good growth and high production
- Popular method in the area
- Ease in management and harvesting
- Maximize use of bamboos (can be reused)
- No sedimentation effect (raft can be transferred or moved to allow washing away of silt)

## Maintenance and management

Bed degradation (i.e., sedimentation), pollution (domestic or pond chemical effluents), occasional lack of seeds (especially for mussel), and biofouling (attached organisms) are some problems reported by oyster and mussel farmers. Many farmers admitted that sedimentation is primarily caused by their farm structures, particularly stakes. Their solutions to these problems include:

- removing stakes after harvest or moving the raft to another available space (but very few farmers do this);
- cleaning or removing biofoulers such as sponges, barnacles, filamentous algae (more mussel farmers do this than oyster farmers); and
- maintaining broodstock (big oysters or mussels) in the farm to ensure a steady supply of seeds.



### Tips

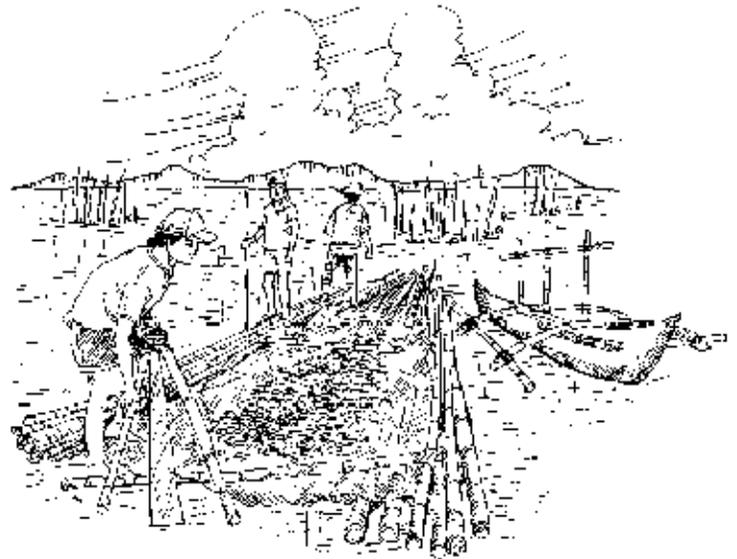
- The stake method of mussel culture may be used only in deep areas with strong water current to avoid sedimentation.
- The bottom method should be used in areas with hard (non-shifting) bottom to avoid mortality due to siltation

Some farmers remove some oysters or mussels in overcrowded substrates to allow faster growth of remaining oysters or mussels. Removed oysters or mussels are either marketed or transferred to another growing area or substrate.

## Harvesting and post-harvest practices

Oysters are harvested when they are 7-8 cm (3 inches) long or 10-12 months after seed collection. But harvesting can also be done at six to eight months, if oysters have good growth. On the other hand, mussels are harvested nine to 12 months after seed collection.

Oysters and mussels cultured using the bottom method are harvested during low tide by taking them from the muddy bottom and placing them inside a sack. In stake culture method, bamboo poles are pulled and hauled to the boat or raft where the mussels are scraped off using a bolo (large knife) or boat paddle. In hanging method, the strings of oysters are simply removed from the rack and placed in the boat for subsequent cleaning and washing. However, if harvesting is partial, big oysters are removed from the clusters using a bolo. Mussels cultured using raft method are harvested by cutting the ropes assembling the raft, hauling the bamboos to the harvesting raft with net flooring, and scraping off the mussels using either a paddle or bolo.



Harvested oysters or mussels are cleaned by placing the harvest in a basket, sack, or screen nets and shaking them underwater (seawater) to remove mud, algae and other attached organisms. Cleaning tools such as brush or bolo are also used to scrub and scrape attached organisms. After cleaning the oysters and mussels, sorting by size is done to make it easier for the buyer to price the products when reselling to market retailers.

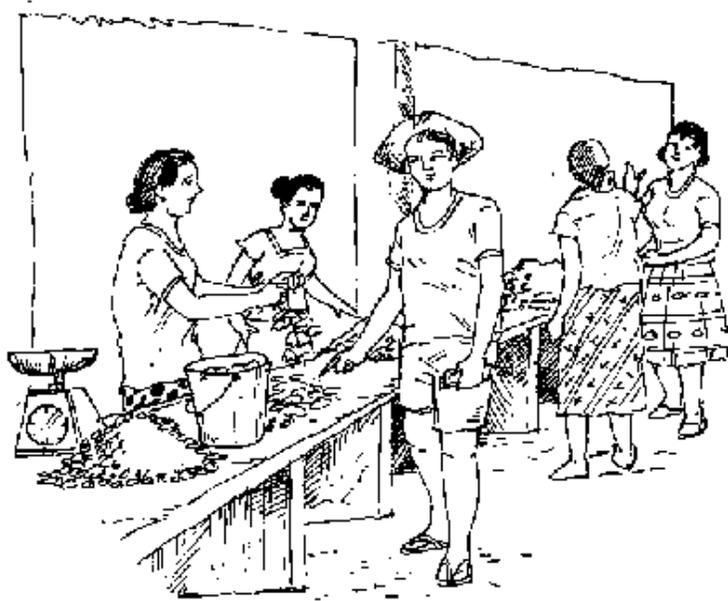


## Marketing

Oysters and mussels are sold either as:

- shell-on fresh;
- shell-on cooked;
- shucked (meat removed from shell) fresh; and
- shucked preserved.

Shell-on fresh is the most preferred form by buyers who are mostly household consumers and restaurant owners. The buyers can then choose the kind of cooking desired by family members or customers.



**Costs and returns of a 1000 sq m oyster or mussel farms, by culture method (US\$1 = P45)**

	Bottom	Stake	Rack hanging	Raft-rack	Stake	Raft
<b>Returns</b>	2804	10937	16979	61110	40253	22968
<b>Costs</b>						
<b>Operating costs</b>						
Materials	265	5393	7891	33428	19613	8147
Hired labor	10	970	1235	3881	5513	3508
Miscellaneous	189	277	184	142	1055	715
<b>Total</b>	464	6640	9310	37451	26181	12370
<b>Non-cash costs</b>						
Unpaid owner labor	220	871	1946	4952	1102	941
Unpaid family labor	245	871	1197	3047	992	706
Depreciation	266	950	815	2075	1568	3321
<b>Total</b>	731	2692	3958	10074	3662	3321
<b>Total production costs</b>	1195	9332	3268	47525	29843	15691
<b>Operating income</b>	2340	4297	7669	23659	14072	10598
<b>Net farm income</b>	1609	1605	3711	13585	10410	7277
<b>Rate of return on capital investment (%)</b>	58	80	138	478	196	134
<b>Payback period (year)</b>	1.7	1.3	0.7	0.2	0.3	0.4

*\*Includes municipal permit, boat rentals, transportation fees (not enough data on bottom method of mussel culture, thus, no analysis)*

**Source:** Samonte G. P. B., W. G. Gallardo, R. F. Agbayani, S. V. Siar, R. S. Ortega, R. E. Tumalian, D. Z. Bermejo and L. A. Espada. 1993. Socio-economic study of oyster and mussel farming in Western Visayas, Philippines. Asian Fisheries Social Science Research Network Report. Southeast Asian Fisheries Development Center, Aquaculture Department. 177 pp.

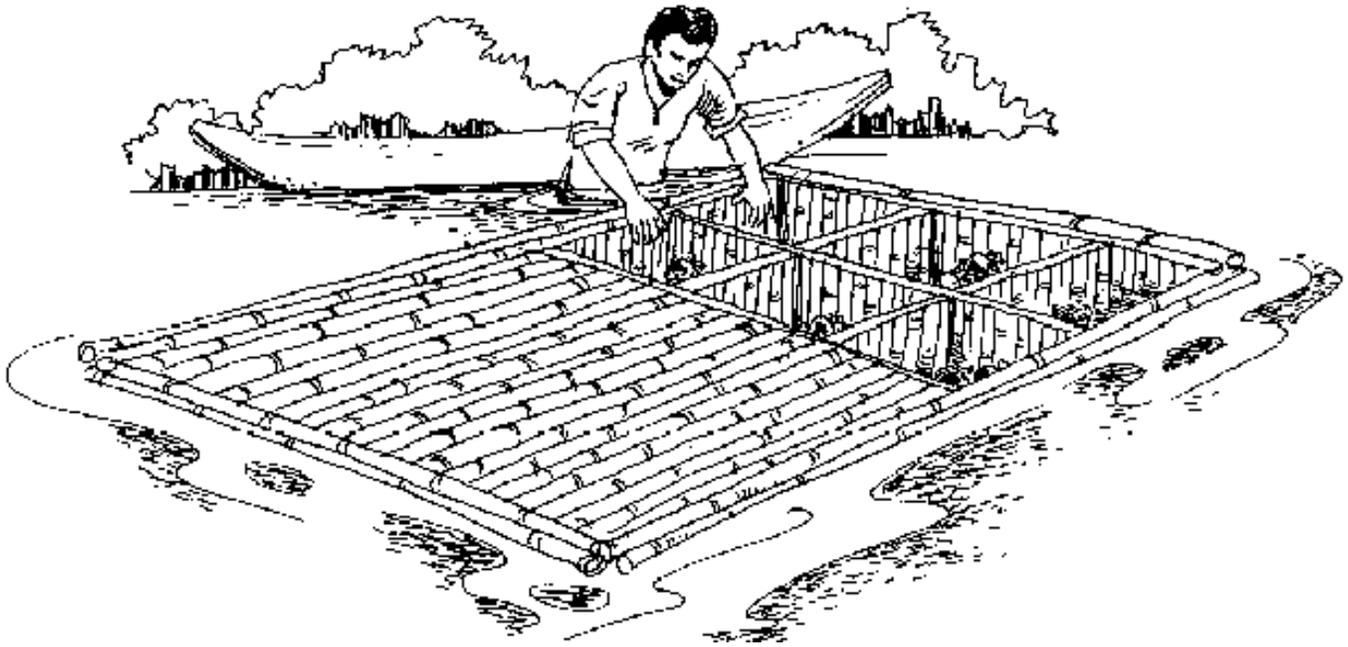
## Conclusion

In oyster culture, the raft-rack hanging method gives the highest yield and income compared to rack hanging, stake or bottom method whereas in mussel culture, the stake method gives better results than

the raft method.

Farmers' methods of oyster and mussel culture by raft-rack hanging and raft methods, respectively, are productive methods, which have not been sufficiently documented in other literatures.

# Mud Crab Systems for Small-Scale Aquaculture



Mud crab farming has traditionally been a small scale activity, originating in China over 100 years ago and spreading across Asia over the last 40 years. Its close affinity to coastal mangrove areas within the Indo-West Pacific limits mud crab fishery to coastal, artisanal style fishing. It was, therefore, natural for fishermen to improve the value of their catch by retaining both underweight and juvenile crabs for rearing purposes. As a family level occupation, mud crab farming proved to be quite profitable, provided there was a sustainable seed supply from the local fishery.

The traditional trade in mud crab has been for hard-shelled crab products, namely meat crab and egg crab. However, in recent years the market for mud crab products has extended to soft-shell crab and processed crab meat.

**Mud crab belongs to the genus *Scylla*. There are four mud crab species currently being recognized for culture purposes:**

1. *Scylla serrata*
2. *Scylla paramamosain*
3. *Scylla olivacea*
4. *Scylla tranquebarica*

**Mud crabs are temperature and salinity tolerant (12-35°C and 2 to 60 ppt, respectively). They are amphibious (they can breathe both in or out of the water). They can crawl out of the water when water quality is sub-optimal and they can avoid the desiccating effects of the sun by burrowing. As such, holding facilities with tidal water exchange can be used and can even be drained completely without any detrimental effects to the crabs. The movement of crabs out of the water and/or burrowing indicate a problem with the water quality, which requires changing the water in the system.**



### Various mud crab products

- **Egg crab** – mature female crabs with mature gonads.
- **Meat crab** – adult crab sold as a live animal. Male mud crabs are more desirable due to their large claws (in a mature male up to 45% of total body weight).
- **Soft shell crab** – recently molted crab, whose shell is still soft.
- **Processed crab meat** – crab meat removed from the shell and usually marketed cooked and canned.



Meat crabs are the only mud crab product most applicable to small-scale aquaculture. The other products require high investment both in terms of technology and food supply. Also, there are environmental considerations with soft-shell and egg crab farming, as they tend to exploit parts of the natural crab population that are most sensitive to overexploitation by requiring a high turnover of juvenile and pre-spawned females, respectively. For these reasons, the rest of the paper will concentrate on production of meat crab.

## Two types of meat crab culture

### 1. Fattening

This is the holding of fished crabs that have recently molted (also known as thin or "watery" crabs) for 10 - 30 days until meat weight has increased.

### 2. Grow-out

This is the process of stocking juvenile crabs (10 g to 100 g) and allowing them to molt and grow. Harvest is after 3-8 months or once the crabs reached 200 g to 500 g size.



Mud crab fattening is the most suitable for small-scale aquaculture because:

- Turnover is fast, hence, the period between investment and returns is short.
- Fattened crabs can be stocked at higher densities (15 crabs/sq m) compared to grow-out systems (1 crab/sq m) as no molting occurs and therefore losses to cannibalism are dramatically reduced.
- Short production time reduces the risk of losing crabs to disease, thus, rendering a higher survival rate for fattening (>90%) compared to grow-out systems (40%).

In addition, crabs can be traded in small numbers as mud crabs are valuable as individual animals. This means that farmers can hold small numbers of mud crab at a moderate stocking density and still make a reasonable profit. Meat crabs can be farmed in ponds, cages and pens both using the fattening or the grow-out systems of stocking and harvesting.

## General considerations

### Seed supply

At present, hatchery-produced mud crab seeds are not widely available. Therefore all crabs used to stock the mud crab systems are caught by the systems' operators themselves and/or

are bought from local fishermen.

## Feed

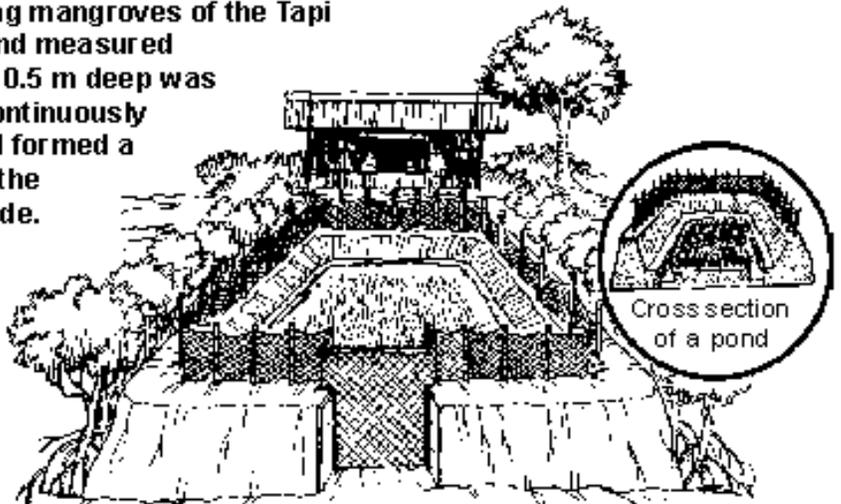
Mud crabs are carnivorous and scavengers. In all cases, the mud crabs are fed with locally caught fish species, which have a low market value. These low value fish species are harvested by the mud crab farmer themselves or are bought locally from other fishermen.

## Pond culture

Earthen ponds are most commonly used in small scale culture of mud crab. Small ponds are built in the homestead (200 sq m or less). Farmers usually build a fence around the perimeter of the pond to prevent crabs from escaping to keep away predators. The fence can be made of a range of materials, e.g., roofing tiles (Vietnam), concrete slabs (Sri Lanka), polyethylene sheets (Philippines) or mesh (Vietnam/Thailand). A simple sluice gate is used to allow water exchange. The method of stocking, feeding and harvesting as well as the level of pond maintenance varies widely from farmer to farmer. The example below is of a very simple system observed in Surat Thani province, Thailand

### **Pond culture of mud crab in Klong Mai Ban, Surat Thani, Thailand**

The homestead was set in the remaining mangroves of the Tapi river, Surat Thani Province. A single pond measured about 9 m x 9 m. A canal 1 m wide and 0.5 m deep was dug around the edge of the pond and continuously filled with water. The center of the pond formed a raised platform with vegetation, which the crabs could use as refuge during low tide. Water exchange was tidally controlled. Polyethylene netting was used to prevent the crabs from escaping. Any underweight crabs caught were returned to the pond along with supplemental stocking of thin crabs bought from other fishermen. Feeding depended on availability. Low-value fish, mangrove snails, crabs and horse mussels were fed to the mud crab. Fattening took 30 days.



## Cage culture

Cage culture of mud crab makes use of estuaries, lagoons and brackishwater ponds. Floating cages, made of bamboo or polyethylene/galvanized wire net, are mainly used for mud crab fattening. The cage culture of mud crabs has been used in the Philippines and Indonesia. These cages can include those that are divided into compartments for individual crabs, thus reducing the mortalities due to aggression and cannibalism. The cages are floated using plastic floats and empty oil barrels to keep the upper side at surface level. A mesh screen is needed on top of the cages to prevent the crabs from escaping. Cages will allow individuals who do not have access to land to farm mud crab.

### **Pen culture**

Pen culture has been used for grow-out of mud crab in the Philippines and Sarawak, East Malaysia. This method integrates the system of crab rearing with the coastal mangrove forests, which does not involve the clearing of mangroves to construct ponds. Instead, the mangrove forest is penned-off and stocked with crabs. The pens can be made of plastic netting supported with a bamboo network (as in the Philippines) or made of wood (as in Sarawak). They rely on tidal water exchange and supplemental feeding. Pens for culturing mud crabs may also be constructed within ponds and shallow rivers.

### **Mud crab fattening in cages in Indonesia**

A recent study has been carried out on the fattening of mud crab using floating cages placed in *tambaks* – or large extensive tidally-fed ponds. These *tambaks* are used for farming milkfish (*Chanos chanos*). The cages are 9 sq m with a stocking rate of 10 crabs/sq m. The average size of the crabs stocked is 350 g. The crabs are fed, approximately 10% crab body weight, with dried fish and small crabs caught from the *tambaks*. The crabs are held for 20 days before harvesting (450 g each). The survival rate is over 85% of the crabs stocked.

## Pen culture of mud crab in the mangroves of Sematan, Sarawak

In 1992, the Department of Agriculture, Sarawak, East Malaysia, introduced the pen culture system to Sematan to help artisanal fishermen improve their income and, at the same time, to conserve the mangrove resource.

The pens are constructed from trunks of the local palm (*Oncosperma tigillarius*) split into planks of about 6 cm x 9 cm x 370 cm. These strips are driven 1.2 m into the soil to form a pen which keeps the crabs in and any potential predators out. The pens have a 18 x 9 x 2.4 m dimension – 162 sq m. Within the stockade a ditch is dug about 0.3 - 0.9 m wide and 0.3 m deep. The ditch is continuously filled with water. Mangrove trees in the center of the pen provide shade for the crabs. Roughly 1000 to 1500 crabs are stocked per pen. These



crabs are usually about 100 g each. It takes about two months to complete stocking. The crabs are fed once a day during high tide with low-cost fish species and horse mussels. About 2.6 kg of food organisms are needed for every kg of harvested crab. The crabs are harvested 4 to 7 months later. Selective harvesting of crabs 300 g or more is used. The average net income from such a system is around Malaysian Ringgit (MR) 424.31/pen/month (US\$1 = MR 3.78) for a production cycle of five months. Although this system is more environmentally sound than pond culture, the rate of survival is low (47% of crabs stocked are successfully harvested). This is believed to be due to loss (escaping crabs) and cannibalism. Lower stocking densities have been suggested to remedy the situation.

## Integrated culture of *Scylla*

The mud crab has been shown to be a good polyculture species, particularly with finfish species (milkfish and Tilapia) and seaweed (*Gracilaria*). An example of this is in the Thai Binh Province, North Vietnam. Mud crabs also have the potential to be farmed in coastal rice fields during the dry season.

## Advantages of mud crab culture

1. Mud crab is a high-value species and its culture can significantly increase the income of rural coastal communities.
2. The technology required to culture crab is relatively uncomplicated (this refers mainly to ponds and pens) and can be easily disseminated to farmers.
3. Previously abandoned shrimp pond areas can be converted for crab culture with relatively little additional conversion costs, e.g., fencing to prevent

the crabs escaping from the ponds.

4. The mud crab has an international market (e.g., the restaurant trade in Singapore, Hong Kong, Bangkok and Taiwan) therefore the culture generates much needed foreign exchange.

5. Unlike exotic species, the mud crab is indigenous to the Indo-West-Pacific, therefore its market trading system is already well established within the region from fished mudcrab products. The transition to also include farmed crab will be relatively easy.

6. Transportation of mud crab is very simple. Individually tied mud crabs are transported in damp conditions in baskets from the pond to the market place. Moreover, crabs can be transported and stored in this way for three to four days.

### **Rice/crab farming in Tra Vinh Province, Vietnam**

Both crab growout and crab fattening are practiced in rice fields in Tra Vinh Province. In both cases, minor modifications are made to the rice fields, namely installing a mesh net around the perimeter or the area that is being used to farm crabs and deepening the waterways.

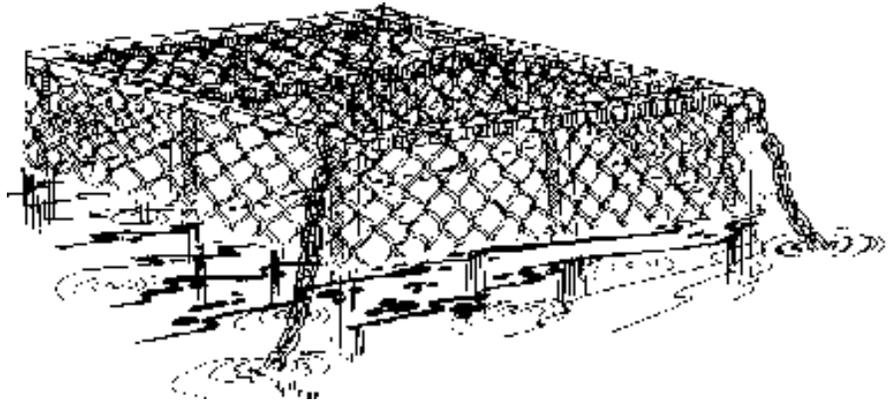
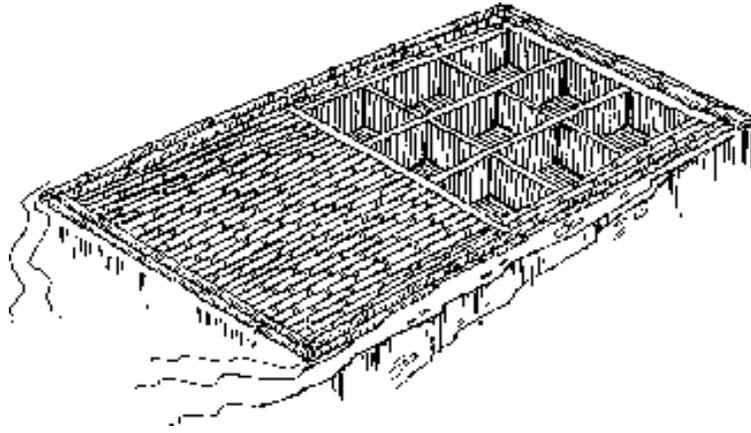
The grow-out system is an extensive system where the crabs are stocked and harvested but there is no supplemental feeding involved. Fattening requires feeding to improve the weight of the crabs in a short period of time; low-cost fish species are used to feed the crabs.

The grow-out systems proved to be the more profitable as smaller crabs, which were cheaper, were used to stock the ponds and there were no feed costs. However, survival was low in the extensive system, mainly due to cannibalism. Both systems are family run, extra labor only being employed during the harvest season.

This system is profitable as long as the salinity levels are kept low to ensure a good rice crop. It also helps farmers save money by avoiding the use of pesticides, which are detrimental to the health of the mud crabs.

The species of mudcrab found is *S. paramamosain*. It does not burrow, therefore, does not affect pond infrastructure.





7. Mud crab farming also involves other sectors of the community who do not have the capital or the land/water access to start crab farming themselves. These people may be involved in collecting food items or crab seed, providing labor for pond maintenance and guarding and harvesting of ponds, as well as transport of harvested crab to the marketplace.

8. The link between the mud crab and the mangrove provides an incentive to preserve the mangrove resource.

## **Constraints of mud crab culture**

1. A fundamental pre-condition for the future sustainability and expansion of the mud crab industry is a reliable seed supply, particularly in soft-shell crab farming, which has a high turnover of juvenile crabs (~ 80g each). Ongoing research into hatchery production of mud crab is starting to produce reasonable survival rates of crab seed. However it is still not on a scale that can be deemed economically viable. Thus, the expansion of mud crab farming is constrained by the availability of seed supply from the wild.

2. Crabs can suffer high mortalities from diseases similar to those that affected shrimps.

3. Although pen and cage cultures have been shown to be suitable for mud crab production, the majority of mud crab is cultured in ponds. This means that any expansion in mud crab farming is going to be influenced by the same issues that faced the shrimp

industry, including competition for coastal sites for ponds and pollution from over development.

4. The high value of mud crab makes it very attractive to richer sectors of the community and in some cases outside investors. This can marginalize the poorer households and prompt them to use less suitable locations to farm crab.

5. There may be competition for locally caught low-value fish species that could be protein sources for the poor members of the community. This potential conflict needs to be outlined and efforts are needed to find alternative sources of crab food.

## **Conclusion**

Mud crab culture is suitable to small-scale farmers as hardy and high value crabs can improve the income of the household even when small numbers are farmed in very simple culture systems. Soon hatchery-produced seed will be available to farmers, substantially reducing fishing pressure on wild crab stocks.

## **Reference**

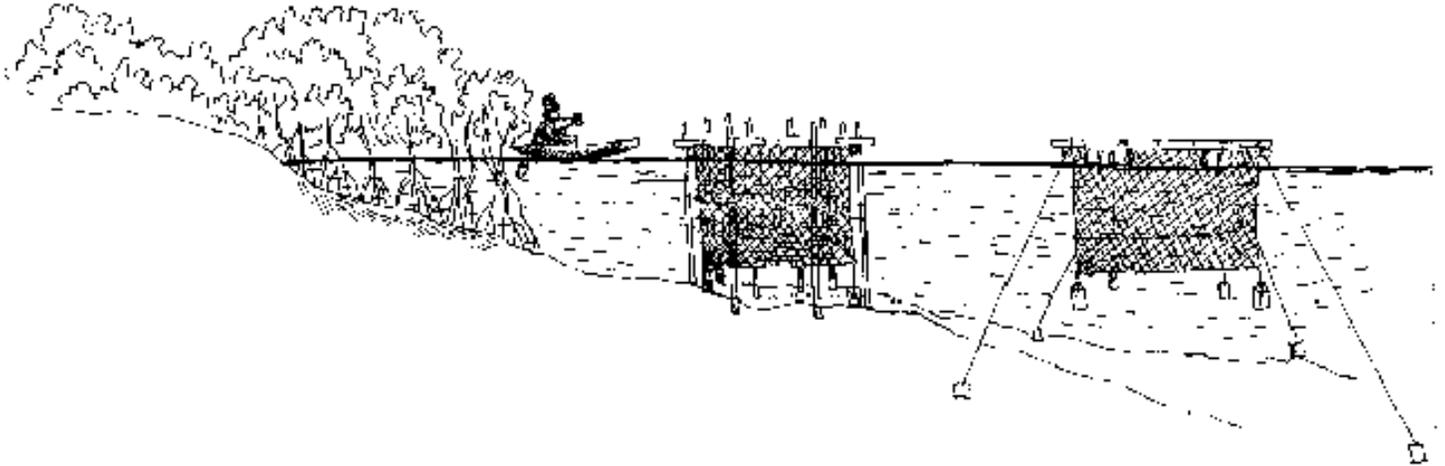
Keenam, C. P. and Blackshaw, A. 1999. Mud crab aquaculture and biology. Proceedings of an international scientific forum held in Darwin, Australia. April 21-24, 1997. ACIAR proceedings No. 78. 216 p.

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Prepared by:

**Julia Lynne Overton and R. K. U. D. Pushpakumara**

# Small-Scale Seabass Culture in Thailand



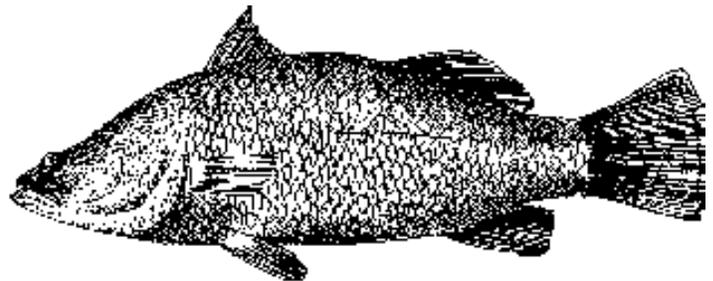
Seabass or giant sea perch (*Lates calcarifer*) has been cultured in Southeast Asia in marine, brackish and freshwater areas. This species is widely distributed in the tropical and subtropical areas of the Western Pacific and Indian Ocean. Its range of distribution includes Australia, Southeast Asia, Philippines and countries bordering the Arabian Sea. Seabass culture in Thailand is still small-scale compared to marine shrimp culture. The market for marine shrimp is global, while the market for seabass is largely regional.

## Advantages of seabass as a species for aquaculture

- Can tolerate wide range of salinity from freshwater to 35 ppt making it suitable for aquaculture in estuaries, river mouths, inner bays and mangrove swamps where the salinity condition is unstable
- Feeds and grows well in high turbid waters
- Fast growing
- Can tolerate high density conditions and handling stress
- Easily tamed for aquaculture conditions and accepts either fish flesh or artificial feeds
- Availability of eggs/fry in commercial quantities

## Spawning of seabass

Two major techniques are employed in mass production of seabass fry: artificial fertilization and induced spawning.



## Artificial fertilization

- Spawners are caught in natural spawning grounds where the water depth is about 10-20m.
- The degree of maturity is immediately checked.
- The unfertilized eggs are stripped directly from the female.
- The eggs are then placed in a dry and clean container with clean seawater and milt is added. A feather is used to mix the milt and eggs.

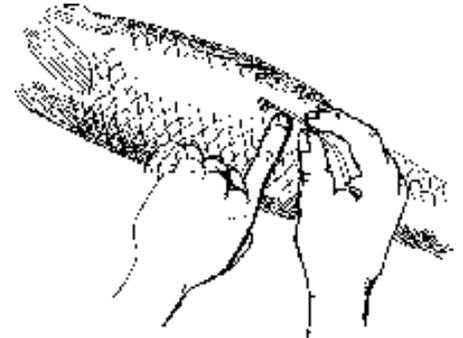
- Clean sea water is stirred into the mixture, which is then left for five minutes.
- The fertilized eggs are transported to the hatching tank.

## Induced spawning

Two methods are normally used for inducing seabass to spawn in captivity: hormonal injection and environmental manipulation.

### Induced spawning by hormone injection

- Seabass brooders are stocked in the pre-spawning tank for two months. The fishes are checked twice a month during spring tide.
- A polyethelene cannula is used to sample eggs from the female broodstock.
- The fish is either anesthetized or inverted gently with the black hood over the head. The cannula is inserted 6-7 cm into the oviduct. Eggs are sucked orally into the tube.
- The female is ready for hormone injection when the tertiary yolk stage (egg diameter 0.4 - 0.5 mm) is reached.
- Spawners maybe injected intramuscularly below the dorsal fin with the required hormone dosage.
- The fishes are transferred to the spawning tank and are expected to spawn within 12-15 hours after injection.



### Induce spawning by environmental manipulation

Steps in stimulating seabass spawning in captivity:

1. Change the water salinity to simulate fish migration.
2. Decrease the water temperature to simulate the decreased water temperature after rain.
3. Lower and subsequently add seawater to the tank to simulate the rising tide and the moon phase.

#### Hormone dose to induce spawning in seabass

	Male	Female
Puberogen	20-50	20-200 i[ /kg of fish
LHRHa	20-100	40 [g/kg of fish
HCG + pituitary gland of Chinese carp	250-1000	250-1000 i[ /kg of fish

**The fish will spawn in about 36 hours after injection. In case no milky white scum is produced (fatty texture) in 12-15 hours after injection, a second injection with double dosage should be given to female spawners.**

At the beginning of the new or full moon, the water temperature in the spawning tank is manipulated by reducing the water level to 30 cm deep at noontime and exposing it to the sun for two to three hours. This procedure increases water temperature in the spawning tank to 31-32°C. Filtered seawater is then added to the tank to simulate the spring tide. In effect, the water

temperature is drastically decreased to 27-28°C. The fish spawn immediately the night after manipulation. If no spawning occurs, manipulation is repeated for two to three more days, until spawning is achieved.

The fish will usually spawn for three to five consecutive days. Since seabass spawn intermittently by batch, the same spawners will continue to spawn during full moon or new moon for the next five to six months.

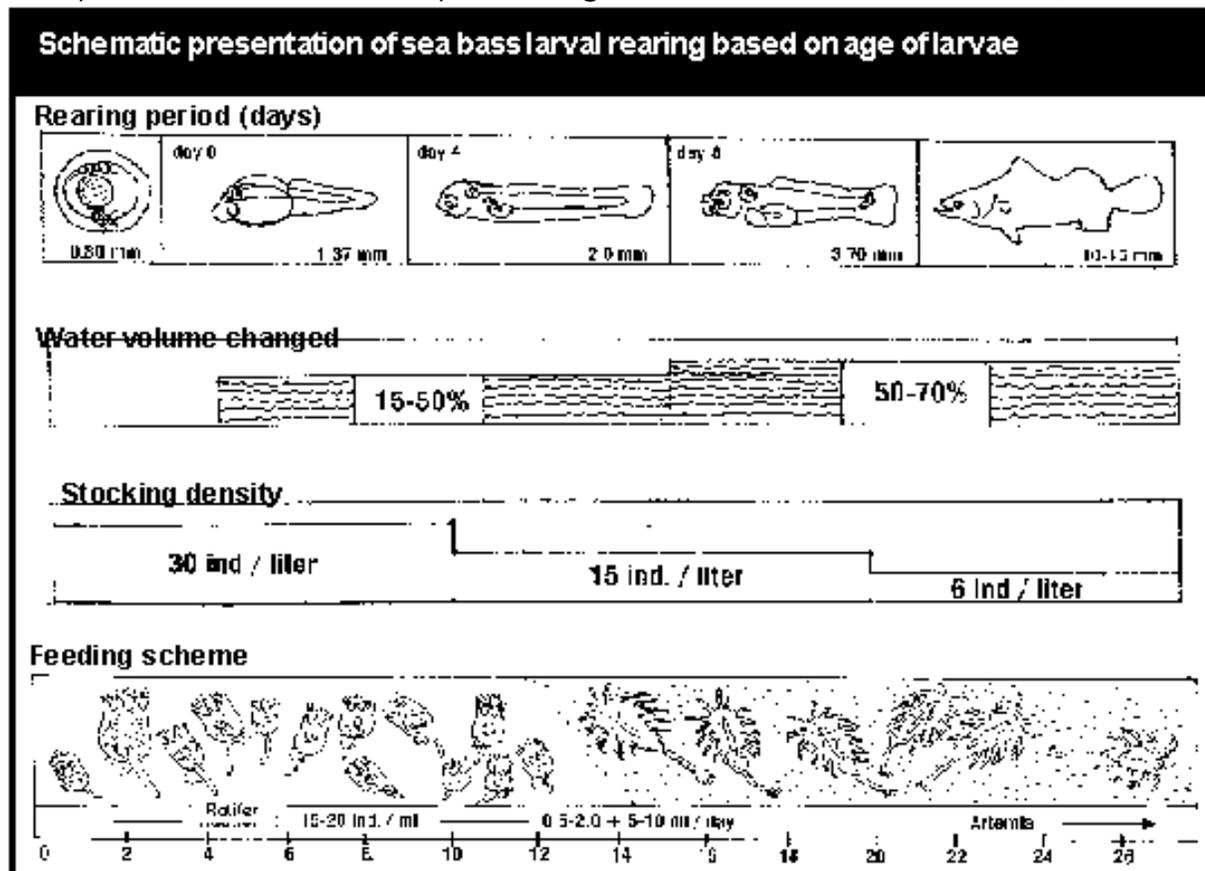
## Larval rearing

### Rearing tanks

- Fabricated from plastic, fiberglass, wood or concrete
- Rectangular or round shape
- Located outdoors, protected from strong heat and heavy rains by a roof tile cover

### Stocking density

- Newly-hatched larvae density in rearing tank is between 30-100 larvae/liter



### Feeds and feeding

- Green water (*Chlorella* or *Tetraselmis*) is added on the first day of rearing to maintain good water quality.
- Beyond three days, rotifers are introduced as feed and are maintained at a density of three to five rotifers/liter with green water.
- Under developing stages (ten-day-old larvae, juvenile and subadult), artemia and

minced fresh fish are available on demand.

## Grading

- Grading of size is needed for homogeneous growth and to minimize losses due to cannibalism.
- This process is done a week after the larvae have started to feed on artemia and every week thereafter.
- Grading trays used are made of plastic with many holes.
- Each tray has specific hole or mesh size which ranges from 0.3 - 10 mm.

## Nursery

- Fry from the hatchery are cultured.
- Solves the problem of space competition.
- Increases the fry survival rate.

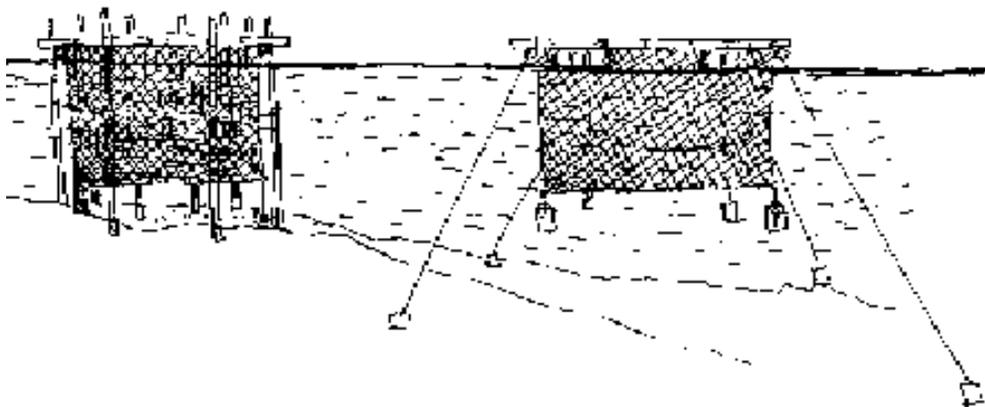
Design of nursery		
	Pond	Net
Material	Concrete, plastic, canvass, fiber	Synthetic netting
Location	Earthen or concrete pond	Flow through
water area		
Size (sq m)	500-2000	3 (3x1x1 m) to 10
(5x2x1 m)		
Density (fry/sq m)	20-50	80-100
Duration (day)	40-50	25-35

## Types of cages

In general, the size of a square or rectangular cage ranges from 20 to 100 m<sup>3</sup>. The cages are hung from floating wooden or bamboo frames using styrofoam blocks or polypropylene tubes fastened to poles and set in shallow waters.

The fish is mostly

fed with chopped trash fish, the amount of which is 5-10% fish weight/day, with a stocking density of 10-40 fish/sq m.



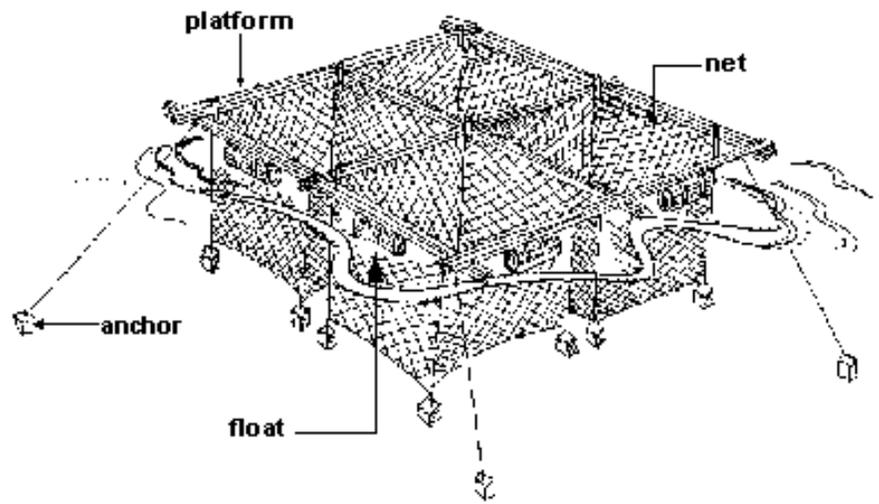
## Floating

The net cages are attached to wooden or bamboo frames. The cages are kept floating by materials such as plastic, styrofoam drum or bamboo. The shape of the cage is maintained with

the use of concrete weights attached to a corner of the cage bottom. Floating cages are suitable in areas where the water is more than 2 m deep and the tidal fluctuation is wide.

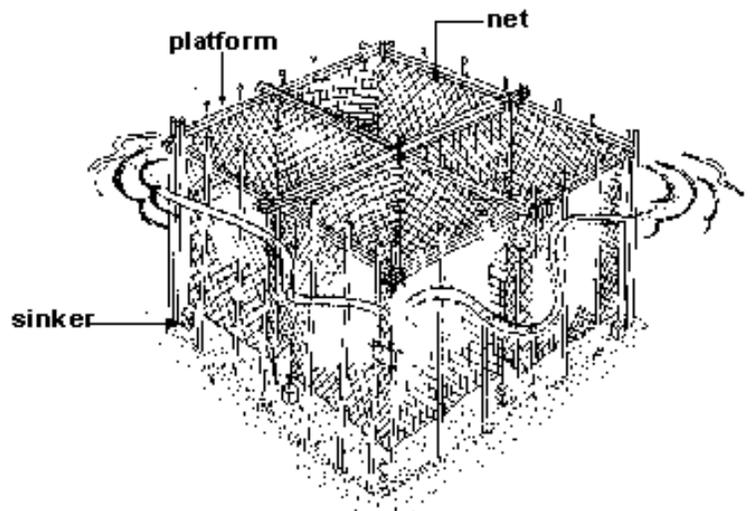
Floating cages are more popular because these are:

- usually placed in sites with better environmental conditions;
- generally located at greater distances from pollution sources; and
- these can be stocked with more fish than stationary cages.

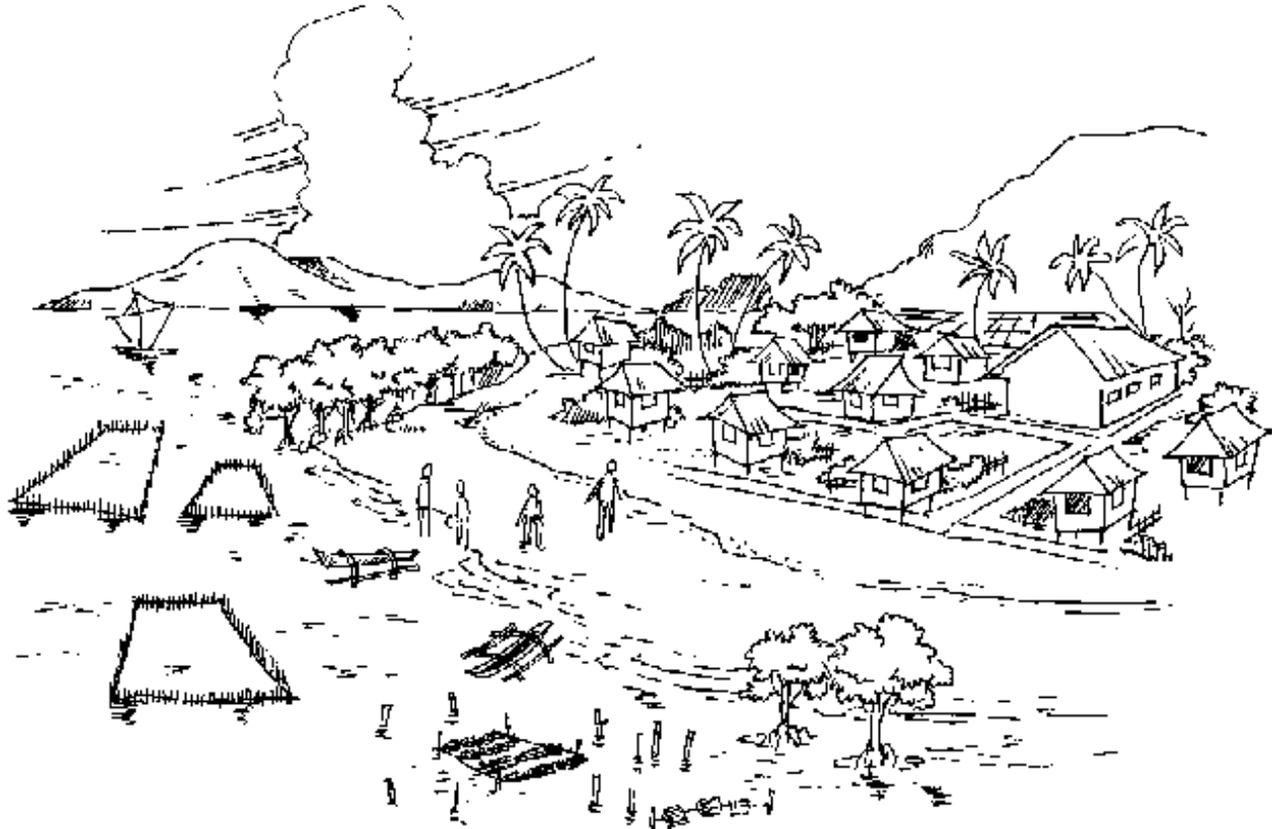


### Stationary

Stationary cages are fastened to bamboo or wooden poles installed at its four corners. These do not move with tidal fluctuations. These are popularly used in shallow bays where tidal fluctuations are less than 1 m.



# Coastal Aquaculture Options



Small scale aquaculture in coastal areas has been slow to develop new approaches and spread existing technology in most countries. The developments that have taken place are largely with the investments of non-residents and are larger scale production systems like shrimp ponds and marine fish culture. The notable exceptions are oysters, mussels and seaweeds in a few countries.

Aside from some seaweeds, mussels and oysters, most coastal aquaculture technologies have been aimed at moderately-high to high valued species. These species are too expensive for poor people to consume at home. The culture of high valued species entails considerable investment in the security of the crop, either for physical confinement or protection from theft. They are thus, for practical purposes, difficult for poor fishers to develop unless they have some existing infrastructure.

In the following sections several species are presented with a brief description of culture methods used. Some of these are of moderate value and the culture technology may be adapted for species that might be used for family consumption or local markets.

The presentations are meant to provide only an indication of the technology, the requirements and the potential. In most cases, there may be sufficient information for interested people to try the techniques with local adaptations of material, feeds and management. Before the details of particular species are presented some

general guidelines for coastal aquaculture development are discussed.

## General Guidelines

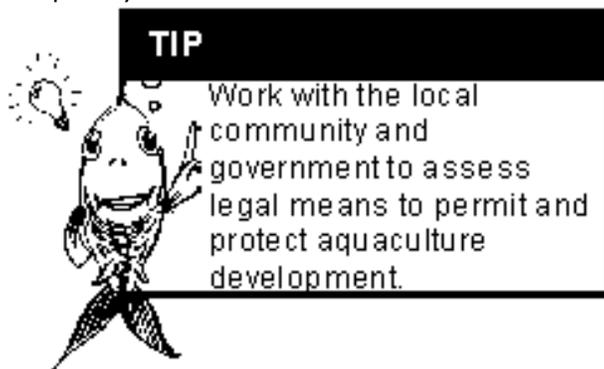
### Try it. Change it.

The information provided here is designed to provide the basis for assessment of the practice and perhaps for preliminary trials. These methods have been used in other places but the many variations can not be shown. Fishers are encouraged to try alternatives, to make adaptations, and to monitor and evaluate the results.

If you use a cage or pen, try culturing a few species together to make better use of the space. First attempts should be at low stocking density to ensure the compatibility of the species. Use your knowledge of species carefully as you do not want to introduce a species which will eat your main species!

## Tenure

Perhaps the biggest constraint to developing aquaculture along the estuaries and marine coastlines is the lack of tenure. In most countries individuals are not permitted to "own" such areas. In only a few cases local governments (municipalities or villages) have authority to manage adjacent marine and estuarine waters. Even when local governments have legal mandates for control, they often lack the resources to enforce national or local fisheries regulations or to protect private property in the water.



Under such circumstances it is difficult to establish aquaculture, which requires an investment and a growing period. Such investments are at risk during the growing period when crops are exposed to natural calamity (storm, floods, etc.) and to theft and vandalism.

## Social acceptance

Whether one has legal permission for an aquaculture venture or not, it is important that the activity is recognized by neighbors as an acceptable and worthwhile practice. Since coastal aquaculture is likely to develop in "our waters", in other words, water areas that have been traditionally used by multiple users, the traditional users of the area will have to support the changes. Peer pressure in a community is often the most effective means to enforce regulations and protect private property.

#### TIP

Work with the community to ensure they agree with proposed changes.



Make the new options available to all interested. Or at least have the community establish a means to decide who will have access.

### Site selection

Aside from the legal and social aspects of site selection, there are a number of points applicable to most species and places:

- Carefully observe the conditions where your chosen species occurs naturally in your area
- Observe the site and note; also observe daily and seasonal changes, particularly salinity changes, current/tidal flow, and exposure to waves.
- Ask fishers in the area about normal and unusual factors, storms and floods.
- Look for sources of domestic and industrial pollution.

#### Remember

Overstocking will reduce growth, survival and yields. Especially in first trials, use a low stocking density and assess the conditions of the site.



### Growing out

Periodic samples should be taken to observe growth and survival.

Watch for the occurrence of predators and pests. Do what you can to remove them but often it is difficult to control many species. If losses are high, try another area.

### Extension and technology transfer

Refer to other chapters in this resource book and look for appropriate means to involve users in adapting technologies.

Explore means for experienced aquaculturalists to share experience with others.

Avoid raising expectations that poor people will get rich quick by culturing high

valued species. Encourage small trials and include local species that can be used for family consumption.



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## Clams

There are many clam species found in shallow coastal waters. Candidates for aquaculture should be those that are naturally found at fairly high densities in mud or sand flats. Species found at very low densities can be tried but seed supply may be a constraint.



If exclusive use of small plots can be assured, clams can be cultured for family consumption and combined with other species. Such culture can reduce the time spent gleaning and provide clams of a larger size.

Cockles are treated in a separate section and giant clams are not considered here because of the difficulty of seed supply. However, some programs are developing hatcheries for giant clams. If the seed is available you can probably obtain advice on grow-out from the hatchery personnel.

## Sites

Avoid areas currently used for communal clam collection. Because of water circulation patterns, a culture site may have a low natural seed or adult density and

still be good for growing.

Generally you should look for intertidal areas of sandy mud or sand. Avoid areas that are so muddy it is difficult to walk.

There should be a good tidal exchange as this will bring in the suspended food for the clams.

## **Pen**

Most clams do not migrate or do so with limited range once they are a centimeter or more. (You should observe your local species to see how they behave.) Thus an enclosure or pen is not normally required for larger clams. But a pen may be useful for small seed, especially after seeding and the animals have not established themselves.

On the other hand, sometimes a pen is useful to keep out other species -- especially humans. In some areas fish, like rays, can be serious predators and a pen may help in excluding them.

A pen may be constructed with poles and a low net (up to a meter high). An area can also be staked off with a row of bamboo or other sticks.

## **Stocking/seed Supply**

Clams spawn seasonally. Observe clam beds for the occurrence of juveniles.

There might be a conflict with those who collect adult clams if you remove a large quantity of clam seeds. Moderate thinning of natural stocks will not have an adverse impact on the yields but do the seed collection carefully and try to collect from different areas.

Initially stock at densities no more than two to three times the natural density with trials in the range of 200- 600 seed clams per sq m.

## **Maintenance**

Feeding is NOT required! In fact there is nothing you can do after you have spread the seed clams. Aside from maintaining the pen, if one is used, and keeping the area free from debris and obvious predators like snails, there is not much to do.

## **Harvesting**

Harvesting can start whenever the clams reach an acceptable size.

One of the reasons for culturing clams is that you can keep them until they reach a larger size. Thus, you should harvest the larger ones and return the smaller ones so they can continue to grow. The small ones should be left on the surface when the tide is rising so they can quickly reestablish themselves in the sediment.

It is best to harvest an area in a systematic way so you do not dig an area frequently.

## **Market**

Carefully consider the value of clams in the market according to size. Harvest your clams when you think they will give you the best price.

## **Economics**

The investment costs for clam culture are small. Even though the market price may not be very high, the returns can be reasonable.

## **Risks**

The risks involved in clam culture are low as long as you have security of tenure and there is not much threat of theft.

Since there is no feeding or other daily maintenance, the stock can be left in the water until you are able to harvest them. However, you will have to determine if there is a possibility of seasonal losses due to low salinity. This will depend on the tolerance of the species selected.

## **Complementarities**

Using an area for clam culture does not preclude its use at high tide for fishing or other purposes, as long as this does not adversely affect the bottom or pollute the clams. It is not advisable to allow dragging fishing gear over clam beds.

Other aquaculture, like pen culture of fish, is possible in the same area. The detritus from fish culture can enhance the food supply for the clams.

## **Special notes**

Like other bivalve mollusks, clams are efficient at removing bacteria and viruses from the seawater. It is best that clams be cultured away from residences to avoid contamination from domestic sewage. However, if clams are only eaten after being cooked well, the threat of contamination from sewage microorganisms is reduced.

Clams are also able to accumulate toxic algae. If you are not aware of the status of toxic algal blooms in your area, consult local fisheries or health authorities.

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## Cockles

The main cockle species of interest is the blood cockle, *Anadara granosa*, which is cultured in Malaysia, Thailand and a few other places. There may be other species of local interest and they can be investigated to determine whether the methods suggested here for *A. granosa* would be appropriate.



## Sites

Blood cockles are mostly found around the mouths of estuaries in muddy areas. The adults need a subtidal area but the seed clams can be found on intertidal flats.

Observe the local occurrence of cockles to assess their salinity tolerance and substrate preference.

Choose a site where the water is in the range of 1-1.5 m at low tide.

## Stocking/Seed supply

Seed clams can be found in soft-bottom intertidal flats. Usually the mud is too soft for walking and a sled or "scooter" with flat bottom is needed to work in the area.

Observe the mud for the presence of juvenile clams. It may take time to learn how to do this. Other fishers in the area may already know how to recognize them and what time of year to expect them.

The seed clams (4-6 mm) are skimmed off the surface of the mud with fine meshed scoops. The mesh size should be adjusted to the size of the seed clams.

The seed clams are then distributed over the growing area from a boat by throwing them over with a scoop. Experience will be the best guide to determine stocking density. This will depend on water flow and depth. Start with low density and increase in subsequent crops. Use a target of 200-300 cockles/sq m at harvest.

## Maintenance

There is little to be done between seeding and harvest. There is no feeding and little that can be done about predators.

Observations are important during the growing period to check growth and survival. Gastropod predators should be observed and their distribution determined. You may find some areas unfavorable to predators produce higher yields.

## **Harvesting**

Cockles are harvested with a "basket rake". This is a rectangular wire basket attached to the end of a 2-3 m pole. A rope is attached just above the "basket" and tied to the boat. As one person drives the boat around the site in a systematic pattern, another pushes the rake down to the mud surface allows it to skim over the mud, picking off the clams. The basket is periodically emptied into the boat.

## **Market**

Cockles can be taken to market in sacks as long as they are kept damp and cool. But they will not last more than a couple of days.

## **Economics**

There is not much equipment required specifically for cockle culture. However, a motorized boat is needed. Cockle culture, thus, may be suitable for a fisher who owns or has use of such a boat. It would not be wise to invest on a boat specifically for cockle culture because the use is rather infrequent.

Aside from the boat the major investment is labor and time. The profit from cockle culture will depend on the local market, supply from fisheries and whether the species is in demand. These factors should be assessed at an early stage.

## **Risks**

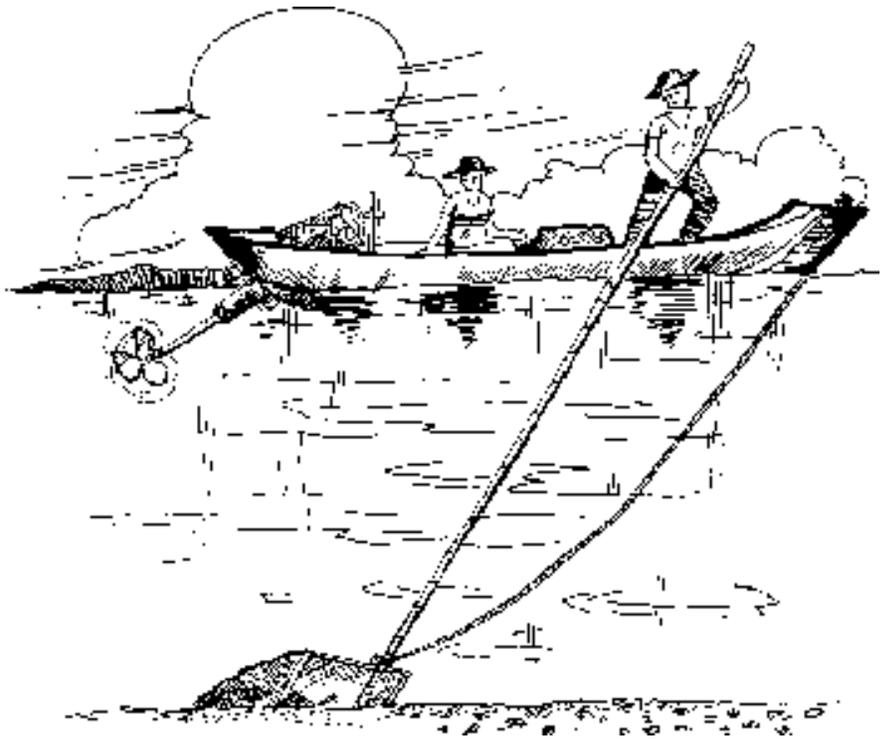
There is not much risk of loss of the cockles if a suitable site has been selected. Before a site proves to be acceptable, however, there is a risk of mortality due to predation

or unsuitable water quality. Thus, early trials should be small.

Use of the bottom area does not preclude multiple use of the overlying water for fishing and transport.

### Labor

Seed collection may involve several family members as it is not heavy labor. Harvesting is more intensive work and may not be suitable for all ages.



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## Sea cucumbers

Sea cucumbers (various species of the following genera *Holothuria*, *Thelenota*, *Stichopus*, *Actinopygga*, and *Bohadschia*) are of varying values in local markets depending on local tastes. However, they are often exported. Sea cucumbers occur in seagrass beds and in sandy/muddy bottoms. If you are in doubt about the value of your local species, inquire with fish exporters.



Not much has been published on sea cucumber culture even though a number of attempts to culture them have been made. The methods discussed here can be tried for growing sea cucumbers from a small size or for short term holding, with some growth, prior to processing for market.

### Sites

Although sea cucumbers may be found on tidal flats, a shallow-water, subtidal site is preferable for culture. Sea cucumbers also occur in sea grass beds but care should be taken in using these sites for culture because they are very important for fisheries and biodiversity.

### Seed supply

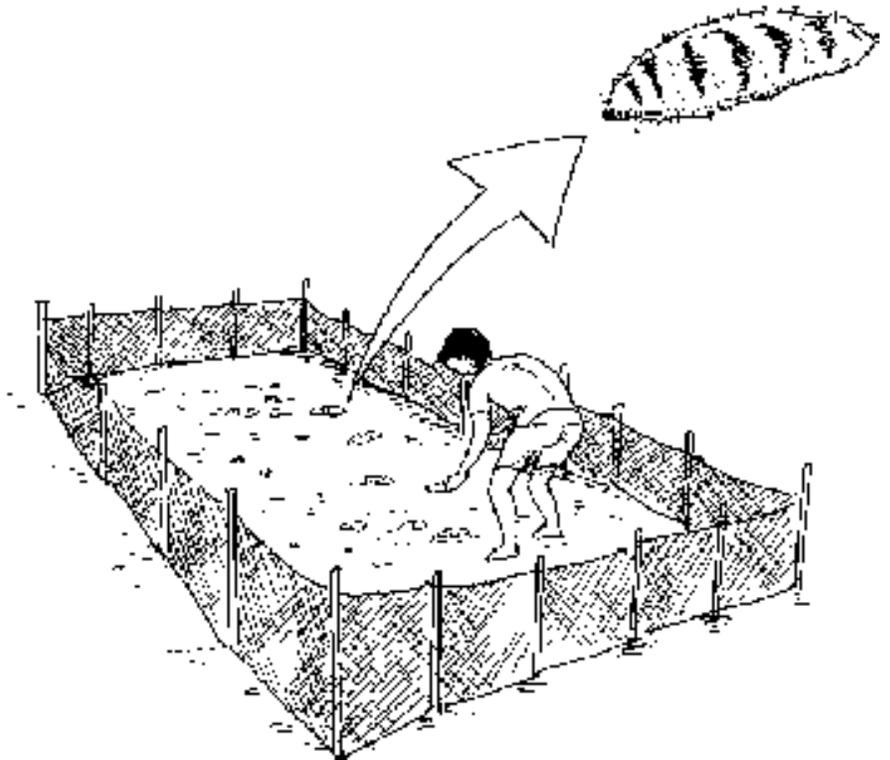
Collect sea cucumbers from local sources. You will probably find a range of sizes

available. The smaller they are at stocking, the longer it will take to grow to market size. For first trials, it would be best to start with larger, submarket-size animals.

## Pen and stocking

A simple pen made of stakes and mesh should be set up. The sea cucumbers feed on the detritus on the bottom so each one will need considerable area. The size of the pen will depend on conditions. It may be better to have a few smaller pens rather than one large one, just for safety sake.

Try stocking about 2-3 animals per square meter. Monitor the growth and survival and decrease the density if there are signs of stress.



## Maintenance

There is little to be done between seeding and harvest. There is no feeding.

Observations are important during the growing period to check growth and survival.

## Harvesting and processing

Harvesting will be done when you think the size is appropriate. Consult buyers for preferred size and base your decision on the risk of loss if marketing is postponed and the value of the harvest at a smaller size. Sea cucumbers are marketed in the dried form. They must be completely dry to avoid spoilage due to mold.

Clean the sea cucumbers by cutting open the belly and removing the internal organs.

Immediately scrape the body wall to remove the hard, chalky growth on the outside.

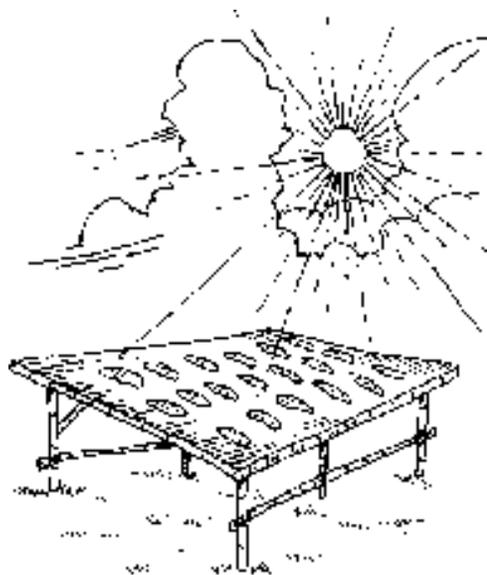
After cleaning boil them in sea water until they become rubbery. Add one teaspoon of alum to the pot to inhibit the growth of mold.

Thoroughly dry the sea cucumbers by smoking or sun-drying until they are .

Pack in plastic bags for market.

(Source: DENR. 1998. Sustainable Livelihood Options for the Philippines. Booklet 3. Department of Environment and Natural Resources, Philippines.)

## Economics



The investment in equipment is minimal for sea cucumber culture and the seed stock is obtained locally. The main investment is time to set up, monitor and harvest. A rough estimate of profitability can be made once you have decided on the size of pen and the stocking density and have determined the local market price.

The product is dried and thus can be stored for marketing later .

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## Lobsters

There are several species of lobsters and it should be determined which are available locally and, of these, whether there are different market values. Fishers will be able to provide information about the ecology of the local species. This information can help in site selection, determining whether juveniles are available, and the size that one might expect to achieve.



### Sites

Lobsters normally require full seawater with little exposure to brackish water.

They cannot tolerate much reduction in oxygen levels so a moderate flow of seawater is needed. For pen culture, seek a site with a sandy or rocky bottom as this normally has good water exchange.

The water depth should be at least one meter at low tide.

Security will probably be a concern, so the site should be near the residence or such that other arrangements (e.g., a guard house) can be made for monitoring.

## Culture unit – pens or cages

### Pens

If funds are available, the farmer may want to invest in a pen.

A good pen size would be about 5 x 5 m and this can be divided into sections (4 sq m for nursery, 6 sq m for transition and 15 sq m for rearing to market size).

The pens can have bamboo or mangrove poles at the corners and on the sides for support.

Plastic netting used to enclose the pen should cover the ground to prevent the lobsters from escape. Farmers may resort to other netting but should watch out for the deterioration of material other than plastic.

The sides can be re-inforced with bamboo slats, coconut slabs or other seawater-resistant material to protect the netting. Care must be taken to ensure good water exchange and that the whole unit is not subject to destruction by strong waves or currents. (Sometimes the more open the cage is the less resistant it is to water flow.)

Cover the top of the pen with bamboo or nipa for security but allow access for feeding and harvesting.

### Cages

Small, floating or suspended cages offer an alternative to pens. Cages can be less expensive although the number of lobsters grown may be less. This is a good way for a person to start lobster culture. They first learn to handle the animals and provide feed. Later they can assess whether a larger investment of money and time is warranted.

Cages can be adapted to local conditions and materials (bamboo, wood) and the size to a person's situation. Cages can be suspended from a wharf or hung from poles but they should never be left to be exposed to air during low tide. Access through the top is needed.

#### Note

**You might provide some material like pieces of bamboo or plastic pipe in cages and pens in addition to rocks where they can hide in pens .**



In Vietnam, fishers are culturing lobsters in cages and in pens. The cages are of different sizes (2 x 2 x 1 m, 3 x 2 x 1 m and 3 x 3 x 1.5 m). They are constructed with iron frames (12-12 mm diameter iron) and covered with netting. They sit off the bottom on legs or are suspended 3-4 m below the water surface. The pens in Vietnam are about 5 x 5 x 5 m or 6 x 6 x 5 m and made of wood and netting.

The juveniles are stocked for nursery at 6.5-8 mm carapace length (CL) and 20-25 mm for culture. At the nursery stage they are stocked at the rate of 150-200 animals per cage and in cages or pens for growing at five to ten animals per sq m. Food consists of small fish, crabs and mollusk that are of low economic value.



The time from stocking to market size is 18-24 months for the ornate rock lobster (*Panulirus ornatus*) and three to four months for the green scalloped lobster (*P. homarus*).

## Stocking/Seed supply

Juvenile lobsters can be captured by the lobster farmer or purchased from other fishers. Care should be taken during capture and handling of the juveniles to avoid damage. Care should be taken so that lobster culture does not pose a threat to the local supply of juveniles to the fishery.

Stock lobsters of the same size in any one unit. They are carnivorous and the bigger ones will eat the small ones.

## Feeding

Feed the lobsters daily, preferably in the morning. Lobsters will eat a variety of foods and the farmer should experiment with various fish, mollusks and seaweeds. Remove uneaten food before it rots. The food should be cut in small pieces.

## Maintenance

The pen and cage should be kept clean to maintain water circulation. Remove biofouling organisms. Leave them in the cage if the lobsters will eat them.

Make sure the pen or cage remains intact and there are no escape holes.

### Note

Some other swimming species, like grouper, can be cultured in the lobster pen because lobsters will stay at the bottom.



As in any aquaculture, the stock should be observed daily to see if there are sick, dying or dead animals. They should be removed immediately.

Remember that lobsters shed their shell when they molt. Do not remove the empty shells because they will be eaten by the lobster and provide nutrients.

## **Harvesting**

The time to harvest will depend on the stocking size, growth conditions, food and preferred size in the market. This may be from six to 24 months.

Harvest lobsters in the morning by gently scooping them up with a net.

Lobsters are best taken to market alive. Wrap the lobsters in paper or cloth pre-soaked in seawater and place them in Styrofoam boxes.

Avoid exposure to fresh water.

## **Economics**

The profitability of lobster culture will depend on what material and feed must be purchased and what can be obtained directly by the lobster farmer.

The biggest investment is probably time.

The labor needed is in the collection of feed and the daily feeding and maintenance. This can be done by any family member who is available.

## **Risks**

Lobsters may attract thieves.

They are sensitive to poor water quality (low oxygen or pollutants) and can be killed quickly.

Growing to market size is long, exposing the lobster farmer to the possibility of losses.

### **Environmental issues**

Lobsters can be cultured with minimal environmental impact. Feeding rates should be adjusted so there is no waste that might pollute surrounding waters. Such pollution will also have an immediate and adverse impact on the lobsters.

Care should be taken to use juveniles wisely. Only enough should be stocked to give

good growth and survival rates. Heavy stocking densities will result in poor growth and survival and less returns for the farmer.

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## **Sea urchin**

Sea urchins have been a traditional food in many countries. With recent infrastructure for export of sensitive seafood products like sea urchin eggs, demand has risen and over-exploitation of sea urchins is now common. Small-scale pen culture of sea urchins exist in the Philippines but they have not been well documented. However, the methods are quite simple and local adaptations are likely to be needed anyway.

The first step is to assess the local situation. Are there commercially important sea urchins around? Is there a shortage of supply or other reasons to establish culture of sea urchins?

### **Sites**

Sea urchins are grazers on coral reefs and associated hard or sandy bottoms. They are usually found among seaweeds. A similar site, close to home, should be identified although it should be kept well away from source of fresh water.

A site with good water flow is needed as the pen will have unnaturally high concentrations of sea urchins and seaweeds.

### **Pen or cage**

A pen or cage to hold sea urchins should be constructed. It does not have to be very large (up to 2 m x 2 m in area). Poles stuck in the sand with netting would be suitable. If a net is a problem, bamboo slats or small mangrove sticks could be used for the sides.

### **Stocking and seed supply**

There are no guidelines available but common sense in terms of over crowding should be used. Small urchins are collected and placed in the pen. It may be best to start with sub-market size animals and see how the system works.

### **Feeding and maintenance**

Seaweed is collected and added to the pen as needed. Try different species of seaweed. Monitor the condition of the pen to see how much is eaten and whether

there is a build up of organic material such as fragments of the sea weed. Clean the pen as needed and continue to supply fresh seaweed.

Check the pen to ensure it is intact.

## **Harvesting and market**

Pick out large sea urchins as needed for festivals or for market.

Check with local buyers to determine how best to market your urchins and when. With a stock of urchins you should be in a good position to work with buyers on a marketing strategy because you will be able to supply the buyer with the product when it is needed.

## **Economics**

The profitability of sea urchin culture will depend on what material is used for the pen. It is assumed that the seaweed will be collected by a family member.

The biggest investment is probably time.

The labor needed is in the collection of feed and the daily feeding and maintenance. This can be done by any family member who is available.

## **Risks**

Sea urchins are valuable and may attract thieves.

They are sensitive to poor water quality (low oxygen or pollutants) and can be killed quickly.

The growth from small to market size is long, exposing the farmer to the risk of losses.

## **Environmental issues**

Sea urchins can be cultured with minimal environmental impact. Feeding rates should be adjusted so there is no waste to pollute surrounding waters.

Care should be taken to use juveniles wisely. Only enough should be stocked for good growth and survival rates. Heavy stocking densities will result in poor growth and survival and not result in better returns to the farmer.

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# Seaweeds

Seaweeds have both an export market and local use in many countries. Seaweed culture for export is an important occupation for many communities in southern Philippines and eastern Indonesia. It can be undertaken on a small-scale but marketing often requires a large quantity depending on the proximity of buyers. In this chapter we will present a few alternative culture systems for consideration. The user will have to determine whether there are local markets and what species are preferred.



The common species for culture are *Gracilaria* spp., *Eucheuma* spp. and in some cases *Caulerpa lentillifera*.

## Sites

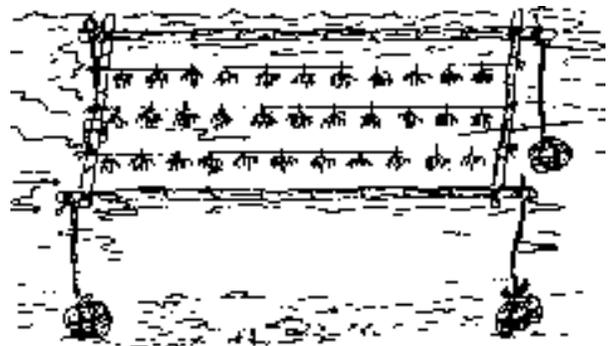
Seaweeds can be cultured in open water but they are frequently heavily grazed by fish. This may not be a constraint if there are large areas of seaweed culture but small plots tend to be heavily affected. *Gracilaria* can be grown in ponds if they are available and would be suitable in mudcrab ponds. *Eucheuma* and *Caulerpa* can not tolerate salinity below approximately 28 ppt so ponds are unlikely to be an option except during the dry season when pond salinity will not drop. These species may be suitable for small-scale culture inside pens used for other species, except rabbitfish, which will definitely eat the seaweed!

Open water sites should be protected from strong waves and current but have good water exchange. The depth should be at least 1m at low water. Sites with firm, sandy or rocky bottoms will probably be more desirable.

## Culture methods

### Bottom culture in ponds

Both *Gracilaria* and *Caulerpa* can be grown by planting small bundles of plant material in the bottom mud of a pond. Spacing would be about 15 cm for *Gracilaria* and 1m for *Caulerpa*. For more intensive culture in ponds dedicated to seaweed culture the addition of inorganic fertilizer would increase yields.



### Lines and floats

*Eucheuma* and *Gracilaria* can be tied to lines attached to short posts, on rafts or on long lines suspended from floats. Experiment with different line available.



Various methods have been used and much depends on the local environment, the scale of production anticipated and the materials available. One can use simple rafts of a bamboo frame or other materials or lines attached to plastic bottles.

Tie cuttings or clusters of plant material to the lines at approximately 20 cm intervals.

Keep the plants and lines clean of other plants and debris.

Maintain the lines and floats in good condition.

## **Harvest**

Harvest the plants after 35-45 days depending on the growth and the weight on the lines.

Clean the harvested plants of foreign material and select the best plants for stocking the next crop.

## **Processing and market**

If the plants are to be sold dry, spread them on a raised platform or on cement pavement on top of a mesh net or dried coconut fronds.

Turn the plants regularly to promote drying and protect from rain.

The plants should be washed after drying for two to three days by placing them in a basket and shaking in seawater. Spread the plants out again to dry.

Other market products may be appropriate and if you are not familiar with how to prepare the plants consult people who are now harvesting them from wild stocks.

## **Advantages/Risks**

Seaweeds are simple to grow but are at risk to grazing by fish. The equipment needed is not expensive and may be obtained with little or no cost. On the other hand, the market price is not high and commercial markets may require a

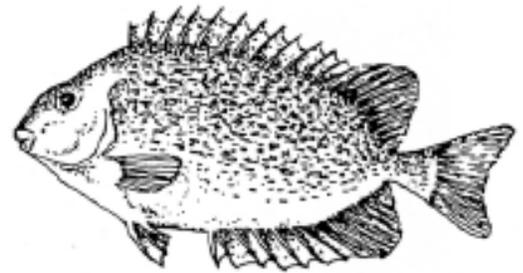
considerable quantity to make the effort worthwhile.

This section was adapted from DENR, 1998. Sustainable Livelihood Options for the Philippines. Booklet 3. Department of Environment and Natural Resources, Philippines

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## Rabbitfish

Rabbitfish or siganids (*Siganus* spp) are desirable fish on most markets. They are found in various coastal habitats usually associated with reefs and seagrass beds. They are herbivorous and unlike groupers are suitable for culturing in higher densities because they commonly occur in schools. (The technology discussed here may be useful for other herbivorous species.)



### Sites

Site selection will depend on the culture method used. Pen culture may be more suitable for a larger effort and cover up to a hectare. Such a large pen may be suitable for a group or communal effort and would have other benefits in management of an area. Rabbitfish can be cultured in cages in a smaller area but this will require more frequent inputs of feed.

The culture site should be in an area where fingerlings are available. It may require some trials to assess the suitability of the species available. In the Philippines, *S. guttatus* has been found to be suitable.

The desired salinity should be determined by the tolerances of the species to be grown. Investigate this before selecting a site.

For pen culture the site should have natural feed available such as seagrasses. Much of the area can be shallow or even exposed at low tide as long as there are tidepools at least 1m deep within the area. The bottom should be sandy-to-muddy. The area should be protected from strong water currents and winds.

For a cage the site should be deep enough at low tide for the size cage to be used, with a buffer of at least 1m below the cage.

### Culture methods

For pen culture enclose the area with a fence made of bamboo strips or other poles and nylon nets. The net should be at least 1 m higher than the highest high tide. Use

a fine-mesh net reinforced on the outside with a stronger polyethylene net.

See the sections in this kit on fish culture for other ideas on pens and for cage designs. Note in particular the chapter on seabass.

## **Stocking**

Collect fingerlings using a beach seine with fine mesh or whatever is used locally. If the fish are 1-2 cm in length (fry stage) they should be held in a cage or pen with mesh of appropriate size, approximately 0.5 cm mesh. These are often called a happas. Fry can be stocked at 600-1,000 fry/m<sup>3</sup>.

For fingerlings in a pen the recommended density is about 50,000 fish per 1 ha. This will require some careful monitoring as it depends conditions but mainly on food supply. (Large numbers can be "counted" by weighing a counted sample and then quickly weighing larger quantities using the number/kg from the sample to determine the count.)

Stocking a cage will depend on the frequency of feeding and water exchange and trials are recommended.

## **Feeding**

The need to feed will depend on the conditions in the pen and the stocking density. Any additional food is likely to be of benefit in increased yield. Additional feed will be necessary in a cage. Try different foods available locally including seaweeds, rice bran, waste fish (if available.) or other plant material. Commercial fish feed can be tried if resources allow.

Try to monitor fish sizes and numbers and feed approximately 3-5% of the total fish body weight per day giving half the amount in the morning and the rest in late afternoon.

Monitoring of growth will indicate whether you are supplying enough food. Also monitor for signs of disease or stress.

## **Harvest**

Determine the optimal size for the local market and try to harvest at that size. You should be able to reach 10-11 fish per kg in three to five months.

Seine the pen or pull up the cage and scoop out the fish.

## **Advantages and risks**

Pen culture of rabbit fish requires a large area, which may be possible for a family but more likely is best done as a communal effort. This can be a productive venture as rabbit fish are primarily herbivorous and the cost of production should be low.

Pens and cages are subject to damage and losses but careful monitor should reduce the losses.

*This section was adapted from Livelihood Options for Coastal Communities Volume II, IIRR and SMISLE 1998.*

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