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AQUACULTURE AND POVERTY : PAST, PRESENT AND FUTURE PROSPECTS OF IMPACT

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Summary

1. The contribution of aquaculture to poverty alleviation is not widely appreciated. Aquaculture is commonly, and erroneously, equated narrowly to the intensive farming of finfish and shrimp. These are usually cultured by better-off farmers in systems that may have adverse social and environmental consequences.

2. Global inland aquaculture is dominated by one country, China where production continues to rise, in contrast to the rest of the world where it has grown more slowly. This implies that there may be potential for aquaculture to significantly contribute to the welfare of the poor in other fish eating countries if constraints to its further development were removed.

3. Attempts to introduce aquaculture to poor households have often failed, especially in Africa and Latin America. In Asia poor farmers are early adopters of aquaculture technology, providing that they perceive the value of fish as food and increasingly to generate income, have confidence in low-cost technology commensurate with their resource base, and seed is available.

4. Generic technologies for rural aquaculture exist. Appropriate inland aquaculture systems are land-based rice / fish and pond fish culture, and water-based enhanced fisheries and possibly cage culture. Coastal aquaculture also has a role to play as it may be the only technical option to farm land under saline conditions .

5. A supportive institutional environment involving public and private sectors is required for aquaculture to contribute to improved welfare of the poor. Favourable government policy and public sector investment are required initially but for aquaculture to contribute sustainably to rural livelihoods it has to function largely as a private sector activity.

6. While generic technologies exist, a farming systems research and extension approach is required to identify the poor and assess their needs and resources, to adapt technologies to local contexts, and to widely disseminate them to potential beneficiaries.

7. The two largest constraints to rural aquaculture are limited knowledge of technology and limited capacity of service providers at all levels.

8. A knowledge base for rural aquaculture should be developed which contains the range of appropriate technologies and their social and economic profiles, case studies of current farmer practice, approaches and methods for service providers who work directly with the poor, and approaches and methods for agencies.

9. Regional networks should be established with action-based partnerships between the poor and development professionals. Better coordination between donors, and government and non government organizations is essential.

10. A limited number of pilot projects within each regional network should be set up at local administrative and agroecological / ecological levels. Pilots should be viewed as public policy experiments. The development of aquaculture has to eventually become integrated into the national governance structure in each country for it to be sustainable.

1. Introduction

There is increasing concern among development agencies that development should be socially as well as environmentally sustainable. A major question that was posed at the Donor Consultation is to what extent is aquaculture a poverty reducing technology ? It is well recognized through a series of reviews, the latest being the Study of International Fisheries Research Needs for Developing Countries (SIFR) (World Bank *et al.*, 1992), that there has been limited impact of most donor funded fisheries development projects in general. With respect to reducing poverty specifically, experience with projects in Africa and Latin America led Martinez-Espinosa (1992) to refer to rural aquaculture, small-scale aquaculture systems appropriate for the poor, as a "myth" and "no panacea for solving the problems of rural social emargination".

The purpose of this paper is to show that aquaculture can and does contribute to the sustainable rural livelihoods of poor farming households; and that it could contribute more widely to improving the welfare of the poor if appropriate approaches were implemented by development agencies.

This paper comprised the lead discussion paper at the Donor Consultation and was supported by contributions from Muir (1999) and Nguyen (1999), parts of which have been incorporated into the revised text. Aquaculture is defined; and the recent development of inland aquaculture in China and the rest of the world are compared to indicate that there may be vast unfulfilled potential for rural aquaculture in many other developing countries which would contribute towards poverty alleviation. The relationships between aquaculture and poverty are discussed; and culture systems with most relevance for the poor are outlined. Approaches and types of activities required for aquaculture to contribute more fully to improved welfare of the poor are discussed in the final section.

During the presentation a series of questions were posed to facilitate discussion by the donors (Box 1). Questions fielded by the donors and answered by the panel are summarised at the end of the paper in Box 17.

2. Aquaculture defined

What is aquaculture is a deceptively simple question, the complexity of which belies a relatively simple answer : farming fish and other aquatic organisms. There are diverse types of aquaculture, farming plants and animals in various systems in inland or rural and coastal areas.

Systems may be land or water based:

- land based systems involving ponds and rice fields can be integrated with agriculture, thereby improving the productivity and profitability of small-scale farms

- water based systems involve use of existing water bodies such as natural lakes, reservoirs, rivers or bays through installation of enclosures such as cages and pens for swimming aquatic organisms, or structures to provide attachment for benthic organisms such as stakes, lines, or rafts. Stock enhancement (enhanced fisheries or culture based fisheries) is aquaculture according to FAO (1988) definition if the stock is managed by a single entity such as an individual or a group of poor people. Water-based systems may provide an entry point for landless people to become involved in aquaculture.

An aquaculture system may be characterized by its degree of intensity of farming as extensive, semi-intensive or intensive. Extensive aquaculture relies on natural food such as plankton for fish in the culture system without intentional human intervention, although run-off and changes in water level in riverine and coastal areas may bring in both nutrients and/or food organisms. In semi-intensive systems natural food within the system is increased by organic (manures) or inorganic fertilizers and/or is complemented by usually low-cost supplementary feed. In contrast, intensive systems depend on relatively high-cost, nutritionally complete diets. These are traditionally based on small wild fish but increasingly diets are in formulated pelleted form. Semi-intensive systems have been highlighted as having particular relevance for poor farming households because they depend largely on natural food which may be increased by low-cost fertilizers such as manures and supplementary feed such as brans and green fodder (Box 2) (Edwards and Demaine, 1997).

In many circles aquaculture is narrowly equated with intensive culture of shrimp and carnivorous fish such as salmon, which are carried out mainly by richer farmers in developing countries primarily for export, and often with adverse environmental impact. This is regretable because it constrains donor support for those forms of aquaculture which could play a greatly expanded role in rural development. This misunderstanding has a long history. In a paper entitled "A fishy business", Purdom and Preston (1977) wrote : "it is abundantly clear that fish farming is not a means of producing cheap protein. While this is true for intensive culture in which feed protein in pelleted feed is converted into fish protein with an efficiency of only about 30% *i.e.,* intensive aquaculture is a net user of protein, it is not true of less intensive forms of aquaculture which dominate production in developing countries.

Following the traditional dichotomy of development into rural or agricultural and urban or industrial, the term "rural aquaculture" has recently been introduced (Martinez-Espinosa, 1992) and defined: the farming of aquatic organisms by small-scale households using mainly extensive and semi-intensive husbandry for household consumption and/or income (Edwards & Demaine, 1997). Such low-cost production technologies are appropriate for the limited resource base of poor farmers and such fish are affordable also to poor consumers.

3. History and current status of aquaculture

There is widespread misunderstanding about the prevalence of small-scale aquaculture systems which constrains the provision of adequate support for research and development because FAO statistics do not break down species production data into either culture systems or social status of farmers. There has been a spectacular growth of global aquaculture with an annual growth rate of about 10%; production has doubled in each of the last two decades. However, more than 50% of global production is from one developing country, China. Production of carps, the principal fish contributing towards rural aquaculture in China as well as globally, continues to increase in that country (Figure 1) but it dwarfs the growth of inland aquaculture in the rest of the world (Figure 2). Over the past decade inland aquaculture production in China has increased at least five times whereas it has only doubled in the rest of the world.

Inland aquaculture systems in Asia where aquaculture is most prevalent are not widespread as commonly believed. China has the longest tradition of aquaculture reflected in current levels of production. India has a tradition of extensive pond aquaculture without fertilizing and feeding. Rice/fish culture is possibly centuries old in the mountains of northern Laos and northern Vietnam. Both pond and rice/fish culture may have been introduced into Java by the Chinese centuries ago. Cage culture probably evolved in Cambodia and Indonesia in the last century. However, Chinese carp polyculture was only introduced to the countries of Southeast Asia by Chinese immigrants and mainly to suburban areas, in the 19th and 20th centuries. Even in the countries of Southeast Asia there are many areas where the prevalence of aquaculture is limited. The practice is relatively recent in most other countries in Asia. In Africa and Latin America inland aquaculture is miniscule in extent and production by comparison.

Most of the few farmers who culture fish (probably <10% in the tropical developing countries of Asia) also do so far less efficiently than their even limited resource base would allow. Farmers have long cultivated crops and raise livestock but, until relatively recently, there were sufficient wild fish in rice fields and local water bodies to satisfy household consumption needs. Stocks of wild fish in most areas have declined because of overfishing from increased human population density and environmental degradation. This provides a stimulus for farmers to culture fish but they have limited indigenous technical knowledge of aquaculture. There are millions of potential new entrant fish farmers, particularly in South and Southeast Asia, but they are constrained above all by limited knowledge of aquaculture. Replication of the Chinese experience in fish culture elsewhere could contribute significantly to the welfare of the poor.

4. Aquaculture and poverty

4.1 Documentary evidence

Aquaculture has certainly contributed towards alleviating poverty in the few societies in the world in which it is traditional practice although it would be difficult to provide documentary evidence. There is literature documenting the role of aquaculture in poor rural societies in the past *e.g.*, China (Hoffmann, 1934), Indonesia (Ilan and Sarig, 1952) and Vietnam (Chevey and Lemasson, 1937). What is surprising is the limited current documentary evidence that aquaculture helps to reduce poverty. Many projects have had reduction of poverty as a goal but there are few documented examples of impact. FAO recently published an annotated bibliography of regional assessments of aquaculture economics in developing countries (Charles *et al.*, 1997). The word "poverty" appeared only four times in over 1,000 references. Nor has livestock a better record. A review of donor experience in about 800 livestock projects by most of the main funding agencies indicated little evidence of sustainable impact on the poor (Anon, 1998); most projects were technology driven and did not support "client-focused delivery of services". A similar review of the impact of aquaculture projects on poverty remains to be carried out.

Aquaculture benefits the livelihoods of the poor in several ways (Box 3). In considering the role of aquaculture in poverty alleviation, distinctions may be made according to whether benefits in food, employment and income, or security are direct, indirect, or general (Muir, 1999). Farming households directly involved in aquaculture production benefit directly whereas there are secondary, indirect opportunities associated with aquaculture as well as general or inclusive, broader benefits from aquaculture which reach the poor (Table 1). Addition of fish and other aquatic organisms has been demonstrated to generate income in rural communities (Charles *et al.*, 1997). Aquaculture may bring small-scale poor households above poverty threshold levels relatively quickly.

4.2 Adoption of aquaculture

A key question often posed is are the poor early adopters of aquaculture technology ? This is a complex question to which the answer yes or no applies depending on circumstance. The conventional view from agricultural extension is the poor are not early adopters of new technology (Rogers, 1983) but this relates mainly to failed attempts to introduce inappropriate, high-tech green revolution technology for poor households in less well endowed areas. However, small-scale farming households have been reluctant to adopt aquaculture, particularly in Africa and Latin America but also in Asia (Box 4) (FAO, 1997b). They probably perceive aquaculture which for most is a new technology to be a risky investment if the benefits have not been proven to them. They invariably adopt a wait and see stance until a neighbour with a similar resource base is successful before they commit themselves.

Martinez-Espinosa (1995) proposed two types of rural aquaculture because of the widespread failure of adoption by the rural poor in Africa and Latin America:

- type 1, the "poorest of the poor" aquaculture characterized as low-cost, low output and mainly subsistance
- type 11, the "less poor" aquaculture characterized as low/medium cost and low/medium output for bettter off farmers who are financially solvent and have

managerial capacity. Formulated feed comprises a major part of the nutrition for the fish and most produce is sold.

It was implied from in constructing the above classification that aquaculture does not have a role to play in poverty alleviation and that assistance should only be targetted at wealthier farmers. However, experience in Asia in particular has shown that poor farmers *are* early adopters of aquaculture provided that they perceive the value of fish as food and increasingly to generate income, they already have a small pond or rice field in which fish can be stocked, seed is available at reasonable cost, and they are familiar with low-cost technology commensurate with their resources. The poor have been, and continue to be, early adopters of aquaculture in a few areas of Asia where it is traditional practice such as China, Java in Indonesia, and Vietnam (Table 2). These have been densely populated historically so wild fish declined long ago, providing an early stimulus for the development of aquaculture.

A crucial factor in the development of aquaculture is a supply of seed. The poor may atttempt to culture fish if they have access to seed in small household ponds (widespread in rural areas, especially in flood plains) in areas where aquaculture is not traditional as wild fish decline due to overfishing and environmental degradation. In Northeast Thailand where seed is widely available from the development of hatcheries throughout the area, many small-scale farmers have failed to culture fish because of inadequate knowledge : fry were stocked at too small a size and at too high a density; and ponds were not fertilized or fed. Many ponds have been abandoned because fish suffered high mortality, were consumed by residual populations of wild carnivorous fish, or did not grow (Edwards and Demaine, 1988). Therefore, a second major constraint for poor farming households to become more widely involved in aquaculture besides lack of seed is insufficient knowledge of how to culture fish. Even in areas in which aquaculture has a long tradition, many small farming households culture fish far below the potential for their resources because of inadequate information.

5. Aquaculture technologies

Aquaculture may be divided into sequential stages of obtaining (wild) or producing seed (in hatcheries), nursing and grow-out. Culture may be in land-based or water based systems, and in inland or coastal areas. The current extent, feasibility for expansion and potential overall impact of the four major types of inland aquaculture systems with relevance for poverty alleviation are compared in Table 3. Pond culture is currently the most important system. All four systems have potential for expansion but pond culture has the greatest potential and is likely to have a correspondingly greater overall impact on poverty alleviation.

The commodity groups most relevant for aquaculture for the poor are herbivorous and omnivorous finfish (carps and tilapias, the latter also with potential in coastal waters with milkfish), molluscs, and freshwater aquatic macrophytes and seaweeds. Crustaceans such as prawns (freshwater) and shrimps (coastal waters) are mainly cultured by better off farmers but are promoted by some projects to improve the welfare of the poor.

5.1 Seed supply

Lack of fish seed or fingerlings is a major constraint to more widespread involvement of the poor in aquaculture (AIT, 1997). Before the development of seed production centres or hatcheries started in the 1960s following successful artificial breeding of Chinese carps

and Indian major carps, farmers relied mainly on wild seed. These were either caught from rivers and transported, often on foot, through seed distribution networks; such networks continue to exist and expand in many countries in South and Southeast Asia although hatchery derived rather than wild seed are more likely to be transported. Alternatively, some farmers bred their own fish; common carp is still spawned by poor farmers from ethnic minorities in the contiguous mountain region of south China, northern Laos and northern Vietnam.

The usual approach of donor funded development projects is to set up large, centrally based, government hatcheries to provide farmers with fingerlings which are rarely sustained following withdrawal of financial support (van den Berg, 1996). They are expensive to build and operate; can only distribute seed over a restricted area, thereby restricting the involvement of poor farmers in remote rural areas in aquaculture; and may soon become redundant as private fish seed production and distribution networks develop as aquaculture development takes off in an area.

Lessons from Lao PDR (Box 5) and Madagascar (Box 6) support the development of decentralized networks for production and distribution of seed. Participation of the poor can be encouraged in activities such as operating small hatcheries (although they may soon be outcompeted as competition grows), nursing fry to fingerlings, manufacturing hapas (small net cages used for nursing), and fingerling transportation. Involvement of the private sector leads to sustainability of seed supply from increasing demand from new entrant farmers which it fosters (Box 7). Large central government stations are then able to concentrate on more appropriate tasks such as research and maintenance of good quality broodstock.

5.2 Inland land-based systems

Land – based culture systems most appropriate for poor farmers in inland rural areas are rice / fish culture and ponds because they can often be integrated with existing agricultural practice..

5.2.1 Rice/fish culture

Farmers have always caught wild fish in rice fields with standing water but catches have declined in most areas due to overfishing and indescriminate use of pesticides. Rice / fish culture has never been widespread and fish are currently cultured in only about 1% of rice fields globally. In the two major countries with rice / fish culture, China, and Indonesia it occurs in less than 5% of the total area of wetland rice (estimated from data in Halwart, (1998).

Where significant wild fish still occur, as in floodplains in areas of southeast Cambodia, southeast Vietnam and northeast Thailand, farmers are both unwilling and unable to stock cultured fish: they do not wish to prevent more economically valuable wild carnivorous fish from entering trap ponds in their rice fields; and residual populations of carnivorous wild fish which enter a pond consume fish seed which have been stocked. An example is given of a successful intervention in which rice/fish culture is leading to improved welfare of poor farmers, including over 90% of farmers giving up using pesticides (Box 8).

Rice/fish culture occurs in both irrigated and rainfed rice. Although introduction of HYVs (high yield varieties) of rice constrains the practice because of shallow water and

increased use of pesticides, culture systems have been designed which permit aquaculture. These involving trenching to provide deeper water refuge areas for fish; and reduction and restriction of spraying pesticides. Indeed, attempts to culture fish in rice fields are now being considered a strategy of IPM (integrated pest management).

There is considerable potential to increase rice/fish culture for small-scale farmers but there are additional constraints to those mentioned above: it is labour intensive to modify rice fields; there is a need for improved water management in both rainy (to prevent flooding) and dry (to ensure an adequate depth of water) seasons; and theft of fish is common in rice fields. Rice fields may also be considered a common property resource.

Potential may be more fully realised where there is a market for the relatively small sized fish harvested from rice fields and farmers consider it worthwhile to invest resources. Rather than being consumed domestically, most rice/fish culture in China and Indonesia is sale of fingerlings to stock intensive culture systems and water bodies i.e., rice fields function as nurseries and serve to generate income for the household.

5.2.2 Pond culture

Small-scale aquaculture mainly occurs in ponds which are widespread on floodplains as they are produced when earth is dug out to raise the ground level of the house to minimize flooding. In other areas and in floodplains farmers are increasingly digging ponds in response to decreasing reliability of water supply, primarily due to deforestation. An example of a successful project intervention through which pond aquaculture has improved the welfare of poor households is given in Box 9.

Various nutritional inputs can be provided for pond culture from on-farm, both fertilizers and supplementary feeds. Nightsoil is used in a few countries such as China, Indonesia and Vietnam although it cannot be recommended without treatment because of public health concerns. Furthermore, it is not a socially acceptable practice in many societies. Livestock on most small-scale farms scavenge for their feed which constrains collection of manure for pond fertilization. However, pigs and poultry may be housed in sties or coops, respectively, in some countries which allows manure to be collected. Scaled-down, feedlot livestock/fish integrated systems have often been introduced to small-scale farms but frequently fail due to competition from large-scale factory farming of livestock. Disease in village-level poultry is a particular constraint to intensification without adequate veterinary support.

Terrestrial and aquatic vegetation may be used either as green manure to fertilize ponds or as green fodder for herbivorous fish. Grass carp is a particularly effective herbivorous fish. Constraints to use of vegetation are its high fibre and moisture content, high labour requirement to collect or cultivate it, and the usually limited areas available on small farms to cultivate it. Brans are commonly used supplementary feeds although there is a need to consider the relative economic efficiency of feeding them to livestock or fish. Furthermore, if farmers do not mill their own grain, brans may need to be purchased and may be neither readily available nor low cost.

For pond aquaculture to fulfil its potential there may be a need to use off-farm inputs to supplement usually limited on-farm resources on the farms of the poor. Inorganic fertilizers have been successfully used by small-scale farmers to fertilize ponds.

5.3 Inland water-based systems

Many households do not own sufficient land to culture fish in a land-based system. For landless farmers, the only option to culture fish may be a water based system such as a cage or pen, or enhanced fisheries in large communal water bodies provided that access to the water body can be achieved.

5.3.1 Cage and pen culture

Farming of fish in cages and pens is receiving increasing attention as a possible means to increase the welfare of small-scale farmers although there are constraints (Beveridge and Stewart, 1998). Usually cage culture is intensive (Guerrero, 1998) as it needs to depend on the provision of nutritionally complete feeds such as small wild fish, moist on-farm formulations, or dried pelleted feed. Thus, cost of production is usually higher than for pond fish culture. Furthermore, poor water quality from excessive numbers of cages or from upstream pollution (including erosion induced high silt loads) may cause fish disease and mortality.

However, there are small farmers who culture fish in cages. Examples are culture of grass carp in bamboo cages in rivers in northern Vietnam, using mainly grass, maize stalks and cassava leaves as fodder and cassava roots; and extensive culture of bighead carp in nylon cages with floating bamboo frames in eutrophic lakes in Nepal. The NGO CARE is introducing cages for poor farmers throughout inland areas in Bangladesh. Research is also being carried out on its appropriateness for the poor in coastal areas of Vietnam with DFID funding.

The main issues are availability of appropriate technology for the poor; and access of the poor to public water bodies. Cage culture of tilapia has developed rapidly recently in Northeast Thailand through promotion by Charoen Phokphand, an agroindustrial company whose main business is production and sale of pelleted feed. The culture operation is essentially a fattening stage with richer farmers creating a demand for 50-100 g sized fish to stock in their cages. The provision of large fingerlings provides a livelihood opportunity for poor farmers who could raise the small fish required to stock the cages in rice fields and "green water" ponds.

5.3.2 Enhanced fisheries

Culture-based or enhanced fisheries are now regarded as aquaculture if the stocked fingerlings are owned by an individual, or with regard to the poor, a group of fishers, throughout their growth until harvested. A technology has now been developed for the poor in semi-enclosed water bodies as self-managed fisher groups of the poor have been successfully developed in oxbow lakes in western Bangladesh. Yields of stocked carps have increased four fold from 129 to 535 kg/ha and are expected to rise to 700-800 kg/ha (Apu and Middendorp, 1998).

The most important factor is to obtain long term security of tenure for the poor fishers so that they can legally exploit the resource. Following tenurial reform, the user rights of the licensed fishers need to be protected as high level government decisions are often ignored by local influential persons who pay off corrupt local officials. Key issues in the establishment of a functional common property regime (a kind of private property and not "open access" as

it is under group management by a single entity) with group management of the resource are given in Box 10.

5.4 Coastal aquaculture

Coastal aquaculture has led to well documented, adverse, social and environmental impacts (Primavera, 1994; Maluk and Bailey, 1996) but the record is not, as commonly believed, all negative. Although the discussion has been largely restricted to inland aquaculture, coastal aquaculture has a role in poverty alleviation. Coastal communities in developing countries are among the most impoverished. Aquaculture may be one of the few technical options for poor households to utilize land resources under saline conditions where rice and other terrestrial crops are barely feasible.

Coastal aquaculture systems may be land based ponds (often converted from mangroves, a wetland ecosystem) or "open" culture facilities for sedentary animals such as most molluscs and some seaweeds. Hard natural or artificial substrates such as rock, bamboo, concrete or rope are used for attachment of organisms. Target species may be cultured on the sea bed or suspended in the water column on poles, frames lines or rafts.

There is small-scale culture of molluscs and seaweeds that contributes to poverty alleviation among coastal communities which are amongst the most deprived in the world (Box 11). Small-scale farmers make up the major proportion of shrimp farmers in Asia, although there is considerable variation between countries (M. J. Phillips, personal communication). A 1996 survey of 400 intensive shrimp farmers in Thailand revealed that the majority were previously either rice farmers or fishermen indicating that coastal aquaculture contributes to local development through diversification of employment opportunities in coastal areas. An example of intensive culture of shrimp providing a livelihood for the poor is a project implemented by a private company, Dipasena Citra Darmja (DCD) Lumpang Province, Sumatra (Nyan Taw, personal communication). The project is funded by a loan from the Government of Indonesia bank, as it is government policy to establish large-scale coastal aquaculture projects to promote rural development in relation to transmigration. The DCD company developed over 10,000 small-scale intensive shrimp ponds (0.2 ha) with each family given two ponds to manage with technical and fully integrated support from the company. This system is also being implemented in areas in Kalimantan and Lombok.

5.5 Social and economic issues

Social and economic issues are more important determinants of more widespread involvement of the poor in aquaculture rather than availability of appropriate technologies, and thus warrant emphasis. A technical option must offer the farmer the farmer economic benefit for it to be adopted. Earlier attempts to promote aquaculture focused on household food security but poor farming households are at least as likely to be seeking new income generating activities as most have entered the market economy. Huisman (1990) has suggested that market studies should precede any intervention to enhance the contribution of aquaculture to development. One possible reason why China and Indonesia dominate rice / fish farming in Asia is there is a market for fish cultured in rice fields to supply fingerlings to stock pond and cage culture, and enhanced fisheries rather than only contributing to household subsistence.

Most poor household potential new entrants to aquaculture will have a diverse livelihood strategy. The main component is likely to agriculture but with increasing amounts of off-farm income. Thus, aquaculture needs to be an attractive option for use of limited household assets and "fit in" with the resource base. Furthermore, poor farming households may not be motivated to produce the maximum amount of fish from a culture system. Rather they may view aquaculture as a relatively small but nevertheless important benefit to their overall household survival strategy.

Access to land or water is a prerequisite for aquaculture. Small-scale farmers have access to land although insecure tenure may constrain investment. Access of the poor to "common" water resources is a major issue as they constitute a resource "of last resort" in most areas and therefore an attractive livelihood option (Townsley, 1998). Open access aquatic resources are often overexploited through overfishing so it is necessary to limit access. Unless communities limit access themselves, or in partnership with government, controlled access may favour richer resources users who are able to bid for leases, leading to the exclusion of a larger number of poorer people who might benefit and who may have depended on the resource previously (Townsley, 1998).

Availability of credit is often considered to be a major constraint to rural aquaculture. However, if farmers have a pond, relatively little investment of money or labour may be required to undertake semi-intensive pond culture. Semi-intensive pond systems also provide a mechanism for poor farmers to gradually and incrementally increase production as they gain confidence with aquaculture and increased cashflow. The profit margin of extensive (without inputs) and semi-intensive (fertilizers and agricultural by-products) is probably higher than intensive (nutritionally complete feed) but the total profit / unit area will be much greater for intensive than extensive or semi-intensive culture (John Hambrey, personal communication). Involvement of the poor in intensive cage and shrimp culture would require more investment and would probably require provision of credit.

Although poor farmers are rarely involved in intensive forms of aquaculture, provided that they receive adequate technical and financial assistance for a well-tested and locally profitable culture system, adoption of an intensive aquaculture system in theory should contribute a greater share of their livelihood strategy. Aquaculture would then contribute in a major way to elimination of poverty. In reality, the least risky strategy for the poor is likely to be extensive and semi-intensive modes of production. The latter also has consideration potential for intensification of production levels to within the lower end of intensive culture.

6. Institutional aspects

For aquaculture to fulfill its potential to contribute fully to improved welfare of the poor, it is essential that the institutional context is supportive. Institutional aspects cover a wide spectrum : education, research and development; and from individual farmers and communities, through local and national service providers to national government (developing and developed country) policy. Institutions have been defined broadly as "the rules of the game that shape the way we behave as individuals and as a society" (North, 1990, cited by Anon, 1998), which includes also philosophy and ethics.

6.1 Philosophical basis of development

Philosophy is intellectually important because it determines our world view, way of thinking and behaviour. It is particularly important that we adopt an appropriate philosophy for aquaculture to fulfil its potential to alleviate poverty. There is growing acceptance of the twin pillars of sustainable development – concerns about inequality or poverty (Schulpen and Hoebink, 1998) and the environment (Robinson, 1993). This is perhaps most eloquently expressed in the Brundtland report (WCED, 1987): "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The ethical basis of sustainability is reflected in the title of FAOs Code of Conduct for Responsible Fisheries (FAO, 1995, 1997c).

The philosophy of Popper (1979) is valuable in our quest for sustainable development because of its systematic unity *i.e.,* it covers evolution of life, the development of human knowledge and science, and social and political issues that influence development. All organisms engage in problem solving. Their genetic make-up determines both the problems that they perceive due to unfulfilled expectations; and the flexibility of their response. Survival is the primary problem, and problem solving is the primarily activity of all organisms, including humans. Humans additionally are opportunity seeking as we seek to improve our welfare through development.

Popper's philosophy helps us to understand the nature of problems, how to identify them, and how to solve them. His fundamental problem-solving schema can be reduced to three steps : analyze the problem or opportunity; propose a hypothesis to solve the problem or exploit the opportunity; and test the hypothesis in relation to the problem or opportunity (Figure 3) (Edwards and Demaine, 1998). Problems with their background or context, the problem situation, are usually complex, especially those relating to poverty. From a research and development point of view this implies:

- adequate understanding of the problem situations of the poor can only be achieved by working with target communities.

- identification of, as well as working on, problems leads to ownership and increased commitment *i.e.,* partnerships are required between farmers, service providers, and research and development specialists rather than top-down assistance

- changes can usually only be made incrementally *i.e.,* by building upon an existing system and knowledge base rather than by introducing a completely new system as in top-down transfer of technology

- subject matter specialism is self defeating *i.e.,* there is a need for interdisciplinarity — teams of natural and social scientists.

As generic technologies for aquaculture to contribute to sustainable rural livelihoods of the poor exist, perhaps the major constraint to aquaculture contributing more widely to poverty alleviation is inefficient transfer of farmer knowledge from localised areas where aquaculture is already practiced, and the results of research relevant to improving the livelihoods of the poor, to potential new entrant farmers through service providers. There is

essentially a break in the research : development continuum, or problem-solving cycle, which requires redressing on a widespread scale.

6.2 Systems frame works

6.2.1 Sustainable technology

A systems framework serves to indicate what is required in general for a given technology to be sustainable for poor farming households (Figure 4):

- production technology – a technology needs to be sufficiently productive for aquaculture to be an attractive option to possible alternative and/or competing uses of resources

- social and economic aspects – low-unit cost input systems may be most appropriate for the limited resource base of most poor farming households; and low production costs mean that fish can be sold at a relatively low market price and be affordable to poor consumers

- environmental aspects – a technology needs to fit into the limited resource base of the poor, not use resources that may be used more productively in other ways, and be environmentally friendly.

It is essential that aquaculture not be considered only in its narrow, technical aspect in isolation from crucial social and economic and environmental contexts. The latter invariably determine sustainability. Technologies need to be characterized with respect to their relevance for contributing to improved welfare of the poor in each and every local situation or context in which they may have potential. Most of the poor reside in unfavourable or resource-poor areas which are mainly rainfed, with undulating terrain and problem soils. The marginal type of agriculture into which aquaculture has to be integrated has been called CDR or complex, diverse and risk-prone (Chambers *et al., 1989*).

6.2.2 Sustainable rural livelihoods

A useful conceptual framework (Figure 5) to analyze the potential contribution of aquaculture technology to alleviate poverty is that of sustainable rural livelihoods (Carney, 1998). The heart of the framework is a pentagon representing five categories of "capital assets": financial, human, natural, physical and social. These are called assets to indicate that, although we are refering to the poor, we should build upon the "positives" that they may already have rather than starting from an analysis of their needs. The pentagon also forces us to think in a systems or holistic way. The framework contains a "vulnerability context" which includes culture, to reflect long term trends and short term shocks which the poor may be particularly affected by. Capital assets are improved by various "transforming structures and processes" to generate various livelihood strategies, including one that is natural resources (NR) – based such as aquaculture, and livelihood outcomes. Feedback loops connect transforming structures and processes to vulnerability context; and livelihood outcomes to capital assets.

Most new entrants to aquaculture will have a diverse livelihood strategy, the main component of which is likely to be agriculture. There is a need to see aquaculture as one aspect of rural development rather than as an isolated technology (FAO, 1997b).

6.2.3 Systems hierarchy

There is a need to consider the hierachy of systems that influences rural aquaculture if its potential is to be fully realized at household level (Edwards and Demaine, 1997). There is a range of systems from the individual farmed animal or plant, through aquaculture technology contributing to a livelihood, to larger macro levels at community, regional, national and international levels (Figure 6). Aquaculture is a subsystem on most land-based small-scale farms in which agriculture predominates but is usually a stand-alone farming system in water-based farms in inland and coastal areas.

The figure has been modified from Conway and Barbier (1990) by addition of the fish subsystem. Aquaculture is usually ignored by agriculturalists, both researchers and development agencies, but its potential role to contribute to poverty alleviation should be assessed. Major issues at macrolevel are market and input supply, government policy, and institutional issues. The sustainable rural livelihoods framework discussed above also recognizes the importance of institutions and organizations to improving livelihoods (Carney, 1998).

6.3 Constraints

6.3.1 Inadequate knowledge

Perhaps the single largest constraint for aquaculture to contribute to the improved welfare of poor households is their limited knowledge of the range of technological options that has potential to comprise part or all of their livelihoods. Potential farmers need to be provided with options from which they could select and adapt the most appropriate to their particular circumstances. In general there is insufficient knowledge or information relating to rural aquaculture available throughout the systems hierarchy from potential new entrant farmers, through all levels of service providers from extension workers to government policy makers. An outline for a proposed knowledge base for rural aquaculture is presented (Box 10).

At the local administrative unit or grass roots level there is a need for an aquaculture knowledge base for service providers. This should outline the range of technologies that currently exist, including their social, economic and environmental and implications for the diverse resource profiles of poor household. The knowledge base would also provide basic information for service providers at grass roots level to facilitate their work in partnership with farmers to develop locally appropriate technologies and corresponding extension materials.

Local development workers need to be provided with the skills to deal with information *i.e.*, how to access it, interpret it, and use it in partnership with farmers to adapt technologies and to develop extension materials. Local level officials should not be given technology for farmers but basic knowledge and interactive skills needed to develop locally appropriate technology through an experiential, learning-based approach. A useful analogy is with medicine as the problem with extension is at the level of the person who makes the

diagnosis – every patient who visits the doctor potentially has a different ailment which requires specific treatment. The same applies to poor households with an almost infinite number of resource contexts and appropriate technological solutions. It is the service provider at grass roots level who should be the doctor and diagnose how aquaculture might fit into a livelihood strategy and prescribe the medicine, not a distant researcher. The local service provider should come up with "best guesses" from the rural aquaculture knowledge base for the farmer to experiment with, and to adapt to a particular situation. Poor farming households need to be provided with the most basic extension information for their contexts (cultural and resource profiles) if they are to be assisted.

There is also a need to learn from the growing body of experience that is being gained by numerous initiatives to promote rural aquaculture throughout the developing world. The situation is similar to the one described by Olsen *et al.*, (1997) for coastal management in which projects are proceding as isolated efforts with little to no communication between them. The rationale behind project design and implementation are rarely stated explicitly and therefore they cannot be tested across the diverse range of contexts in which they are being carried out. Furthermore, most experience is either undocumented or published in anecdotal form. This experience should be reviewed to develop common approaches and methods to promote rural aquaculture which would then comprise part of the proposed knowledge base for rural aquaculture (Box 12).

6.3.2 Human capacity building

Perhaps the second largest constraint to aquaculture contributing to improved welfare of the poor is the limited capacity of national institutions to function as service providers at all levels in the systems from poor farmers to national policy.

Key questions are:

- who are the most appropriate people to train?
- what should the content of their training ?
- how should they be trained ?

Clearly the most important people who require training are the farmers themselves but there is a need to focus on service providers : those with responsibility in policy making, planning and management, and education, research and development. It can be argued that priority for training should be given to local administrative level staff as they work directly with target farmers, but capacity building of individuals at all levels is required.

To have the most immediate impact on poor farmers, training should have a problem-based focus involving assessment of aquaculture in a given area with an appropriately identified target group. How people should be trained is a major debate in education concerning conventional teaching versus experiential learning; and content versus process. Conventional top-down transfer of knowledge is less effective than learner–centered approaches. However, a balanced approach is needed so that the learning process can be informed with advice from experienced professionals about "what" might be appropriate "where" based on voluminous, existing knowledge.

On-the-job training of local officials supported by relevant formal and non-formal short-course training has proved to be effective through the network established by the AIT Aqua Outreach programme in Cambodia, Lao PDR, Northeast Thailand and Vietnam (Edwards and Demaine, 1997, 1998). The three focused components are (Figure 7):

- aquaculture as an introduced or improved technology in a specific geographical location;
- increased capacity of developing country national institutions responsible for promotion of aquaculture in the area; and
- assistance of AIT and its international collaborators

It has started to influence government policy through impact at grass roots level in participating countries which is required for aquaculture to eventually fulfil its potential contribution to sustainable livelihoods of the poor.

6.4 Promotion of rural aquaculture

6.4.1 Policy

Government policies tend to favour the more productive industrial sector and urban areas rather than the agricultural sector and rural and coastal areas. Within aquaculture special attention has been given to intensive aquaculture, particularly shrimp culture, because it is favoured by richer entrepreneurs and exporters, rather than small-scale aquaculture. While governments promote intensive aquaculture because of the need to earn foreign exchange, there is a need for balance in policy formulation and implementation.

Supportive government policy and public sector investment are required initially to promote rural aquaculture because private sector involvement, with its profit making aim is unlikely to get involved at the outset. For aquaculture to ultimately contribute to sustainable rural livelihoods it has to function largely as a private sector activity *i.e.*, there is autonomous development (Huisman, 1990). Examples are the success of small-scale aquaculture where the private sector became involved in seed production and distribution; and the greater development of rice / fish culture in China and Indonesia than elsewhere because there is a market for fingerlings nursed in rice fields to stock other culture systems.

6.4.2 Strategic versus adaptive research

Three is a long standing imbalance between strategy research to develop new knowledge of general significance, and adaptive research to assist farmers to adapt and adopt new or improved technology (Edwards and Demaine, 1997). Increasingly a farming systems research and extension (FSR&E) approach is being followed by projects (Figure 8) and this trend needs to be accelerated.

FSR&E involves an interdisciplinary team of natural and social scientists working in partnership with farmers and service providers to :

- assess needs and resources of poor farming households in each target area
- identify and field test appropriate technologies

- analyze and monitor extension options for both extension materials and extension systems to deliver appropriate technologies to the target group.

As most generic technologies for aquaculture exist, a review of existing technical knowledge may suffice in most cases. However it is important to stress that "promising" technical recommendations" still need to be tested in partnership with poor farmers, and likely modified or "adapted" to suit each local context before research procedes to the next stage, research into extension. Direct or "top-down" transfer of technologies to poor farming households is likely to be ineffective

The "E" of FSR&E was originally intended to represent extension as a development activity following research to produce technology. However, research to develop both extension materials and an extension delivery system, is also required as a precursor to extension as a development activity to widely disseminate proven extension packages to a wider target audience on completion of the first round of adaptive research and development (Edwards and Demaine, 1997, 1998). Ideally the process would be repeated in future to satisfy the rising aspirations of farmers for improved technology from aquaculture to further improve their welfare and lift them well out of poverty.

6.4.3 Extension

It is increasingly recognized that conventional approaches to agricultural extension have failed to respond adequately to the needs of poor farming households (Cox *et al.*, 1998) and there is a need to devise alternative approaches.

The training and visit (T & V) approach promoted by the World Bank has been criticized for being unresponsive to local needs as its focus is usually on better off contact farmers. They are supplied with standard packages of research station derived technologies and set up as demonstration farms. A major problem with the T&V system is most departments of fisheries do not have a conventional extension service with adequate numbers of personnel to visit target poor farmers. National extension services mainly address agriculture. The few fisheries extension staff, usually with narrow technical backgrounds, have rarely been trained in extension theory and practice. Novel extension strategies are required that do not depend on a high level of costly institutional support with large number of local officials (government and nongovernment) and expatriate project staff if the large number of potential target, poor households is to be reached.

A major extension project has been launched in Vietnam with UNDP assistance which has many characteristics of the T&V system (Box 13). However, in contrast to the usual T&V technical recommendations, the technological packages being distributed through demonstration farms and farmer training are relatively low-cost, semi-intensive modes of culture. However, it remains to be demonstrated whether technology does spread through this "trickle down" system of aquaculture extension from better off contact farmers to their poor neighbours who invariably have a less well endowed resource base and who consequently might require a modified technology to better suit their circumstances.

An alternative, minimalist approach to extension has been developed through use of mass media in the form of leaflets which may be more appropriate to reach larger number of poor farmers (Turongruang & Demaine, 1998). Conventional extension materials designed by research scientists contain too much technical information written in too educated a

language for farmers to understand. Extension materials for a low-cost package of technical recommendations have been developed through a participatory approach with farmers which are written in a way consistent with their local language, culture and experience, and level of education. Materials were pretested with a different group of farmers to the one which participated in their design, which included on-farm trials. Subsequent modification ensured that the materials would convey the message intended. Evaluation of the leaflets distributed to non-project farmers through nonspecialist existing channels such as local agricultural extension and public health offices at district levels showed that 90% understood them and 40% who already had a pond took up some part of the recommendations (Box 14).

6.4.4 Remaining strategic research needs

Major gaps in knowledge concern social & environmental/resource aspects rather than production technology. Relatively little is known about social and economic aspects of aquaculture's actual and potential contribution to sustainable livelihoods of the poor. Major gaps in knowledge are also the interface between culture and capture of fish, and between agriculture and aquaculture, including use of fish as a strategy in integrated pest management.

Research is required on potential new species for culture, particularly for areas where there is concern that introduction of exotic species might adversely affect local species and ecosystems. Although adequate breeds for rural aquaculture exist they are essentially wild in terms of genes. There is tremendous scope for genetic improvement as demonstrated by agriculture & animal husbandry. Research is required in seed quality, particularly maintenance of broodstock in hatcheries because many farmers now perceive that the fish they culture, particularly common carp and tilapias, are not good quality fish. There is limited need for research on fertilization and supplementary feeding of systems for poor farmers. It is generally believed that disease is only a major problem in hatcheries and intensive systems but as disease is caused by bad management, it can also impact systems operated by poor farmers with limited knowledge and skills. The collapse of grass carp culture in bamboo cages and its increasing incidence in pond culture in Vietnam may be due to poor management.

6.4.5 Regional networks

The SIFR recommended the establishment of regional networks to promote aquaculture sustainably (World Bank, 1992). A regional approach is recommended because it is an effective mechanism to understand and handle widely varying contexts within and between countries. Exchange of experiences leads to widened vision and horizon and will facilitate the development of a comprehensive knowledge base and appropriate research and extension approaches. A regional perspective maximizes building on lessons learned : essentially avoiding re-inventing the wheel; or worse, trying an approach that has failed elsewhere. A regional approach would provide economies of scale through cost sharing in carrying out FSR&E. It would also lead to increased scale and coverage by obtaining greater resources, and provide a guide or entry point for other agencies to buy in to the network (Gijsberg and Constant, 1996). The essence of the approach is a coordinated regional network (Figure 9) of people with a shared ethos for action-based programmes (Box 15). The approach involves a partnership between development professionals and the poor in a shared learning process to identify, analyze and resolve problems. Examples of such networks are ALCOM in Southern Africa (Madhu, 1992) and AIT Aqua Outreach in Northeast Thailand and Indochina (Edwards & Demaine, 1998).

Partnerships are required to more effectively address the potential contribution of aquaculture to eliminating poverty. In each country it is the role of government to "create an enabling framework". Otherwise independently implemented projects will never be able to achieve nationwide coverage through "fragmented project-by-project approaches" (Akroyd and Duncan, 1998). There a need for governments to better coordinate activities of donors and nongovernment agencies, as well as the private sector. However, there are constraints to implementing such a scheme. Developing country governments have difficulty coordinating the "multiplicity of donors, objectives and management procedures" even when projects are well designed and executed (Akroyd and Duncan, 1998), which places a certain onus on the donors to better coordinate their assistance to developing countries. Many governments have inadequate policy and are unable to support an effective civil service so benefits from projects may not be sustainable. NGOs are considered to be an alternative for development assistance when donors consider governments to be insufficiently effective. It is well known that partnerships are difficult to form and manage because of frequent conflicting personal and institutional agendas which may not be apparent in the early stages of cooperation. However, partnerships are crucial to address the enormous task of assessing and implementing the potential contribution of aquaculture to eliminating poverty. Fortunately, increasing emphasis is being given to forming partnerships and guidelines have recently been developed to facilitate the difficult task of forming "active" partnerships between agencies (Lewis and Ehsan, undated).

An holistic, systems approach to testing and adapting appropriate technologies is required to improve the lives of the poor in the diverse inland and coastal areas of target countries. To achieve technological change to secure sustainable livelihoods for poor people in each geographical area there is a need to carry out the steps outlined in Box 16. Although the poor may be early adopters of aquaculture technology in areas where seed is available, where aquaculture is a completely new technology they will need to be specifically identified and targetted for selection for inclusion in programmes using poverty ranking techniques which have been used by ALCOM in Africa (Noël, 1997) and DFID in Bangladesh (Gregory, 1992). Communities should also be involved in the identification and selection of their poorer members with assistance from local government and nongovernment organizations.

Given the complexity of the development task, the wide range of relevant institutions, and the need to integrate technical with social, economic and environmental expertise, there is a strong argument for initially limiting geographic scope, and working on pilot aquaculture development projects at local administrative and agroecological/ecological levels within a limited number of countries. At the Donor Consultation it was learned that a number of international donors are promoting a learning–based approach to coastal management (CM) that is similar to what proponents of rural aquaculture (RA) are moving towards (Olsen *et al.*, 1998). As the initiatives in CM are more advanced, there is considerable scope for capitalising on lessons learned. Individual CM initiatives are viewed as public policy experiments. The aim should be to make the transition from pilots with activities concerning planning and training, to programmes that are a formal element of the national governance structure in each country. Following a similar approach in rural aquaculture should enable aquaculture to contribute more fully towards poverty elimination.

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