Increasing and Sustaining the Productivity of Fish and Rice in the Flood-Prone Ecosystems in South and Southest Asia

Final Report

IFAD
INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT

WorldFish CENTER

INCREASING AND SUSTAINING THE PRODUCTIVITY OF FISH AND RICE IN THE FLOOD-PRONE ECOSYSTEMS IN SOUTH AND SOUTHEAST ASIA

FINAL REPORT

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INCREASING AND SUSTAINING THE PRODUCTIVITY OF FISH AND RICE IN THE FLOOD-PRONE ECOSYSTEMS IN SOUTH AND SOUTHEAST ASIA (TAG 350)

Final Report to the International Fund Agricultural Development

Prepared by

WorldFish Center

In association with
Bangladesh:
Bangladesh Fisheries Research Institute
Proshika
Bangladesh Rice Research Institute
Vietnam:
Research Institute for Aquaculture No. 1
Research Institute for Aquaculture No. 2
Philippines:
International Rice Research Institute

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ABSTRACT

During the rainy season in extensive river floodplains and deltaic lowlands, floods lasting several months render the land unavailable for crop production for several months each year. These waters are considerably underutilized in terms of managed aquatic productivity. This raises the opportunity to enclose parts of these floodwater areas to produce a crop of specifically stocked aquatic organisms aside from the naturally occurring 'wild' species that are traditionally fished and are not affected by the culture activity, overall resulting in more high-quality, nutrient-dense food production and enhanced farm income for all stakeholders, notably the poor. The WorldFish Center and its national partners recently tested the concurrent rice-fish culture in the shallower flooded areas and the alternating rice and fish culture in the deep-flooded areas of Bangladesh and Vietnam through a community-based management system. Results indicate that community-based fish culture in rice fields can increase fish production by about 600 kg/ha/year in shallow flooded areas and up to 1.5 t/ha/year in deep-flooded areas, without reduction in rice yield and wild fish catch.

INCREASING AND SUSTAINING THE PRODUCTIVITY OF FISH AND RICE IN SEASONALLY FLOODED ECOSYSTEM IN SOUTH AND SOUTHEAST ASIA

FINAL REPORT

APRIL 2002

EXECUTIVE SUMMARY

The past decade has seen growing recognition of the crisis facing the world's water resources and the need for concerted action to use these more efficiently. The efficiency of water use (or water productivity) can be increased by producing more output per unit of water used, or by reducing water losses, or by a combination of both. So far, strategies for increasing output have been limited to crop cultivation only. Water productivity at several organizational levels can be increased further by integrating fish and other living aquatic resources into the existing water use systems. Such opportunities of integration include community based fish culture in irrigation schemes and seasonal floodplains.

A variety of studies show that reservoirs and canals of irrigation systems continue to yield substantial fish harvests, which are important sources of protein and livelihoods for the poor and landless households. Yet the current use of irrigation systems and floodplains for fish production falls far short of potential. In seasonal floodplains, fish production essentially emanates from capture activities by seasonal or part-time fisher-farmers where wild fish enter, reproduce and are harvested from the flooded fields. In Cambodian floodplains, the value of fish caught through trap ponds within rice fields reaches 37-42% of that of rice production.

A number of studies have been conducted in the 1980s to test the technical feasibility of culturing fish in seasonally flooded rice fields in India, Bangladesh, Cambodia, and Vietnam. These studies show that fish production can be increased by more than 1 mt/ha/year by stocking flooded ricefields with fish (i.e. individual farmers fencing their plots and stocking fish during the flood season). In addition, the culture of fish within ricefields can increase rice yields, especially on poorer soils and in unfertilized crops where the fertilizing effect of fish is greatest. Savings of pesticides and earnings from fish sales lead to increased yields and result in net incomes that are 7 to 65% higher than for rice monoculture. But the adoption of this technology by farmers has been very low due to the high cost of fencing individual plots.

This report presents the results of work conducted recently by the WorldFish Center together with its partners within an IFAD funded project (TAG-350) where a new approach was established in Bangladesh and Vietnam. Fish is cultured communally during the flood season and the same land is cultivated with rice during the dry season by individual farmers. The results of these trails show an additional 10% lower cost of rice production and a net return from fish production of 400 US$/ha in the Ganges and Meghna floodplains (Bangladesh), 340 US$/ha in the Red river delta (Vietnam), and 220 US$/ha in the Mekong delta (Vietnam). Significantly, these benefits were obtained with no reduction in the wild fish catch, composed mainly of small indigenous species (SIS). The returns from the sale of the produced fish were distributed among the group members according to a sharing arrangement that was pre-negotiated among group members at the beginning of the season. Gains to the landless were in form of cash income, which was significant as they did not have any alternative income generating opportunities.

Floodplain Farming System Evolution

Farming practices in the flood-prone ecosystem are governed by a number of interacting physical factors, of which the chief ones are the flooding regime (onset, depth, recession, and variability), topography, rainfall pattern, soil texture and water management regime. Traditionally, farmers used to grow deepwater rice and capture fish during the rainy/flood season and subsequently cultivate a wide range of crops (such as pulses, oil seeds, and vegetables) during the post-flood dry season. In Gangetic floodplains (Bangladesh and eastern India), farmers used to get a maximum 2 t of traditional rice and approximately 200 kg of wild fish per hectare per year with an average income of about USD 300 per hectare per year.

During the last few decades, the flood-prone ecosystems in Asia have undergone some dramatic changes due to the establishment of deep wells (for example, in Bangladesh and eastern India) and construction of the Flood Control Drainage and Irrigation (FCDI) systems. With the availability of irrigation facilities, farmers grow high yielding varieties (HYV) of rice in the dry season under irrigated conditions. In Gangetic floodplains, the dominant farming pattern in shallow flooded areas is irrigated HYV rice during the dry season, followed by transplanted deepwater rice varieties during the rainy seasons; while the dominant pattern in deep flooded areas is single-crop irrigated HYV rice. Late harvest of HYV dry season (winter) rice does not allow timely establishment of a deepwater rice crop in the deep-flooded areas during the rainy season.

In shallow flooded areas in the Red River Delta (in northern Vietnam), farmers generally grow high yielding irrigated rice during the dry season, and a tall-growing local or higher yielding variety during the rainy season. In the Mekong Delta of southern Vietnam, where rice fields are also deeply flooded in the rainy season, two irrigated crops of high yielding rice varieties are grown with a flood fallow period in between. Although the introduction of irrigation-based 'green revolution' technology has increased the total rice production in flood-prone areas (from about 2 t/ha/yr to about 6-7 t/ha/year), the wild fish harvest from flooded rice fields has declined substantially (from 200 kg/ha/yr to less than 100 kg/ha/yr).

An opportunity for further increased production in the flood-prone ecosystem is the integration of fish culture with rice farming. The flood-prone areas are seasonally flooded during the monsoon and remain submerged from 4 to 6 months. In these flood-prone areas, land ownership is fixed according to tenure arrangements during the dry season. But during wet season floods, individual land holdings are not visible and waters are a community property granting all members access to fish in all areas of the community. Therefore, it is essential that the rice-fish culture activity in the flood-prone ecosystem is undertaken by the rural community under a group approach. The group should 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 are stocked with fish.

Generally, three types of rice-fish culture systems can be established in flood-prone areas: (i) concurrent culture of deepwater rice (with submergence tolerance[1]) with stocked fish during the flood season followed by dry season rice in shallow flooded areas; (ii) concurrent culture of deepwater rice (with elongation ability[2]) with stocked fish during the flood season, followed by dry season non-rice crops; and (iii) alternating culture of dry season rice followed by stocked fish only during the flood season (that is, without rice) in the enclosed area (for example, as in a fish pen).

With funding from IFAD (TAG-350), the WorldFish Center and its national partners recently tested the concurrent rice-fish culture in the shallower flooded areas and the alternating rice and fish culture (option iii above) in the deep-flooded areas of Bangladesh and Vietnam through a community-based management system. Results indicate that community-based fish culture in rice fields can increase fish production by about 600 kg/ha/year in shallow flooded areas and up to 1.5 t/ha/year in deep-flooded areas without reduction in rice yield and wild fish catch. These and other potential technical options need to be tested and validated in various floodplains of Asia and Africa under varying institutional arrangements suitable for locally prevailing socio-cultural-economic and political conditions.

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[1] Rice variety used in areas of shallow to moderate flooding depths, in which young plants tolerate total submergence of leaves for up to 10 (some varieties maximum 20) days, and after this period grow quickly and produce panicles.
[2] Rice variety used in deepwater areas with longer flooding durations of up to 4 to 5 months in which the stems have the ability to elongate quickly, in response to increasing flooding depth.

Conclusions from Conducted Trials
In the trials conducted over a three-year period (1998 to 2000) in Bangladesh and northern and southern Vietnam, the approach taken was that communities were encouraged to determine the management criteria and institutional arrangements which they considered suitable to their local conditions and social environment.

Institutional Arrangements
Arrangements between stakeholders are necessary within the context that during the flooded season when individual plots are not discernable, the water body becomes a temporary a common property, in contrast to the dry season in when individual land holdings are clearly discernable and respected; this approach is needed to exploit the resource.

A group approach was used with around 20 households per group, comprising landowners, fishers of the community and landless laborers (with customary access rights for fishing in the flood season). Benefit arrangements are required to organize and consolidate the group. Landowners comprise participating (active) and non-participating (passive) persons. Landowners participating actively in the group activities received an additional share of benefits for their role as group members (on top of the share they already receive through mere provision of their land).

It was found that existing social harmony among the groups before the introduction of the community-based fish culture approach was a requirement for its successful implementation. Artificial memberships based on previous linkages with facilitating organizations (e.g. NGOs) proved to have destabilizing effects or were even detrimental. The predisposition of the population to community-based activities in some countries also was an important determinant. For example, in southern Vietnam farmers were highly averse to any form of group arrangements, even if these involved close relatives, and preferred individual management of smaller, individually owned and controlled areas. Further assessments on the attributes of successful group approaches and the reasons for spontaneous adoption and spread of the technology are planned in the near future.

Selection of Concurrent vs. Alternating System
Depending on flooding pattern in the area, and on preferences among the groups.

Selection of Appropriate Sites
Topographically opportune areas, need to include as much as possible existing embankments; initially perceived to be limited; however "spontaneous adopters" fenced up to 75% of perimeter (rest were existing embankments), with higher cost, but these still proved to be highly profitable.

Fish Species, Stocking Densities, Sizes
Recommendations were given on stocking densities of several fish species in a polyculture, preferably of larger sizes to avoid predation and to achieve greater sizes at harvest. However, these were not prescriptive packages (to avoid straightforward rejection), so the actually stocked numbers of individual fingerlings and species proportions depended on the local availability from hatcheries and other sources. Given the size of some of the enclosed areas, these were large numbers far greater than the usual requirements for fish ponds, which together with the preference for larger sizes and several different species posed considerable logistical challenges (sourcing, transport) to the communities and the facilitating NGOs.

Market Supply vs. Timing of Harvests
Both the capture phase for wild fish and the harvest phase are bound to coincide as they depend on the flood duration, levels and recession pattern. However, the culture operation can be staged over a longer period through sequential harvests leading to thinning out of the standing fish stock for higher growth, and greater returns. Further, deeper pits in the area can

be used to keep fish beyond the normal capture season until fish prices increase and greater returns from markets can be achieved. This was done by some of the trial groups.

Financial Management Issues
In the first year the communities received financial support for the initial investment in fences. In subsequent years, communities were expected to re-invest a portion of their proceeds from the previous year's fish sales into the subsequent year's fish culture operation, e.g. for the purchase of fish fingerlings and the maintenance of the fence.

Effects on Biodiversity (Wild Fish)
It was generally concluded that wild fish biodiversity and abundance was not affected by the culture operation, although no specific analyses were conducted as part of these early trials. The conclusion is based on comparisons of wild fish catch both in terms of biomass and species composition, which was essentially similar, except for predators such as snake head (*Channa* sp.) and catfish (*Clarias* sp.), which were reduced. However, in some cases farmers observed that the biomass of small indigenous species were considerably higher than in neighboring unfenced areas, and few species which had previously been seldom in their areas, had appeared again in their catches in the fenced areas. This was attributed to the strongly reduced abundance of predators within the fenced area. More detailed studies are required to establish the benign effect of stocking fenced areas of seasonally flooded waters but controlling for predator access to the fenced areas.

Beneficiaries and Impact
Inland capture fisheries are the most threatened globally, with a constant negative trend. These fish are of highest importance for the rural poor for income, nutrition and food security, but the demand is increasing which is reflected in constant price increases. Fish also have a high value for nutrition of the poor due to their nutrient density and quality (protein, oils, micronutrients) that is in highly bio-available form in most small fish species.

Fish production from the fenced floodplain areas will be increased at least two to 10 fold over the natural catch through the culture activities, as shown from our previous work in Bangladesh and Vietnam. Harvests are in bulk and therefore are sold on the market producing cash returns that are shared among group members, including the landless. Capture of non-stocked, small indigenous species by landless with traditional fishing methods within the culture areas during the culture period is specifically permitted by the groups, and thereby ensure their continued supply of protein and income over the culture season from the fenced areas. Cash income will increase for all involved, notably for the landless relative to their base income. We expect similar levels of benefits from group based fish culture approaches in irrigation systems.

In the longer term, the approach aims at providing the rural populations in the floodplain areas and irrigation systems of the targeted basins with an equitable source of additional income and supply of fish, both from natural fish production, as well as from stocked culture species. This will directly benefit the members of the communities involved, but also fish consumers outside the culture areas due to increased supply on the markets, thereby countering the negative trend of inland fisheries production. Revenues from fish production can also be used to improve the maintenance and hence the sustainability of irrigation systems.

Extrapolation Domains
The potential application areas for the community-based fish culture approach in floodplains and irrigation systems are considerable. These areas are usually densely populated, the seasonal floodwaters, however are underutilized.

The approach helps mitigate the trend of declining inland capture fisheries production, with increasing prices of fish, rendering these less affordable to the poor. For example, in

Bangladesh alone, there are 3 million hectares of medium and deep flooded areas, out of which about 1.5 million hectares are estimated to be suitable for community-based fish culture. If this approach is adopted in only 50% of these areas, annual fish production will increase by 450,000 t (additionally to presently produced 60,000 t of wild fish caught in these areas) at an approximate value of 340 million US$ and will be of benefit to an estimated 6.7 million people (2.7 million of which are landless and/or functionally landless). Similar opportunities are seen for floodplain and deltaic systems in other countries in Asia and Africa.

In the Mekong river basin, 0.8 million hectares of medium and deep-flooded areas exist which could be utilized by the communities living in them for joint fish culture activities during the flood season, which is otherwise a fallow season with very low economic and agricultural activity. Of 5.2 million hectares of medium and deep flooded areas the Indo-Gangetic basin, 3 million hectares are in Bangladesh, wherein an estimated 27 million potential direct beneficiaries live. If only 25% of these adopt the approach, 6.7 million would benefit, of which 2.7 million persons are landless. Other seasonally flooding areas suitable for the approach in other basins in Asia are in Myanmar (1.2 million hectares), Thailand (0.7 million hectares), and the Red river delta in Vietnam (0.1 million hectares).

In Africa, the potential for application of community-based fish culture is greatest seasonal floodplains and in irrigation schemes. In West African floodplains, 470,000 hectares are used to grow deepwater rice which could be used for concurrent deepwater rice and fish culture.

Need for Further Research

There are many options for enhancing food production from fish in managed aquatic systems. The most appropriate technology will vary from country to country and site to site. Additionally, the social and economic conditions under which these technologies can be implemented need to be understood. Although our recent studies in Vietnam and Bangladesh demonstrated the feasibility of the community-based fish culture systems, much more work is needed to understand the social and economic viability of these approaches under different socio-cultural and institutional environments, and to design appropriate institutional arrangements for different social settings. Similarly, the governance arrangements for fish culture in irrigation systems (canals, fields, reservoirs) also require detailed analyses if the full social value of these resources is to be harnessed.

At the ecosystem or basin level, water provides a wide range of goods and services, all of which need to be considered in broader analyses of the value obtained from water. Most of the previous studies of water productivity have concentrated on measuring the value of crop production only and excluded the existing and potential contributions by living aquatic resources. There is therefore a need not only to increase water productivity, but also to improve the methodologies for measuring water productivity.

1. INTRODUCTION

1.1. Background and Rationale

Over 10 million ha, or 15% of the total rice land in Asia suffer from uncontrollable seasonal flooding. Of these, over half are in the Indian subcontinent, mainly in Bangladesh and Eastern India while the rest (44%) are located in Southeast Asia, mainly in Myanmar, Thailand, Vietnam and Cambodia. These areas are home to more than 100 million farmers who are among the poorest in Asia. Moreover, women and children are in a particularly disadvantaged position in these areas due to the low food supply and lack of opportunities for alternative occupation and income generation.

Bangladesh and Vietnam are two countries, which are heavily reliant on the flood-prone rice ecosystem. More than half of Bangladesh's 10.2 million ha of rice land and about 10% of Vietnam's 7.0 million ha of arable land are flooded to depths of more than 50 cm during the rainy season. Bangladesh and Vietnam have a total population of approximately 190 million, of which 90% live in rural areas, and 80% depend either directly or indirectly on agriculture for their income. Farming is basically for subsistence and mainly rice-based in these two countries.

Farming practices in the flood-prone ecosystem are governed by a number of interacting physical factors, of which the chief ones are flooding regime (onset, depth, recession, variability), topography, rainfall pattern, soil texture and water management regime. Traditionally, farmers used to grow deepwater rice and capture fish during the rainy/flood season and subsequently cultivate a wide range of crops (such as pulses, oil seeds, vegetables) during the post flood dry season (Fig. 1).

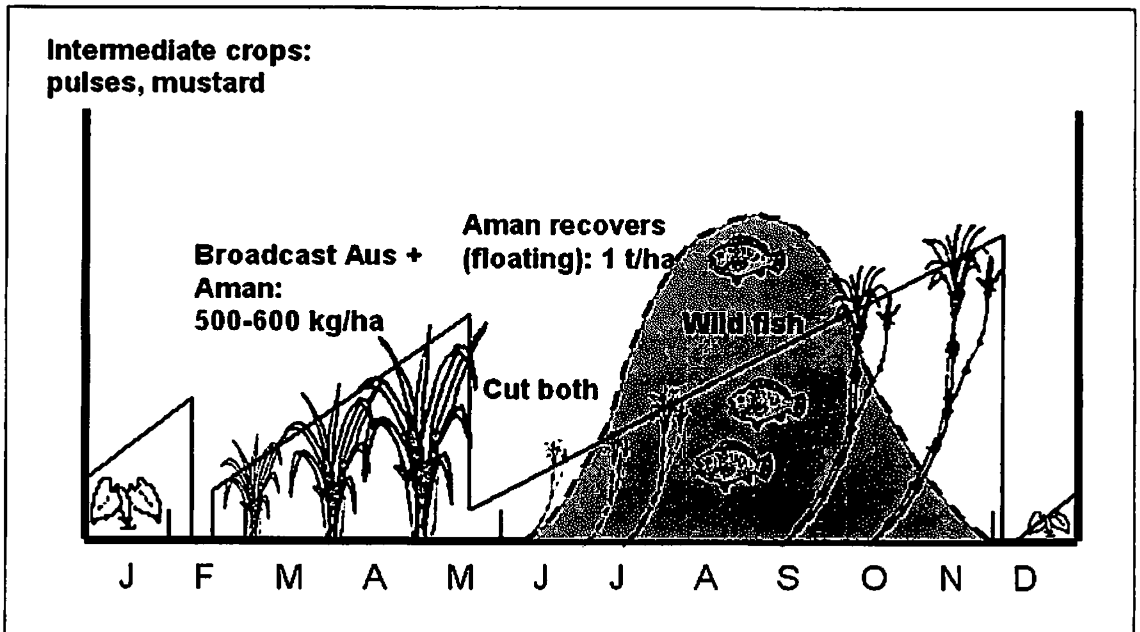

Fig. 1. Most dominant farming system in the flood-prone areas of Bangladesh before the introduction of high yielding varieties (HYV) of rice (until early 1970's).

During the last few decades, the flood-prone ecosystems in Bangladesh and Vietnam have undergone some dramatic changes due to the establishment of deep wells (in Bangladesh) and construction of the Flood Control Drainage and Irrigation (FCDI) systems. With the availability of irrigation facilities, farmers grow high yielding varieties (HYV) of rice in the dry season (known as Boro rice in Bangladesh) under irrigated condition. In Bangladesh, the dominant farming pattern in shallow flooded areas is Boro rice during the dry season, followed by transplanted deepwater Aman during the rainy season (Fig. 2); while the dominant pattern in deep flooded areas is single-crop irrigated Boro rice (Fig. 3). In shallow flooded northern Vietnam, farmers generally grow high yielding irrigated rice during the dry season, and a tall-growing local or higher yielding variety during the rainy season. In southern Vietnam, where rice fields are also deeply flooded in the rainy season, two irrigated crops of high yielding rice varieties are grown with a flood fallow period in between.

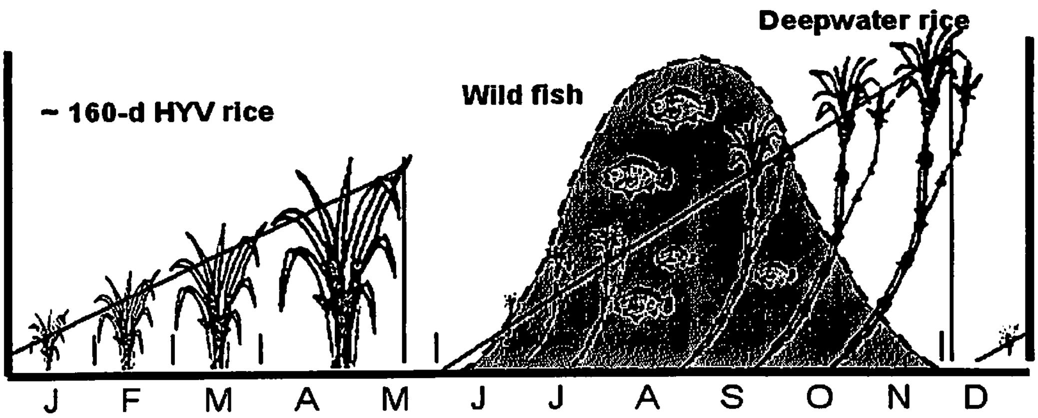

Fig. 2. Most dominant farming system in shallow flooded areas of Bangladesh after the introduction of high yielding varieties (HYV) of rice.

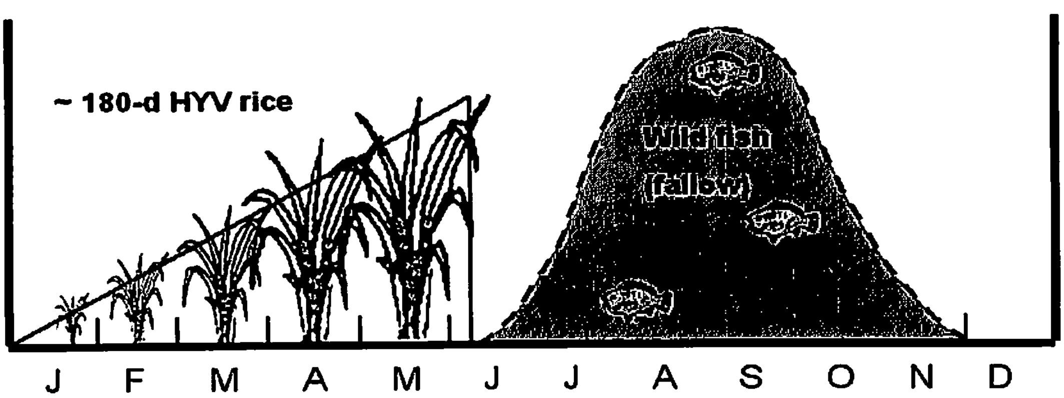

Fig. 3. Most dominant farming system in deep flooded areas of Bangladesh after the introduction of high yielding varieties (HYV) of rice.

An opportunity for increased production in the flood-prone ecosystem is the integration of fish culture with rice farming. The flood-prone areas are seasonally flooded during the monsoon and remain submerged for 4 to 6 months. The vast water bodies can provide natural habitats for various aquatic resources including wild fishes and shrimps. The yearly silt deposition and organic matter decomposition favor the natural growth of flora and fauna. The abundance of natural organisms favors fish culture for 4 to 5 months in these flood-prone areas.

In the flood-prone areas, land ownership is fixed according to tenure arrangements during the dry season. But at times of floods during the wet season, individual land holdings are not visible and fish are a community property granting all community members access to fish in all areas of the community. Based on experiences in other areas, it is likely that poor communities will sustainably manage common propertyresources over which they have effective control. Therefore, it is essential that the rice-fish culture in the flood-prone ecosystem is undertaken by the rural community under a group approach. The group should 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 are stocked with fish.

Resource management approaches, such as integrated resource management and ecosystem-based planning, are essential for the sustainable use of natural resources. Community-based management approaches have been successfully used to achieve both socioeconomic and ecological objectives through integrated conservation-development planning. Community-based management can also serve as a mechanism for economic development by promoting participation of all categories of resource users and the community in actively solving problems and addressing needs.

Rice and fish are the two main food sources for the people living in flood-prone areas of Bangladesh and Vietnam. Fish provides about 80% and 30% of dietary animal protein in Bangladesh and Vietnam, respectively. Increased food production from rice-fish culture in the flood-prone ecosystem could play a vital role in reducing malnutrition, increasing household income and promoting food security. It would also help mitigate the trend of declining capture fisheries production.

So far, there have been very successful results from fish culture in very shallow flooded ricefields (flooded to less than 50 cm of water) both in Bangladesh and Vietnam. However, large-scale integration of fish culture with rice cultivation in flood-prone areas (with more than 50 cm of flooding), where land is not bounded, has been constrained by technical and institutional factors. There is a need to identify appropriate fish species and rice varieties, develop cultural practices, and establish suitable management/institutional mechanisms towards the identification and promotion of economically viable, socially acceptable and ecologically sound rice-fish technologies for the flood-prone ecosystem.

These considerations establish the basis for an interdisciplinary and integrative action research program for community-based participatory management of resources of the seasonally flooded ecosystem of Bangladesh and Vietnam. The policy environment in these countries is strongly receptive to innovative approaches to resource management and rural poverty alleviation. In Bangladesh, this is shown by the government's increasing interest in taking steps to implement the concept of community-based resource management. While in Vietnam, the potential for rice-fish farming is believed to have a positive impact on rural nutrition.

The World Fish Center submitted a proposal to the International Fund for Agricultural Development (IFAD) for the implementation of a collaborative action research project on "Increasing and Sustaining the Productivity of Fish and Rice in the Flood-prone Ecosystems in South and Southeast Asia". IFAD provided a technical assistance grant (TAG no. 350-ICLARM) of US$435,000[1] to World Fish Center for implementing the project for three years starting from 1 April 1997 in Bangladesh and Vietnam. Due to the delay in initiating project activities in Bangladesh and Vietnam, IFAD granted a no cost extension of the project up to 31 December 2001 (that is, grant closing date). This Project Completion Report discusses the results of the project. Other publications prepared based on the findings of the project are given in the Appendix.

1.2 Scope and Objectives

The research program's overall objective was to develop, through participatory action research, sustainable resource management systems in the deepwater rice ecosystem. The aim was to integrate "indigenous" resource management techniques with semi-intensive rice-fish culture and management technologies for increased income of rice farmers.

After examining and reviewing a number of options to increase deepwater rice and fish production in flood-prone areas, a three-pronged approach for the program was identified:

1. Comparative analysis of alternative resource management strategies in flood-prone ecosystems

   A study and assessment activity, in which (i) the resource use patterns in the flood-prone areas were studied to measure their productivity and alternative use options, and (ii) fish biodiversity and its value to society was assessed.

2. Participatory development of viable income generating technical options for possible application/replication to other flood-prone ecosystems and their field testing and validation

   An intervention activity, in which various technical options for improvements in the productivity of the deepwater rice system (including fish stocking, land use, improved deepwater rice varieties) were identified, tested and analyzed.

3. Identification of viable community-based mechanisms and institutional arrangements to ensure (i) target group access to water bodies; (ii) adequate and timely supply of fingerlings; and (iii) harvesting and marketing of fish

[1] The total contribution of IFAD for this project (TAG no. 350-ICLARM) is US$585,000, of which US$150,000 went to INFOFISH for the implementation of component (iv) of the project. INFOFISH was directly responsible and accountable to IFAD for the implementation of this component and in the financial and technical reporting thereof.

An implementation and evaluation activity was designed, in which considerations were given to alternative ways of implementing technical options. Special emphasis was placed on the institutional options for introducing community-managed enhanced fisheries into deepwater rice areas and communities where such management has not yet been tried. Studies were undertaken on the results of community managed stocking, husbanding and harvesting of fish through participatory studies.

1.3 Methodology

A sound methodology was developed for the study after a review of different studies and through group discussions among personnel of participating agencies as well as with the participating farmers. The following steps were followed in implementing the study.

1.3.1 Identification of Landscape/Stockholders

After collecting relevant information on potential sites through the review of secondary sources and reconnaissance field visit by multidisciplinary teams, several rounds of group discussions were made with the users in each potential site. In selecting project sites, both the agroecological condition of the landscape and the socioeconomic institutional aspects of the users of the landscape were considered. The unit of analysis of the project, thus, was the resource management domain (RMD) at the landscape level. For each project site, a control site with similar agroecological environment was selected.

1.3.2 Assessment of Users' Needs

The users/stockholders included landowners as well as other people of the community who rely on the landscape for fishing during the rainy season. In identifying users, discussions were made with representatives from various classes of the society namely poor farmers, rich farmers, landless laborers of the nearby communities, and members of local organizations.

The steps followed in assessing users' needs were: (i) diagnostic survey conducted by scientists and representatives from local level organizations (that is, NGOs in Bangladesh, local agriculture extension offices in Vietnam); (ii) baseline surveys of socioeconomic, institutional, and biophysical conditions; and (iii) group discussions with users. Preliminary results of diagnostic and baseline surveys were presented and discussed during the group meetings. One main objective of the baseline survey was to generate baseline information on various socioeconomic aspects of the farmers so that the same parameters could be compared during the impact assessment of the project.

1.3.3 Participatory Design and Testing of Technical Options

Technical options were designed by researchers in consultation with users based on users' need and indigenous knowledge. As the concept of managed fish culture in deepwater rice fields is new, small-scale experiments were first initiated in Vietnam to know the potential of the technical options. The results of these trials were subsequently used as input to initiate discussions between researchers and users about various aspects of the trials, which were subsequently utilized in fine-tuning the technical options.

Site-specific technical options were tested by users, with minimum support from researchers. Users provided labor in managing experiments and collecting simple experimental data (for example, input use level). Researchers basically acted as resource persons. The project provided financial support, as seed money, during the first two years to cover material costs. Users deposited a certain portion of the sale proceeds from the experiments to cover future project expenditure.

Users designed institutional options (such as group formation, sharing arrangement) for testing technical options; researchers and NGO workers acted as facilitators. Users included participating farmers, non-participating farmers, and practicing non-farmers who used to rely on the landscape for fishing. Groups were formed with more or less homogenous users. A Project Implementation Committee (PIC) was formed in each site with representatives from different categories of users, local organizations (such as NGO in Bangladesh), and the research team. The functions of the PIC were: (i) preparation of a budget; (ii) finalization of sharing agreement; (iii) overseeing the implementation of the project; (iv) settlement of conflicts; (v) supervision of fish sales; (vi) distribution of proceeds from experiments; and (vii) management of the project account.

1.3.4 Monitoring and Evaluation

A range of variables including biophysical (for example, water quality, soil quality), agricultural (for example, input use, crop yield, fish culture, fish catch) and socioeconomic (input and output price, profitability, fish consumption) variables were monitored in both the control and project sites. In addition, group performance was also monitored in the project sites. This information was used in analyzing the impact of the community-based fish culture in flooded rice ecosystem namely impact of both the technology and the community-based mechanism. Monitoring was done mostly by researchers and NGO representatives because users were very busy in managing the site.

1.4 Implementation Arrangements

Over a three-year period, activities were conducted in Bangladesh and Vietnam. In most cases the intent was to implement all three activities concurrently in a given site. In both countries, emphasis was placed on the involvement of local institutions of research and development, including NGOs. Both the World Fish Center and the International Rice Research Institute (IRRI) have established existing partnerships with institutions in each country. Principal participating institutions were: (i) Bangladesh Fisheries Research Institute (BFRI); (ii) Bangladesh Rice Research Institute (BRRI); (iii) Proshika Manobik Unnayan Kendra (an NGO in Bangladesh); (iv) Research Institute for Aquaculture No.1 (RIA1) in northern Vietnam; (v) Research Institute for Aquaculture No. 2 (RIA 2) in southern Vietnam; (vi) Vietnam Agriculture Science Institute (VASI); (vii) Institute of Marine Aquaculture, Can Tho University, Vietnam; (viii) (IRRI) and (ix) the World Fish Center. The World Fish Center acted as the main implementing agency

Knowledge on deepwater rice ecosystem and approaches to integration of aquaculture was shared between project staff and collaborators in Bangladesh, and scientists and decision makers in Vietnam. Field visits and in-depth study tours were organized for the resource persons involved with the project.

1.5 Study Location

The project was implemented in four areas of Bangladesh representing the floodplain ecosystems of the Ganges, Brahmaputra and Meghna, and in two areas of Vietnam representing the Red River and Mekong River floodplains.

2. EXISTING RESOURCE USE PATTERNS, INSTITUTIONAL ARRANGEMENTS AND FISH CONSUMPTION

2.1 Biophysical Characteristics of the Study Sites

The project areas represent varied biophysical environments (Table 1). These project areas can be categorized as shallow and medium flooded (with 50 to 150 cm flooding depth) and deep-flooded (150 to 250 cm flooding depth). The flooding is generally uncontrolled in Bangladesh and in the Mekong River Delta of southern Vietnam, but it is controlled in the shallow/medium flooded Red River Delta (northern Vietnam). The dominant farming system in the shallow and medium flooded project areas in Bangladesh (Narail and Muktagacha-Mymensingh) is HYV (high yielding variety) Winter Rice (known as Boro rice) during the dry season grown under irrigation, followed by transplanted deepwater Aman rice during the rainy season. In the deep-flooded project areas in Bangladesh (Kuliarchar-Kishorganj and Brahman Baria), farmers usually grow single-crop irrigated HYV Boro during the dry season (January to June) and keep the land fallow during the rest of the year. In these areas, late harvest of Boro does not allow the establishment of a deepwater rice crop before the arrival of the flood (in May/June). In the shallow flooded project areas in the Red River Delta (northern Vietnam), where flooding is relatively controlled, farmers generally grow high yielding irrigated rice during the dry season, and a tall-growing local or higher yielding variety during the rainy season. In the project areas located within the Mekong Delta (southern Vietnam), where rice fields are also deeply flooded in the rainy season and flooding is uncontrolled, farmers grow two irrigated crops of high-yielding rice varieties with a flood fallow period in between (August to November). The details of these project areas are given below.

Table 1: Description of the Different Project Areas

Country	Area/District	Floodplain	Flooding Duration	Maximum flooding depth (m)	Existing farming system	Flood control regime
Bangladesh	Brahman baria	Meghna	May/June - Nov/Dec	2.50	HYV Rice (Boro) - Fallow	No
	Kishorganj	Brahmaputra	May/June - Nov/Dec	1.80	HYV Rice (Boro) - Fallow	No
	Narail	Ganges	June/July - Dec	1.25	HYV Rice (Boro) - TDW Aman	No
	Mymensingh	Brahmaputra	July/Aug- Nov/Dec	1.25	HYV Rice (Boro) - TDW Aman	No
Vietnam	Vu Ban (North Vietnam)	Red River Delta	June - Dec	1.00	MV Rice - L/MV Rice (Spring/Summer - Autumn)	Available
	Thap Muoi (South Vietnam)	Mekong River Delta	Aug - Nov	2.20	MV Rice - MV Rice (Spring - Spring)	No effective flood control

Note: HYV = high yielding variety; TDW = transplanted deepwater; MV = modern variety

2.1.1 Bangladesh

In each of the four project areas in Bangladesh (Kuliarchar-Kishorganj, Brahman Baria, Narail, Muktagacha-Mymensingh) two project sites were selected. A few of the project sites were discontinued due to various social and technical reasons and new sites were selected. Each of the project sites had unique agroecological characteristics. For ease of understanding, the agroecological features of individual sites are described separately.

Bagpara, Kuliarchar

In this site, project activities started in 1998. The total land area of the site was 8.70 ha which belonged to 58 owners. The project activities were initiated with 132 members of whom 98 were members of a group formed by Proshika. Of the 98 members, 84 were landless and most of them were from Agarpur village. A High Yielding Variety of rice is grown during the Boro season (December toApril) and land remains fallow during the rest of the year. Local transplanted Aman rice is grown in some of the areas from August to November. This site was discontinued due to conflict and misunderstandings among the participating households.

Monoharpur, Kuliarchar

The area has 2.22 ha of land on the Bhairab-Kishorganj road. In this site a group of farmers and non-farmers cultivated fish in 1997 and continued up to 1998. Within this group there were 19 farmers, 15 of whom were Proshika group members. The four other non-Proshika members were landless fishers. In 1998 when an extreme flood occurred throughout the country, a flood washedout some of the stocked fish through overflowing at the sides. Consequently, the profit from stocked fish was less than the amount they had expected. However, groups still continued the same arrangement for the next year, but subsequently some of them declined to continue in 1999. Therefore, the project had to continue without those who were not interested in 1999. In the year 2000, the site had to be abandoned.

Konapara, Kuliarchar

The project site is situated in the village of Konapara, 7 km north-west of Kuliarchar *thana* (thana is a sub-district) of Kishoreganj district and within Osmanpur Union. The total project area covers 1.74 ha of land of which 0.7 acres are a semi-permanent ditch. Flooding water entering the area comes from the river. On two sides there are complete natural barriers. Two sides needed fencing. More than 33% of the total area has clay loam soil and more than 38% has a sandy loam type of soil. The maximum flooding depth is 1.82 m and flooding occurs during the months of June to October. The main cropping pattern is single HYV Boro rice during the dry season. In the shallow flooded fringe, some farmers grow transplanted local rice (tall and photo sensitive) varieties during Aman (rainy) season (June to December) after the harvest of Boro rice.

Agarpur-Jagotchar, Kuliarchar

The site is situated in Ramdi Union of Kishorganj district and is located 5 km north of Kuliarchar *thana*. The total project area is 6.9 ha of which 3.16 ha is a deep depression and retains water of up to 0.5 m depth for 6-7 months. Flooding usually occurs due to rain and inflows of rising river water. The flooding period is June to October with a maximum water depth of 1.93 m. The usual cropping pattern is Boro-Fallow-Fallow. During the Boro season, the rice varieties farmers grow are: Hazishail, BR-26 and BR-29. Soil is clay loam (55.42%) and sandy loam (44.58%). In this site, natural fish species like shoal, shing, magur, koi, puti, taki, gutum, baim, and mola are common. Farmers have not tried to culture fish in this site.

Uzanisher, Brahman Baria

The site is situated in Sadar *thana* of Brahman Baria district. The total project area is 18.34 ha. On the southern side of the area, there is a borrow pit where farmers were retaining fish for the rest of the year. Although it is a big area and there is a sluice gate for water control, the beneficiaries previously had not tried to culture fish though they were holding fish in the adjacent *khal* throughout the year and also fencing the area to catch natural fish at the end of the rainy season. The most prevalent soil type is sandy loam (> 58% of the total area). The normal flooding period occurs during the months of May to November with a maximum recorded water depth of 2.64 m. In this vast area, farmers only grow one crop (Boro paddy) during the winter season. Rice varieties grown are BR3, BR28, BR14 and Chandina. The natural fish that they were harvesting during the rainy season were kaski, mola, puti, chanda, shing, magur, kalisa, among others.

Urshiura, Brahman Baria

This site is also situated in Sadar *thana* of Brahman Baria district. The project site covers 3.20 ha of land. May to October is the period of normal flooding with a maximum recorded flooding depth of 2.13 m. The most prevalent soil type is clay loam (> 58% of the total area). In this area, farmers only grow one crop (Boro paddy) during the winter season. Rice varieties grown are BR1, BR3, BR14 and BR28. The natural fish that people were harvesting during the rainy season were kaski, mola, puti, chanda, shing, magur, kalisa, among others.

Kuripara, Muktagacha

Kuripara site is located on the Muktagacha-Jamalpur road in Sadar *thana* under Borogram Union. The two ditches in the 1.32 ha of land are bounded by a road, a raised village path and raised homestead areas. June to December is the period of normal flooding with maximum flooding depth of about 0.75m. The soil type of more than 67% of the area is sandy loam. Farmers usually follow Boro (HYV)- Fallow- T.Aman (HYV) and Boro (HYV)- Fallow- T.Aman (local) cropping patterns. A minor quantity of small fish species is available in this site as there is very little connection with the natural fish sources. Natural fish species available are mola and puti. Fish culture has never been undertaken in this site.

Halida, Muktagacha

The site is also known as Hugly *beel* with a 3.15 ha depression bounded by raised homesteads, higher land of Sal (*Sorea robusta*) forest and is situated in Goga Union of Muktagacha Sadar *thana*. Only one channel drains water in and out, and it is closed by the landowner using a fence. About 0.8 acre of permanent waterbodies of 1.25-1.5 m depth remains flooded throughout the year. The rest of the area where about 0.75 m water stands during the monsoon season is cultivated with LT Aman. The main source of water is rainwater from the canal. Normal flooding occurs during the month of June to December with maximum flooding depth of 1.31 m. The most prevalent soil type is clay (>40 % of the total land area). During the last winter, landowners re-excavated the deeper part of the area to retain more water for irrigation. The soil type in deeper areas is red clay. The most serious problem of this site is wash-off of red soil after heavy rainfall which makes the water turbid. The cropping pattern is Boro-Fallow-T. Aman (local). The local T. Aman varieties grown are Aloi and Mariam.

The whole area is owned by five brothers of an extended family. One of them lives in the site and takes care of the land property, while the others live away due to their jobs. The family has been culturing fish in the deeper area and in the adjacent pond for the last eight years. They had stocked carp but did not receive the expected returns from this area. The population of natural fish (such as koi, magur, puti, mola) is also abundant in the area.

Maizpara, Narail

The site is situated in Narail Sadar *thana*. The site has 3.2 ha of land area. Three ditches hold water throughout the year. May to December is the period of normal flooding with maximum flooding depth of 1.28 m. The soil type of more than 61% of the area is clay loam. Farmers cultivated HYV Aman rice (BR11) and a local transplanted Aman rice variety (Gocha). After harvesting Aman rice farmers cultivate winter rice (Boro).

Sadhukhali, Narail

This is a 3.12 ha rain fed T. Aman rice growing area and is situated in Sadar *thana* of Narail District. May to December is the period of normal flooding with maximum flooding depth of 1.00 m. The soil type of more than 41% of the area is sandy clay loam. Farmers follow a Boro-Fallow-T. Aman and Fallow-Jute-T. Aman cropping pattern. There is a ditch in the middle of the project area where farmers used to "rot" jute[1] before implementing the rice–fish project. The area is bounded by a road in one side and high dykes on the other side.

2.1.2 Red River Delta, Northern Vietnam

In northern Vietnam, the project was implemented in the Vu Ban district of Nam Dinh province, which is one of the typical lowland areas in the Red River delta. The district has over 1000 ha of deepwater rice fields that are often flooded in the peak monsoon season (July-September). In order to control flooding, irrigation systems have been constructed all over the province during the 1960's and 1970's. The irrigation systems include canals and pumping stations which can pump water out of rice fields to protect rice from flooding in the rainy season. However, the cost of pumping for the protection of the rice crop could be very high during heavy rain.

The study area is flooded during July to October, with a maximum water depth of about 100 cm in August. Being a central part of the Red River delta, agricultural land in the study area is very fertile and the soil is not acidic. Rice fields are often used for two rice crops per year. Rice yields are as high as 5.0 t/ha/crop. During the last two decades, high yielding varieties (HYVs) of rice have been cultivated to replace the traditional rice varieties. With intensive culture of HYVs, large amounts of chemicals and pesticides were used. Under those conditions, natural populations of freshwater prawn, snail, crab and carps declined to a great extent. In addition, overfishing in the rivers and irrigation canals altered the aquatic fauna, and some species totally disappeared in the region. Only few wild fish species such as snakehead and eel still remained.

2.1.3 The Mekong River Delta, Southern Vietnam

The Mekong delta is located in the lower basin of the Mekong River, covering an area of 3.9 million ha, of which 2.06 million ha (52.9 %) is a rice land area. With a population of 16 million, it contributes significantly to national exports (30% to the national GDP in 1990), particularly through rice and fish products. Paddy production in the Mekong Delta amounted to 16 million tons in 1999, 52% of the total Vietnamese production.

[1] The usual practice is that farmers cut the jute plants and then place them under water for a number of days to extract fiber of the plants.

The flood-prone area is located in the northern part of the Mekong delta. Its total area is 1.9 million ha, covering Long An, Tien Giang, Ben Tre, Dong Thap, Vinh Long, Can Tho, An Giang and Kien Giang provinces. Three zones can be differentiated based on flooding water depth: a deep flooded zone (> 2.0 m), a semi-deep flooded zone (1.0 – 2.0 m) and a shallow flooded zone (0.5 – 1.0 m).

The project was implemented in the Trap Muoi district of Dong Thap Province. In addition, an experimental trial was conducted in the neighboring province (Tien Giang) during the first year of project implementation to test the technical feasibility of fish culture in the flood-prone rice ecosystem of southern Vietnam. These areas represent the deep flooded zone of the Mekong delta. Though there are some dike systems and sluice gates to control early floods, flooding in this area for most part of the rainy season is generally uncontrolled.

The arrival, departure and duration of the flood in the study area are strongly affected by the flooding regime of the Mekong delta. Flooding generally begins in August and continues for about 13.5 weeks. The maximum level of flooding ranges from 150 to 220 cm in the study area (mean = 180 cm). The maximum depth of flooding occurs around the first to the third week of October. After reaching the highest level, floodwater begins to recede and the farmers can start preparation for rice cultivation activities in November. In recent years, the occurrence of abnormally high floods has become more common in the Mekong delta. Over the last ten years, the project site has experienced three such abnormally high floods, which caused considerable crop losses.

Historically, the study area belongs to the floating rice area. Up to the early 1970s, the main cropping pattern in this area was single floating rice. Some farmers used to grow upland crops such as sweet potato, mungbean and vegetables after the harvesting of flooding rice. With the construction of an irrigation and drainage system in the Plain of Reeds after 1975 and with the availability of high yielding varieties (HYV) of rice, farmers in this area have started growing two rice crops per year since the late 1980s. At present the dominant cropping pattern is Winter-Spring HYV rice (December / week 3 - March / week 4), followed by Summer-Autumn HYV rice (April / week 1 - July / week 1). Under this system, the average rice yield is 10 t/ha (around 6.5 t/ha for Winter-Spring rice and around 3.5 t/ha for the Summer-Autumn rice). Farmers generally keep the land fallow during August to November (during the flooding season).

This flood-prone area has a very rich and diversified fauna which includes aquatic animals, amphibians, reptiles and birds. During the flood season, people catch various freshwater fish species, including high-valued species such as cyprinids, snakehead, climbing perch and several catfish species (for example *Clarias* and *Pangasius*).

2.2 Socioeconomic Profile of the Farmers

2.2.1 Bangladesh

2.2.1.1 Survey Methodology

In Bangladesh, a baseline survey was conducted in all the eight sites selected during 1999-2000 to generate information on the present socioeconomic condition of the farmers. For each site, both the project (participating) and control (non-participating) farmers were interviewed using a pre-coded questionnaire. Within the project and control groups, respondents were further grouped into landowners and landless. For each site, 32 respondents (16 from project and 16 from control) were randomly selected, for a total of 256 farmers. Among the 256 households, 104 were taken from the landowner group and another 152 households were taken from landless group, with equal numbers of households from both project and control groups **(Table 2)**.

Table 2 : Distribution of Sample Households by Land Ownership and Sites, Bangladesh, 2000.

District	Site	Project		Control		Total
		Landowner	Landless	Landowner	Landless	
Kishorganj	Agarpur	8	8	8	8	32
	Konapara	8	8	8	8	32
Mymensingh	Halida	2	14	2	14	32
	Kuripara	2	14	2	14	32
Narail	Sadhukhali	8	8	8	8	32
	Maizpara	8	8	8	8	32
B. Baria	Uzanisher	8	8	8	8	32
	Urshiura	8	8	8	8	32
Total		**52**	**76**	**52**	**76**	**256**

2.2.1.2 Household Size of the Sample Farmers

The average household size was 5.78 members. Landowners of Sadhukhali in the control group had the largest number of household members (11 members per household) followed by the farmers of Maizpara (9 members per household). In general, landowners of control group had the largest number of household members (7 members per household) compared to all other groups **(Table 3)**.

Table 3 : Average Household Size by Land Ownership and Sites, Bangladesh

District	Site	Project		Control		All
		Landowner	Landless	Landowner	Landless	
Kishorganj	Agarpur	5	5	4	5	4.75
	Konapara	4	4	6	5	4.75
Mymensingh	Halida	6	5	5	4	5.00
	Kuripara	6	4	5	4	4.75
Narail	Sadhukhali	6	8	11	7	8.00
	Maizpara	7	5	9	7	7.00
B. Baria	Uzanisher	6	5	8	5	6.25
	Urshiura	7	6	6	4	5.75
All		**5.88**	**5.63**	**6.50**	**5.12**	**5.78**

2.2.1.3 Education Level of the Family Members

Most of the family members (32-41%) had formal education of one to five years. The family members in the landowner group were more educated than the landless group in both project and control sites **(Table 4)**.

Table 4 : Education Level of the Family Members by Land Ownership and Sites, Bangladesh

Level of education	Location							
	Project				Control			
	Landowner		Landless		Landowner		Landless	
	No	%	No	%	No	%	No	%
No schooling	38	12.42	53	16.93	51	15.64	60	18.58
Can sign only	33	10.78	68	21.73	48	14.72	88	27.24
1-5 years	99	32.35	121	38.66	128	39.26	133	41.18
6-10 years	89	29.08	62	19.81	65	19.94	33	10.22
>10 years	47	15.36	9	2.88	34	10.43	9	2.79
All	**306**	**100**	**313**	**100**	**326**	**100**	**323**	**100**

2.2.1.4 Average Farm Size Owned by the Farmers

Land is the most critical resource of the farming community. The collected values of fragmented land areas owned by the individual farmers were summed and expressed in hectares. On average, a household owned0.49 ha of land. Farmers from the project site owned slightly larger land areas (0.53 ha) compared to the farmers in the control site (0.45 ha). Within the project area, the average farm size was highest in Sadhukhali (0.87 ha), which was as large as the average farm size of farmers in the control area in Uzanisher **(Table 5).**

Table 5 : Average Farm Size of the Sample Households, Bangladesh

District	Site	Project		Control		All	
		Number	Average farm size (ha)	Number	Average farm size (ha)	Number	Average farm size (ha)
Kishorganj	Agarpur	16	0.59	16	0.38	32	0.48
	Konapara	16	0.59	16	0.50	32	0.55
Mymensingh	Halida	16	0.22	16	0.13	32	0.18
	Kuripara	16	0.13	16	0.14	32	0.14
Narail	Sadhukhali	16	0.87	16	0.69	32	0.78
	Maizpara	16	0.64	16	0.53	32	0.59
B. Baria	Uzanisher	16	0.84	18	0.87	32	0.85
	Urshiura	16	0.38	16	0.38	32	0.38
All		**128**	**0.53**	**128**	**0.45**	**256**	**0.49**

2.2.1.5 Distribution of Land by Soil Type

Soil types play an important role in determining the productivity of crops as well as of fish culture. As an example, neither crop nor fish can be cultured successfully in sandy soil The soil type of the study area is suitable for crop and fish culture since only a small portion, specifically 5.82%, of the total land area is sandy soil. No significant variation in soil type was observed between the project and control sites. The water holding capacity of the study area is satisfactory as about 60% of total land area is clay and clay loam type of soil **(Table 6).**

Table 6 : Distribution of Land by Soil Type in the Project and Control Area, Bangladesh

Area	Site	Percent of total area by Soil Type				Total area (m^2)
		Clay	Clay loam	Sandy loam	Sandy	
Project Area						
Kishorganj	Agarpur	0.00	55.42	44.58	0.00	944.53
	Konapara	2.29	33.76	38.77	25.18	938.87
Mymensingh	Halida	40.13	21.52	26.76	11.59	363.16
	Kuripara	6.01	22.85	67.13	4.01	323.48
Narail	Sadhukhali	30.28	41.69	25.66	2.36	1,386.64
	Maizpara	27.78	61.26	10.96	0.00	1,030.36
B. Baria	Uzanisher	8.90	29.86	58.08	3.17	1,342.51
	Urshiura	10.11	55.93	13.14	20.82	600.81
Total area (m^2)		1,065.59	2,910.93	2,345.34	4,87.04	6,808.91
% of total		15.65	42.75	34.45	7.15	100
Control Area						
Kishorganj	Agarpur	12.49	28.26	59.25	0.00	606.07
	Konapara	9.98	37.63	52.38	0.00	806.88
Mymensingh	Halida	23.88	15.53	51.07	9.51	208.50
	Kuripara	9.09	37.24	53.67	0.00	231.58
Narail	Sadhukhali	25.86	39.26	34.88	0.00	1,100.40
	Maizpara	42.37	46.36	11.27	0.00	851.42
B. Baria	Uzanisher	7.54	54.14	29.84	8.47	1,390.49
	Urshiura	35.77	30.24	16.03	17.95	611.13
Total area (m^2)		1,195.95	2,357.89	2,005.26	247.37	5,806.48
% of total		20.60	40.61	34.53	4.26	100
Grand total area (m^2)		**2,261.54**	**5,268.82**	**4,350.60**	**734.41**	**12,615.39**
%		**17.93**	**41.77**	**39.49**	**5.82**	**100**

2.2.1.6 Average Annual Income of the Farmers

Average annual income of the farmers was estimated and converted to US Dollars using the official exchange rate that prevailed during the study year. The average annual income of the farmers was US$978/household. On average, annual income of landowners was greater than that of the landless, both in the project and control areas. In general, farmers from Urshiura and Uzanisher had the highest income **(Table 7).**

Table 7: Average Annual Income (US$) of the Sample Households, Bangladesh

District	Site	Project		Control		Total
		Landowner	Landless	Landowner	Landless	
Kishorganj	Agarpur	2,068	793	1,141	631	1,158
	Konapara	1,408	612	2,042	727	1,197
Mymensingh	Halida	617	522	301	427	467
	Kuripara	1,442	709	1,127	909	1,047
Narail	Sadhukhali	381	326	218	497	356
	Maizpara	1,207	490	875	617	797
B. Baria	Uzanisher	1,223	1,191	2,311	829	1,389
	Urshiura	1,550	466	2,093	1,549	1,415
Total		**1,237**	**639**	**1,264**	**773**	**978**

2.2.1.7 Sources of Income

Except inUzanisher, neither rice culture nor fish culture was the major source of income of the farmers (both in the project and control areas). Instead, income from non-farm and off-farm sources were the major portions of income contributing about 68% and 95% of the total household income in the project and control areas, respectively (**Table 8**).

Table 8 : Contribution of Income Sources to Total Income of the Farmers, Bangladesh

District	Site	Project	Control	All
Kishorganj	Agarpur			
	% of income from other source	88.14	83.30	85.21
	% of income from rice	8.91	14.18	11.55
	% of income from fish culture	2.95	3.52	3.24
	Konapara			
	% of income from other source	93.39	96.07	94.72
	% of income from rice	2.89	2.05	2.47
	% of income from fish culture	3.72	1.88	2.80
Mymensingh	Halida			
	% of income from other source	91.57	95.29	93.42
	% of income from rice	3.14	4.39	3.77
	% of income from fish culture	5.29	0.32	2.81
	Kuripara			
	% of income from other source	96.26	94.23	95.24
	% of income from rice	0.52	0.44	0.48
	% of income from fish culture	3.22	5.33	4.28
Narail	Sadhukhali			
	% of income from other source	60.53	74.59	67.55
	% of income from rice	15.10	25.41	20.26
	% of income from fish culture	24.37	0.00	12.19
	Maizpara			
	% of income from other source	78.26	83.63	80.94
	% of income from rice	8.39	13.66	11.03
	% of income from fish culture	13.35	2.71	8.03
B. Baria	Uzanisher			
	% of income from other source	25.48	49.27	37.37
	% of income from rice	15.13	45.32	30.23
	% of income from fish culture	59.39	5.41	32.40
	Urshiura			
	% of income from other source	76.04	91.83	83.94
	% of income from rice	8.35	6.39	7.36
	% of income from fish culture	15.61	1.78	8.70

2.2.2 Red River Delta, Northern Vietnam

2.2.2.1 Survey Methodology

The baseline survey was conducted in Nam Dinh province of Northern Vietnam in 1998. A total of 50 households consisting of 20 project and 30 control households in Hien Khanh commune were interviewed using a pre-coded questionnaire. The distribution of sample households is presented in **Table 9.**

Table 9 : Distribution of the Sample Households According to Location, Red River, Northern Vietnam.

Location	Number of Sample
Project area	20
Control area	30
Total	**50**

2.2.2.2 Household Size of the Sample Farmers

The average household size was five members. The proportion of female members was higher in the project area (60.60%) compared to that of the control area (47.60%). But there were more working family members in the control area (three member) compared to that of the project area (**Table 10**).

Table 10 : Household Size and Number of Working Family Member/Household, Red River, Northern Vietnam.

Parameters	Location		All
	Project	Non-rice- fish	
Average family members (No)	4.7	4.9	4.8
Male (%)	39.4	52.4	45.9
Female (%)	60.6	47.6	54.1
Average number of working family member	2.3	2.6	2.45

2.2.2.3 Education Level of the Sample Household Heads

The education level of the household head plays an important role in making judicious decisions in daily farming activities and adoption of modern technologies. Results from the survey showed that none of sampled household heads was illiterate. Most of the household heads completed secondary education. In particular, 86% of the household heads of the project area completed secondary school compared to 61% of the control area. On the other hand, 24% of the household heads of the control area completed high school education compared to 14% of the project growing area (**Table 11**).

Table 11 : Education Level of the Sample Household Heads, Red River, Northern Vietnam

Level of Education	Location			
	Project		Control	
	No	%	No	%
Primary school	0	0	15	15
Secondary school	86	86	61	61
High school	14	14	24	24
Total	**100**	**100**	**100**	**100**

2.2.2.4 Average Farm Size Owned by the Farmers

The average farm area owned by households is 0.64 ha. Farmers from the project area owned a slightly larger farm (0.68 ha) compared to farmers in the control area (0.63 ha). The difference in total farm size is due to the difference in area of the fish pond. No variations were observed with respect to land area of the garden, the homestead and cultivated land in the two areas **(Table 12).**

Table 12 : Average Farm Size (in ha) of the Sample Household Heads, Red River, Northern Vietnam

Parameters	Location		All
	Project	Control	
Garden and homestead	0.0258	0.0253	0.0255
Cultivated land	0.5844	0.5786	0.5815
Fish pond	0.0710	0.0316	0.0293
Total	**0.6812**	**0.6039**	**0.6425**

2.2.2.5. Structure of the House

More than 66% of the houses of the respondents had floors built with tiles. More than 80% of the respondents from the control area had floors in their houses built with tiles compared to that of 52% percent in the project area. Around 21% of the households had earthen floors **(Table 13).**

Table 13 : Materials Used for Floor Construction of the Living House, Red River, Northern Vietnam

Materials	Location		All
	Project (%)	Control (%)	
Soil	33.80	9.10	21.45
Brick and cement	14.30	9.10	11.70
Tile	51.90	81.80	66.85
Total	**100**	**100**	**100**

2.2.2.6 Ownership Patterns of Valuable Items (Assets)

Ownership of valuable items is an indicator of the standard of living of an individual. The results from the survey showed that most of the farmers owned a bicycle (99%) and a desk fan (95%). More households located in the project area possessed a motorcycle (19%) and a radio and cassette player compared to households in the control area. But more households in the control area (39%) owned a boat compared to households in the project area (24%) (**Table 14**).

Table 14 : Ownership Patterns of Valuable Items, Red River, Northern Vietnam

Items	Location		All
	Project (%)	Control (%)	
Television	52.40	57.60	55.00
Radio and cassette player	70.40	54.50	62.45
Ceiling fan	19.10	33.33	26.20
Desk fan	100.00	90.90	95.45
Sewing machine	9.50	10.00	9.75
Bicycle	100.00	97.00	98.50
Motorcycle	19.10	0.10	9.80
Boat	23.80	39.40	31.60

2.2.2.7 Sources of Drinking Water

The aquifer is the main source of drinking water both in the project area and the control area with more or less 87% of the household respondents dependent on it. Around 13% of the total respondents depend on open wells as source of water (**Table 15**).

Table 15 : Drinking Water Source of the Sample Farmers, Red River, Northern Vietnam

Source	Location		All (%)
	Project (%)	Control (%)	
Open well	14.30	12.10	13.20
Aquifer	85.70	87.90	86.80
Total	**100**	**100**	**100**

2.2.2.8 Average Annual Income

The three major sources of income of the sample households were from on-farm, off-farm and non-farm. Unlike the respondents in Bangladesh, rice production and fish culture were the major sources of income among the respondents in the Red River delta. Income from rice production and fish culture (that is on-farm) contributed 77% and 7% of the total household income, respectively. Under the off-farm income category, labor wages contributed 5% of the total income. Income from trading was higher in the control area compared to the project area. On the other hand, income from fish culture was higher in the project area compared to the control area **(Table 16)**. On average, the annual household income of farmers from the control area was higher than that from the project area. Average annual household income of farmers from the control area was of the same level as the average annual household income of landowners in Bangladesh. In general, the annual household income of farmer respondents from the Red River delta was higher than that of farmer respondents in Bangladesh.

Table 16 : Average Annual Income (US$) of the Sample Households, Red River, Northern Vietnam

Item	Location				All	
	Project		Control		Amount	%
	Amount	%	Amount	%		
On farm:						
Rice production	703	74.55	967	78.87	835	76.88
Pig raising	75	7.95	65	5.30	70	6.45
Poultry	29	3.08	5	0.41	17	1.57
Fish culture	104	11.03	50	4.08	77	7.09
Fish capture	2	0.21	7	0.57	5	0.46
Off farm:						
Labour wage	27	2.86	76	6.20	52	4.79
Non farm:						
Trading	3	0.32	56	4.57	30	2.76
Total	**943**	**100**	**1226**	**100**	**1086**	**100**

2.2.3 Mekong River Delta, Southern Vietnam

2.2.3.1 Sampling of the Households

The baseline survey was conducted in hamlets 3 and 4 of Doc Binh Kieu Village of Southern Vietnam in 1998. A total of 50 households including 30 households in hamlet 3 and 20 households in hamlet 4 were interviewed using a pre-coded questionnaire.

2.2.3.2 Household Size and Number of Working Force

On average, each household consisted of five household members. Males contributed around 53% of the total household members. About 88% of the total household members were engaged in any kind of work **(Table 17).**

Table 17 : Household Size and Number of Working Family Members, Mekong River, Southern Vietnam

Parameters	Average no	%
Family size	5.46	-
Male	2.92	53.48
Female	2.54	46.52
Work force	4.80	87.91

2.2.3.3 Education Level of the Sample Household Head

Compared with the household in the Red River delta, 20% of household heads in the Mekong delta had not received any formal education. Thirty six (36) percent of them attended 1-3 years of schooling. Around 28% and 12% attended 4-6 and 7-10 years of schooling, respectively. Only 4% of the household heads attended more than 10 years of schooling **(Table 18).**

Table 18 : Education Level of the Sample Household Head, Mekong River, Southern Vietnam

Years of Schooling	No	Percent of total (%)
No formal education	10	20
1-3 Years	18	36
4-8 Years	14	28
7-10 Years	6	12
>10 Years	2	4
Average	3.54	-

2.2.3.4 Average Farm Size Owned by the Farmers

The average farm size was around 1.47 ha which was more than twice the size of that owned by households in the Red River delta. Around 81% of the total farm area was utilized for rice cultivation. The average size of the homestead area was 0.08 ha , which accounted for 6% of the total land area. More than 11% of the total land area was utilized as a garden. Of the total land area, only 2% was utilized for a fish pond with an absolute size of 0.03 ha. This was two times smaller than the fish pond in the project area in the Red River delta, and as small as the fish pond of farmers in the control area in the Red River delta **(Table 19)**.

Table 19 : Average Farm Size (ha) of the Sample Farmers, Mekong River, Southern Vietnam

Land use pattern	Average area (ha)	Percent of total (%)
Homestead	0.08	5.66
Garden	0.16	11.16
Rice field	1.19	81.11
Pond	0.03	2.07
Total	**1.47**	**100**

2.2.3.5 Distribution of the Sample Farmers According to Farm Size

The sampled farmers were grouped into five categories based on the size of land they owned. Only 8% of the farmers had a total farm area that was less than 0.5 ha and 22% had a total farm area that was greater than 2 ha. Twenty four (24) percent of the farmers were within the >1.0-1.5 ha group and the rest (26%) were within the farm category of <1.5 to 2 ha **(Table 20)**. This analysis showed that the distribution of land in the Mekong River delta is quite equitable.

Table 20 : Distribution of the Sample Farmers According to Farm Size, Mekong River, Southern Vietnam.

Farm size group	Number of farmers	Percent of total (%)
<0.5	4	8.00
0.5-1.0	10	20.00
>1.0-1.5	12	24.00
>1.5-2.0	13	26.00
>2.00	11	22.00
Total	**50**	**100.00**

2.2.3.6 Average Annual Income of the Sample Farmers

The average annual income of the farmers was US$1,781, which is much higher compared to that of farmer respondents in the Red River delta and in Bangladesh. Unlike farmer respondents in Bangladesh, but similar to farmer respondents in the Red River delta, income from rice production under the on-farm category was the major contributor of total income, with more than 72% of the total income. This was followed by income from livestock and poultry. The large difference in income between farmers in the Red River delta and farmers in the Mekong delta could be attributed to the difference of farm size. The contribution of fish culture was minimal and almost negligible (0.57%). Wild fish capture under the off-farm category contributed only 4% of the total income. On the other hand, income from business under the non-farm category contributed 7% of the total income **(Table 21)**.

Table 21 : Average Annual Income (US$) of the Sample Households, Mekong River, Southern Vietnam.

Sources of Income	Amount (US $)	Percent of total (%)
On farm:		
Rice production	1,294.58	72.71
Tree plantation	9.48	0.53
Livestock/poultry	210.20	11.81
Fish culture	10.12	0.57
Off farm:		
Agricultural labor wage	0.74	0.04
Wild fish capture	69.11	3.88
Non farm:		
Business	126.07	7.08
Salary	27.44	1.54
Subsidy/pension	25.40	1.43
Leasing out property/equipment	7.41	0.42
Total	**1,780.55**	**100**

2.2.3.7 Classification of the Sample Farmers According to Income Group

Based on average annual income, the farmer households were grouped into five income categories. The results show that 22% of the households earned an annual income of less than US$185 and another 20% earned an annual income between US$185 to US$296. Thirty (30) percent of the households earned between US$267 and US$407 per year and 18% earned between US$408 and US$519 per year. Only 10% earned more than US$519 per year **(Table 22)**. The distribution of annual income is not as equitable as the distribution of farmers according to farm size.

Table 22 : Sample Farmers According to Per capita Annual Income, Mekong River, Southern Vietnam

Income group (US$)	No	Percent of total (%)
<185	11	22.00
185-296	10	20.00
267-407	15	30.00
408-519	9	18.00
>519	5	10.00
All	**50**	**1000**

2.3 Productivity and Profitability of Various Land Use Patterns

2.3.1. Returns to Rice Production

2.3.1.1 Bangladesh

In Agarpur, Konapara, Uzanisher and Urshiura, there is only one rice cropping season known as the Boro season which takes place during the months of December to March.

The land remains fallow during the rest of the year. On the other hand, in Halida, Kuripara, Sadhukhali and Maizpara, there are two rice-cropping seasons:.the first cropping season which is the Boro season, and the second season also known as transplanted Aman season which takes place during the months of June to November. Although the Aman crop is not very profitable, the farmers in some areas are still interested to grow it as a subsistence crop and for maximum utilization of their own resources. During the baseline survey, data on input use, price of input, yield and price of output were collected on the above rice cropping seasons. Data was analyzed on the basis of individual crops grown within the period of one year and finally two crops were combined together to obtain the yearly return from rice production where two crops are grown.

The results from the survey showed a profit of US$379/ha to US$544/ha from rice cultivation during the single Boro rice cropping season in the single Boro growing project sites. Farmers in the Uzanisher project site obtained a higher profit because of higher yield (**Table 23**). On the other hand, in the single Boro rice growing sites in the control area, farmers received US$ 411 /ha to US$ 467 /ha as profit. In these areas, farmers from Konapara received a higher profit as they invested a lower amount of money on inputs, especially on fertilizer and hired labor (**Table 24**). This might be due to high natural fertility of the soil in these areas, which does not require higher doses of fertilizer. As the fertilizer response is very low the marginal productivity of fertilizer is negligible in such type of single Boro rice growing areas with high soil fertility. Among the cost components, hired labor was the largest and accounted for more than 50% of the total cost. Fertilizer and irrigation were the other two most important cost items.

Table 23 : Costs and Returns (US$/ha) of Boro Rice Production at Single Boro Rice Growing Project Sites, Bangladesh

Parameters	Sites			
	Agarpur	Konapara	Uzanisher	Urshiura
Input costs:	**387**	**420**	**587**	**661**
Seed	5	8	12	13
Land preparation	23	31	23	24
Fertilizer	56	73	113	114
Hired labor	180	196	307	351
Irrigation	70	92	96	117
Pesticides	53	20	36	42
Gross Return	**805**	**817**	**1131**	**1040**
Net Profit	**418**	**397**	**544**	**379**

Table 24: Costs and Returns (US$/ha) of Boro Rice Production at Single Boro Rice Growing Control Sites, Bangladesh

Parameters	Sites			
	Agarpur	Konapara	Uzanisher	Urshiura
Input costs:	**437**	**407**	**604**	**663**
Seed	5	8	13	13
Land preparation	32	39	23	22
Fertilizer	63	47	117	141
Hired labor	184	207	318	329
Irrigation	93	70	95	119
Pesticides	60	36	38	39
Gross Return	**792**	**818**	**1021**	**1078**
Net Profit	**355**	**411**	**417**	**415**

Productivity analysis of rice production at the double rice growing sites showed that at all the sites the Boro rice cultivation was more profitable than the transplanted Aman rice cultivation. This is due to the use of HYV varieties and higher application of fertilizer and irrigation in Boro rice. In case of the second crop, due to higher water depth, it is not possible to grow HYV rice. The local tall varieties suitable in such ecosystem conditions are less responsive to fertilizer.

On average, farmers of Sadhukhali received the highest annual profit per unit area at both project and control sites (**Tables 25 and 26**). This was due to higher returns from the Aman crop and partly better return from Boro rice. Like in single rice crops, hired labor was the major contributor tothe total cost, accounting for more than 50%. Fertilizer and irrigation were the other two most important cost items.

Table 25: Costs and Returns (US$/ha) of Boro and Aman Rice Production at the Double Rice Growing Project Sites, Bangladesh

Parameters	Sites							
	Halida		Kuripara		Sadhukhali		Maizpara	
	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman
Input costs:	**227**	**160**	**221**	**158**	**208**	**120**	**238**	**142**
Seed	14	8	8	8	18	18	17	15
Land preparation	40	57	51	57	29	30	41	39
Fertilizer	29	44	43	44	22	2	21	10
Hired labor	74	51	59	49	69	70	94	78
Irrigation	70	-	60	-	70	-	65	-
Return	**595**	**263**	**676**	**213**	**641**	**319**	**578**	**346**
Profit	**368**	**103**	**455**	**55**	**433**	**199**	**340**	**204**
Total Profit		**471**		**510**		**632**		**544**

Table 26: Costs and Returns (US$/ha) of Boro and Aman Rice Production at the Double Rice Growing Control Sites, Bangladesh

Parameters	Sites							
	Halida		Kuripara		Sadhukhali		Maizpara	
	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman
Input costs:	**194**	**159**	**225**	**160**	**206**	**119**	**200**	**99**
Seed	8	8	7	8	20	16	17	15
Land preparation	57	57	58	58	42	41	36	40
Fertilizer	17	44	45	44	26	5	25	-
Hired labor	52	50	45	50	60	57	52	44
Irrigation	60	-	70	-	58	-	70	-
Return	**546**	**209**	**665**	**227**	**615**	**334**	**546**	**300**
Profit	**352**	**50**	**440**	**68**	**409**	**215**	**346**	**201**
Total return		**402**		**508**		**624**		**547**

2.3.1.2 Red River Delta, Northern Vietnam

In the Red River delta there are two rice cropping seasons in a year. Analyses of the data on input used and output received from the two rice cropping seasons showed that the first rice crop was more profitable than the second rice crop. In both seasons, the farmers in the project areas received higher returns compared to the farmers of the control areas. But the farmers in the control area invested more resources on input in both seasons **(Tables 27 and 28).** Fertilizers, both organic and inorganic were the most important input cost items contributing more than 50% of the total cost.

Table 27 : Input Costs and Returns (US$/ha) from the 1st Rice Crop, Red River, Northern Vietnam

Parameters	Location		All
	Project	Control	
Input	**217**	**272**	**243**
Seedling	34	34	34
Fertilizer	93	93	93
Manure	63	115	89
Pesticides	14	17	16
Irrigation	13	13	13
Output	**699**	**679**	**689**
Profit	**482**	**407**	**444**

Table 28 : Input Costs and Returns (US$/ha) from the 2nd Rice Crop, Red River, Northern Vietnam

Parameters	Location		All
	Project	Control	
Input	**170**	**224**	**198**
Seedling	33	23	28
Fertilizer	93	91	92
Manure	15	70	43
Pesticides	2	20	11
Irrigation	27	20	24
Output	**443**	**384**	**414**
Profit	**273**	**160**	**216**

2.3.1.3 Mekong River Delta, Southern Vietnam

Like the Red River delta, two rice crops are also grown in a year in this area. The productivity and profitability was higher for the first rice crop than for the second rice crop, though the cost of production was higher in the former. No significant difference was observed in the distribution of total costs according to cost items between the two rice crops. In both cropping seasons, pre-harvest labor and fertilizer were the two most important cost items, contributing more than 50% of the total costs **(Table 29).** In general, farmers in the Mekong delta are receiving less profit from rice cultivation than farmers in the Red River delta. However, since they are cultivating a relatively larger farm area, they are obtaining higher incomes from this activity.

Table 29: Input Costs and Returns (US$/ha) from the First and Second Rice Crop, Mekong River, Southern Vietnam

Parameters	Rice Crop	
	First crop	Second crop
Input	**334 (100)**	**301 (100)**
Pre harvest labor	78 (23.35	69 (22.92)
Machine for land preparation	6 (1.80)	5 (1.66)
Seed	30 (8.98)	27 (8.97)
Fertilizer	92 (27.55)	90 (29.91)
Pesticides	20 (5.99)	20 (6.64)
Irrigation	9 (2.69)	13 (4.32)
Post harvest labor	55 (16.47)	35 (11.63)
Other post harvest	11 (3.29)	10 (3.32)
Equipment renting	5 (1.50)	4 (1.33)
Land tax	28 (8.38)	28 (9.30)
Yield (mt/ha)	**6.52**	**3.59**
Value of output	**719**	**405**
Profit	**385**	**104**
Rate of return	**2.15**	**1.35**

2.3.1.4 Comparison of Returns to Rice Production at Two Places

Costs and returns of rice production between the study area and Tien Giang province were compared . The results showed that the total costs for rice production per hectare was lower in the Tien Giang province compared to the study site. The cost for pre-harvest labor was quite high in the study area compared to the Tien Giang province, which might be due to a higher wage rate at the study area. The gross return and net income were higher at Tien Giang province compared to the study site **(Table 30).**

Table 30 : Costs and Returns (US$/ha) for Rice Cultivation in the Study Area and Tien Giang Province, Southern Vietnam

Parameters	Study area	Tien Giang
Cost of pre-harvest labor (%)	24.00	16.00
Cost of seed (%)	9.30	10.00
Cost of fertilizer (%)	29.60	25.00
Cost of pesticides (%)	6.60	11.00
Irrigation cost (%)	3.50	5.00
Cost of post-harvest labor (%)	14.60	18.00
Land tax (%)	10.00	13.00
Other costs (%)	3.50	2.00
Total cost (US$/ha)	**616.00**	**587.00**
Gross return (US$/ha)	**1123.00**	**1189.00**
Net income (US$/ha)	**507.00**	**602.00**
Return to investment (US$/US$)	**1.82**	**2.02**

2.4 Existing Institutional Arrangements for Farming

2.4.1 Bangladesh

Farming in Bangladesh is performed on an individual basis. Generally there are three types of farm operators. These are the owner operator, owner cum tenant and purely tenant. The owner cultivators perform farming activities in their own land only. The owner cum tenants operate their own land and take a share in or mortgage some land from others to utilize their own resources, specially human labor, more intensively as well as for their livelihood. The pure tenants are the landless farmers who operate land belonging to others and pay a crop share or fixed rent to the landowners depending on the formal/informal agreement made between the two parties. In most cases of mortgage or lease, a formal agreement is made between the owner and the tenant. However, no formal agreement is made between the owners and tenants in case of share cropping. The tenants pay mostly 50% of the output to the owners and bear input costs partially or fully depending on the cropping systems of the area, productivity and demand for land.

There are five types of land in Bangladesh on the basis of elevation. Among them, medium low land, low land and very low land are suitable for natural fish growth in flood conditions. Rice cropping is not practiced in the very low land due to submergence. However, single or double cropping is practiced in medium low and low lands. In these two types of land the floodwater remains standing from June to December. Single Boro or Boro followed by a local rice variety of Aman (tall) is grown. After harvesting of Boro rice in April, the land remains fallow for the whole period and in some cases the second rice is planted in June/July and harvested in November/December. After harvesting of the first crop, the monsoon starts and it remains flooded until December. During this period different types of wild fish are naturally grown. People catch them as common property and no one imposes any restriction on others in catching the fish.

The respective agricultural research institutes are responsible for generating technologies suitable for different agro-ecological regions of the country. The department of agricultural extension is responsible for diffusion of agricultural technologies among the farmers. Different private and government commercial banks along with the Bangladesh Krishi Bank are providing credit to the farmers for adopting modern technologies. Different NGOs are also providing credit to the rural poor for adopting different income generating activities. Among them, the Grameen Bank, BRAC and Proshika are playing a vital role in this respect.

Nowadays, it has been observed that the landowners with the assistance of landless farmers have started fish culture in some of the areas on a cooperative basis during the monsoon period. They hoist flags or some sort of indication that fishing is not allowed in the specific area. Participating farmers distribute the harvested fish among the participants. They also share the input costs. It is also observed that some small institutions like local clubs are trying to culture fish in such type of land by taking a lease from the landowners. Due to limitations of resources of the poor people, some NGOs are mobilizing the landless poor people in carrying out fish culture as a common property activity. The NGOs help the farmers in forming groups and provide training as well as credit for the initial investment. They also provide technical support, determine the sharing arrangement of inputs and outputs among the participating members and also help in minimizing conflicts, if any, among the participants. Similar to other parts of Bangladesh, landless, marginal and small farmers represented more than 70% of the total farmers at the study sites. Thus, for the economic benefit of this group of people under the present project, alternative sharing arrangements were tested by engaging the landless people in the project activities.

2.4.2 Red River Delta, Northern Vietnam

Before 1986 (under the subsidy regime), agricultural land belonged to the cooperatives. The farming system and production plan were fully based on the decision of the authorities from central to grass root levels. After 1986 (under the economic reform), agricultural land has been allocated to farmers for long-term ownership of land use (50 years or more).

There are three institutional arrangements of fish culture in flooded rice fields in the study area as explained below.

Cooperative group: In this system three to four farmers of a same locality form a group and jointly grow rice and fish. They share inputs, outputs as well as risk of failure. The profit is distributed among the members on the basis of their contribution of land area, labor and capital investment.

Fish culture group: In this system two to three households rent a deepwater rice area from other farmers for rice-fish production. The operators pay a certain quantity of paddy to the landowner on the basis of the agreement signed between the two parties. The group makes all necessary investments for fish culture and obtains all the benefits derived from fish culture.

Individual household: In this system a single farmer, through bidding, rents a piece of land from the commune for rice-fish culture. The household independently invests the required capital and enjoys the benefits.

2.4.3 Mekong River Delta

2.4.3.1 Existing Local Organizations

There are a number of government (GO) and non-government organizations (NGO) relating to the management of natural resources, especially land, water and aquatic resources in the region as well as in the study area. In terms of GOs at the local level, respondents named the village's People Committee Council; local police; Office of Soil and Land Use Management; Office of Agriculture and Rural Development including fisheries and extension; and Office of Science, Technology and Environment. NGOs in the study area are recognized through the activities of the farmers' union or group, women's union, youth's union, extension network, health care, and education/schooling.

2.4.3.2. Formal and Informal Rules/Regulations

The above-mentioned organizations have their own activities to support the local people in conducting productive community activities. They are mainly working based on the current formal policies and regulations. However, they also often follow good traditional rules or regulations, especially to solve social issues. Each farmer, therefore, has to follow not only formal but also informal rules or regulations in order to conduct his/her productive and livelihood activities. Formal rules imposed on rice cultivation are mainly in terms of boundary of the dikes, land tax payment, irrigation/drainage and broadcasting activities. Informal rules can be the participation in Integrated Pest Management activities (IPM) or extension activities. Raising ducks in the rice field is gradually disappearing because this type of farming can damage the dikes of rivers and canals as well as the rice, and pollute the surface water resources. Even though wild fish capture is traditionally conducted freely in the region, people should not conduct detrimental fishing activities such as using electricity, chemicals or inappropriate net mesh size. The fishing season should also be taken into account in order to protect and develop natural aquatic resources, especially broodstock and fry during the annual breeding period (May to September).

2.5 Capture of Wild Fish

Wild fish is considered as one of the most valuable resources in the study area, particularly for the low-income group. An investigation was made to determine the extent and trend of wild fish capture in terms of quantity as well as species composition.

2.5.1 Bangladesh

2.5.1.1 Distribution of Households by Wild Fish Catch

In Bangladesh, wild fish can be caught from the open waterbodies all year round. However, catch is higher between September and December as floodwater recedes during this period of the year. The results obtained from the baseline data showed that 44% to 56% of the sample households catch wild fish. The proportion of landowners who catch wild fish was higher than that of landless people. This could be due to time constraint of the landless people as they were busy earning their daily needs. In the project area of Sadhukhali, the proportion of landowners catching wild fish was higher compared to that of the landless. Similarly, in the control area Halida and Maizpara, the proportion of landowners catching wild fish was higher compared to that of the landless. In general, the proportion of farmers who catch fish did not vary across sites (**Table 31**).

Table 31: Percent of Households Which Catch Wild Fish, Bangladesh

District	Site	Project		Control	
		Landowner	Landless	Landowner	Landless
Kishorganj	Agarpur	50	50	47	53
	Konapara	45	55	60	40
Mymensingh	Halida	50	50	80	20
	Kuripara	50	50	33	67
Narail	Sadhukhali	75	25	54	46
	Maizpara	44	56	80	20
B. Baria	Uzanisher	67	33	43	67
	Urshiura	67	33	46	54
Total		**56**	**44**	**55**	**45**

2.5.1.2 Annual Quantity of Wild Fish Catch

The quantity of wild fish catch varied significantly across control and project areas. On an average, the respondents of the project site caught 275 kg/ha/year of wild fish, which was more or less five times higher than that of the respondents from control sites (58.70 kg/ha/year) (**Table 32**). The highest catch was observed in the project site at Uzanisher followed by Urshiura, a control site. The high volume of fish catch in these areas could be attributed to their favorable environment for fish growth.

Table 32 : Quantity (kg/ha) of Wild Fish Catch in the Study Area, Bangladesh

District	Site	Project area	Control area
Kishorganj	Agarpur	41.14	34.38
	Konapara	72.98	75.43
Mymensingh	Halida	33.01	36.98
	Kuripara	29.54	38.17
Narail	Sadhukhali	49.03	32.05
	Maizpara	40.62	62.18
B. Baria	Uzanisher	490.91	38.48
	Urshiura	171.87	231.95
Average		**275.42**	**58.70**

2.5.1.3 Perception of the Sample Farmers Regarding Change in Wild Fish Catch

Farmers were asked about their perception on the changes of the volume of wild fish catch in three time periods: the present, 5 years ago and 10 years ago. All respondents perceived present fish catches to be lower than in the past. Around 34% of the total respondents perceived that the present fish catch has reduced by 50% compared to the catch 5 years ago while 24% of the total respondents perceived that the present fish catch has reduced by as much as 75%. Only 9 percent of them perceived that the present fish catch has reduced by 25% compared to the catch five years ago **(Table 33).**

Table 33 : Percent Reduction in Fish Catch as Reported by the Sample Farmers, Bangladesh (total sample size = 256)

District	Site	Compared to 5 years ago percentage reduction (%)		
		25	**50**	**75**
Kishorganj	Agarpur	4	21	6
	Konapara	2	17	8
Mymensingh	Halida	0	4	11
	Kuripara	2	2	4
Narail	Sadhukhali	6	6	6
	Maizpara	2	5	7
B. Baria	Uzanisher	6	14	12
	Urshiura	0	17	7
Total respondents		**22**	**86**	**61**
% of total		**8.59**	**33.59**	**23.83**

2.5.1.4 Reasons for Change in Wild Fish Catch

When asked about the reasons for reduction of wild fish, the respondents reported that overfishing due to population growth, loss of fish habitat, fish disease and use of insecticides in the crops have been the major reasons for the reduction of wild fish.

2.5.2 Red River Delta, Northern Vietnam

2.5.2.1 Capture of Wild Fish

Around 19% of the households catch wild fish. Of these 30% catch wild fish solely for home consumption while 70% catch wild fish for home consumption as well as for income generation. Seventy (70) percent of the total respondents used nets and 30% used traps as gear for catching fish.

2.5.2.2 Perception of the Farmers Regarding Change of Wild Fish Catch

On average, farmers perceive that the present total wild fish catch has reduced by 27% and 68% compared to the catch 5 and 10 years ago, respectively. Species-wise, shrimp which has the lowest present contribution to total wild fish catch in terms of volume, has the highest decrease. This could be due to higher demand for this species in the domestic as well as in the foreign markets **(Table 34).**

Table 34 : Change in Wild Fish Catch Over a Period of 10 Years, Red River, Northern Vietnam

Species	Amount catch (kg)			Percent change	
	1998	5 years ago	10 years ago	Compared to 5 years ago	Compared to 10 years ago
Carps	65	90	145	-27.78	-55.175
Snakehead	25	22	70	13.64	-64.29
Shrimp	8	25	85	-68.00	-90.59
Crab	12	13	40	-7.69	-70.00
Total	**110**	**150**	**340**	**-26.67**	**-67.65**

2.5.3 Mekong River Delta, Southern Vietnam

2.5.3.1 Distribution of the Farmers According to Purpose of Catching Wild Fish

Around 80% percent of the interviewed households catch fish of which 38% catch wild fish solely for home consumption, and 55% of the total households catch wild fish for home consumption as well as for income generation. About 8 percent catch wild fish solely for income generation **(Table 35).**

Table 35 : Wild Fish Catch and Purpose of Catching, Mekong River, Southern Vietnam

Purpose	No of household	Percent of household
Home consumption only	15	37.50
Home consumption and sale	22	55.00
Sale only	3	7.50
Total	**40**	**100**

2.5.3.2 Average Quantity of Wild Fish Catch

The average annual catch of wild fish was 136 kg per household. Most of the respondents (65%) caught snakehead which accounted for 42% of the total wild fish catch followed by catfish and "trash fish" (14% each). Other wild fish species usually caught by the farmers were climbing perch and eel, each accounting for 8 and 6% of the total catch, respectively **(Table 36).**

Table 36 : Average Quantity per household of Wild Fish Caught by Species in 1997, Mekong River, Southern Vietnam

Species	Household		Average quantity (Kg)
	No	%	
Snakehead	26	65.0	57.12
Catfish	19	47.5	19.04
Climbing perch	10	25.0	10.88
Eel	3	7.5	8.16
White carp	6	15.0	5.44
Snakeskin gourami	6	15.0	5.44
Silver barb	2	5.0	2.72
Macrobrachium sp.	3	7.5	2.72
Nandus nandus	2	5.0	2.72
Sand goby	2	5.0	2.72
Trash fish	10	25.0	19.04
All	-	-	**136.00**

2.5.3.3 Perception of the Farmer on the Change of Wild Fish Catch

Around 68% and 63% of the total respondents expressed that there was no change on the present quantity of wild fish catch compared to that of 5 years ago and 10 years ago, respectively. The majority of them (95-98 %) mentioned that there was no change of species composition over the past 5 and 10 years **(Table 37).**

Table 37 : Farmer's Perception on the Change in Fish Availability, Mekong River, Southern Vietnam

Perception	Household	
	No	%
Change in fish quantity:		
Present vs 5 years before		
Not changed	27	67.5
Changed	13	32.5
Present vs 10 years before		
Not changed	25	62.5
Changed	15	37.5
Change in fish combination:		
Present vs 5 years before		
Not changed	39	97.5
Changed	1	2.5
Present vs 10 years before		
Not changed	38	95.0
Changed	2	5.0

2.5.3.4 Factors Affecting the Change in Wild Fish Catch

Among the minority who perceived a reduction of wild fish catch, 67% mentioned that overfishing has been the most important cause of reduction of wild fish catch. Other mentioned factors included fish capture by electricity, change of water level and overuse of chemicals for farming **(Table 38).**

Table 38 : Factors Affecting the Change in Wild Fish Catch, Mekong River, Southern Vietnam

Factor	Household	
	No	%
Overfishing	12	66.7
Capture by electricity	4	22.2
Change of water level	1	5.6
Overuse of chemicals for farming	1	5.6
Total respondents	**18**	**100.0**

2.6 Nature and Extent of Fish Consumption

2.6.1 Bangladesh

2.6.1.1 Monthly Fish Consumption

On average, the per capita monthly fish consumption was around 1.5 kg, which is twice the national average. Fish consumption of household respondents during peak months (October to December) was only 0.30 kg higher compared to their consumption during lean months. Landowners consumed 0.15 kg more fish compared to the landless group. In general, there was no significant difference in per capita monthly fish consumption between the households of the project and control areas. However, per capita monthly fish consumption varied across sites **(Table 39).**

Table 39 : Monthly Fish Consumption During Peak and Lean Months (Kg/capita), Bangladesh

District	Site	Category	Project			Control		
			Peak	Lean	All	Peak	Lean	All
Kishorganj	Agarpur	Owner	1.34	1.00	1.17	1.47	1.14	1.30
		Landless	1.98	1.01	1.50	2.08	1.33	1.71
		All	**1.67**	**1.01**	**1.34**	**1.77**	**1.24**	**1.51**
	Konapara	Owner	0.93	1.18	1.05	0.84	0.59	0.72
		Landless	1.49	1.00	1.25	0.80	0.66	0.73
		All	**1.26**	**1.09**	**1.17**	**0.81**	**0.64**	**0.73**
Mymensingh	Halida	Owner	1.09	0.95	1.02	1.29	1.18	1.29
		Landless	1.09	0.90	1.00	1.22	0.94	1.08
		All	**1.09**	**0.92**	**1.01**	**1.25**	**1.06**	**1.16**
	Kuripara	Owner	1.08	1.23	1.16	0.98	1.51	1.24
		Landless	0.81	0.80	0.80	1.24	1.40	1.32
		All	**0.95**	**1.02**	**0.98**	**1.12**	**1.45**	**1.29**
Narail	Sadhukhali	Owner	2.05	2.01	2.03	2.32	2.22	2.27
		Landless	3.52	2.65	3.08	1.73	1.50	1.61
		All	**2.79**	**2.33**	**2.56**	**2.02**	**1.86**	**1.94**
	Maizpara	Owner	1.30	1.34	1.32	0.73	1.01	0.87
		Landless	0.93	1.11	1.02	0.63	0.81	0.72
		All	**1.11**	**1.23**	**1.17**	**0.68**	**0.91**	**0.79**
B. Baria	Uzanisher	Owner	3.10	2.05	2.57	3.03	1.84	2.43
		Landless	2.06	1.27	1.67	2.88	1.71	2.29
		All	**2.65**	**1.72**	**2.18**	**2.96**	**1.78**	**2.37**
	Urshiura	Owner	1.43	1.07	1.25	2.85	1.82	2.34
		Landless	2.36	1.66	2.01	2.43	1.70	2.07
		All	**1.90**	**1.37**	**1.63**	**2.64**	**1.76**	**2.20**
		Owner	**1.54**	**1.36**	**1.45**	**1.72**	**1.45**	**1.58**
All average		**Landless**	**1.75**	**1.32**	**1.54**	**1.59**	**1.26**	**1.43**
		All	**1.65**	**1.34**	**1.49**	**1.65**	**1.36**	**1.50**

2.6.1.2 Fish Consumption by Source

Marketed and wild fish catch were the two most important sources of fish consumed by the sample farmers. In general, most of the fish consumed were bought from the market except in Maizpara. There was no distinct variation in source of fish consumed between the landowners and landless groups **(Table 40).**

Table 40 : Average Monthly Fish Consumption (kg/capita) According to Source, Bangladesh

District	Site/Source	Project Landowner	Project Landless	Control Landowner	Control Landless	Average (kg)
Kishorganj	**Agarpur**					
	Bought (%)	90.91	84.20	89.64	83.66	-
	Wild catch (%)	9.1	15.80	10.36	14.38	-
	From others (%)	0.00	0.00	0.00	1.96	-
	Kg/capita	**1.17**	**1.50**	**1.30**	**1.71**	**1.42**
	Konapara					
	Bought (%)	87.94	81.91	71.69	91.16	-
	Wild catch (%)	12.06	16.34	27.30	8.84	-
	From others (%)	0.00	1.74	1.01	0.00	-
	Kg/capita	**1.05**	**1.25**	**0.72**	**0.73**	**0.94**
Mymensingh	**Halida**					
	Bought (%)	48.32	85.32	73.29	96.13	-
	Wild catch (%)	51.08	12.57	26.71	2.31	-
	From others (%)	0.59	2.11	0.00	1.56	-
	Kg/capita	**1.02**	**1.00**	**1.29**	**1.08**	**1.09**
	Kuripara					
	Bought (%)	86.87	86.38	95.60	86.15	-
	Wild catch (%)	13.13	13.62	4.40	13.85	-
	From others (%)	0.00	0.00	0.00	0.00	-
	Kg/capita	**1.16**	**0.80**	**1.24**	**1.32**	**1.13**
Narail	**Sadhukhali**					
	Bought (%)	62.60	54.80	57.40	50.70	-
	Wild catch (%)	36.70	44.10	41.90	48.20	-
	From others (%)	0.50	0.00	0.50	1.00	-
	Kg/capita	**2.03**	**3.08**	**2.27**	**1.61**	**2.24**
	Maizpara					
	Bought (%)	15.75	17.76	20.09	32.89	-
	Wild catch (%)	84.25	82.24	79.91	67.11	-
	From others (%)	0.00	0.00	0.00	0.00	-
	Kg/capita	**1.32**	**1.02**	**0.87**	**0.72**	**0.98**
B. Baria	**Uzanisher**					
	Bought (%)	80.51	62.41	57.29	34.75	-
	Wild catch (%)	14.62	32.41	36.39	59.32	-
	From others (%)	4.86	5.18	6.32	5.93	-
	Kg/capita	**2.57**	**1.67**	**2.43**	**2.29**	**2.24**
	Urshiura					
	Bought (%)	64.27	64.77	73.54	62.71	-
	Wild catch (%)	36.73	35.23	26.46	37.29	-
	From others (%)	0.00	0.70	0.00	0.00	-
	Kg/capita	**1.25**	**2.01**	**2.34**	**2.07**	**1.91**
All (kg/capita)		**1.45**	**1.54**	**1.58**	**1.43**	**1.50**

2.6.1.3 Yearly Expenditure on Food other than Fish

On average, farmers spent US$446 on food annually. The annual food expenditure of the landowners was around US$40-60 higher than the landless farmers at both project and control areas. Farmers in Konapara, both in the project and control areas, had the highest food expenditures **(Table 41).**

Table 41 : Yearly Household Expenditure (US$) on Food (Other Than Fish), Bangladesh

District	Site	Project		Control		Total
		Landowner	Landless	Landowner	Landless	
Kishorganj	Agarpur	564	383	414	339	425
	Konapara	656	512	940	429	634
Mymensingh	Halida	230	252	215	339	228
	Kuripara	255	260	327	429	276
Narail	Sadhukhali	625	624	570	214	600
	Maizpara	333	307	307	263	297
B. Baria	Uzanisher	432	663	609	583	542
	Urshiura	585	427	680	242	564
Total		**460**	**428**	**508**	**463**	**446**

2.6.1.4 Yearly Expenditure on Food Including Fish

On an average, fish accounted for more than 14% percent of the total food expenditure. The proportion of fish expenditure to total food expenditures was higher among landowners by 2 – 3%. The highest proportion of fish to total food expenditure was observed in Kuripara (20 – 32 %) although the amount of fish consumed was less compared to other sites **(Table 42).**

Table 42 : Percentage of Fish Expenditure to Total Food Expenditure, Bangladesh

District	Site	Project		Control		Total
		Landowner	Landless	Landowner	Landless	
Kishorganj	Agarpur	8.39	10.92	9.39	8.51	**9.30**
	Konapara	9.49	9.99	4.66	7.58	**7.93**
Mymensingh	Halida	12.95	12.50	17.78	15.51	**14.68**
	Kuripara	22.02	20.43	31.76	19.95	**23.54**
Narail	Sadhukhali	17.93	11.11	17.08	14.79	**15.22**
	Maizpara	13.60	11.85	17.65	25.56	**17.16**
B. Baria	Uzanisher	17.43	11.83	11.58	6.82	**11.91**
	Urshiura	15.32	15.26	16.67	14.15	**15.35**
Total		**14.64**	**12.98**	**15.82**	**14.11**	**14.38**

2.6.2 Red River Delta, Northern Vietnam

2.6.2.1 Fish Consumption by Income Group

On average, per capita monthly fish consumption was around 1.86 kg, which conforms with the national average. Per capita monthly fish consumption varied across different classes of the society. Fish consumption increased as income increased. High-income households consumed 2.40 kg/capita/month of fish, which was double the amount consumed by low-income households **(Table 43).**

Table 43: Fish Consumption /Month (Kg/capita) by Income Group, Mekong River, Northern Vietnam

Income group	Amount consumed (Kg/capita/month)	Percent of households
Low income household	1.20	56
Medium income household	2.00	28
High income household	2.40	16
All	**1.86**	**100**

2.6.2.2 Preference of Fish Species

Common carp was the most preferred fish species followed by grass carp, while silver barb was the least preferred fish species in the study area **(Table 44).**

Table 44 : Preference of Fish Species by the Sample Farmers, Red River, Northern Vietnam

Fish Species	Percent
Common carp	45
Grass carp	26
Tilapia	13
Silver carp and bighead carp	9
Silver barb	7

2.6.3 Mekong River Delta, Southern Vietnam

2.6.3.1 Fish Consumption by Lean and Peak Months

On an average, the per capita monthly fish consumption was around 2.56 kg during lean months (February to August), and 3.97 kg during peak months (Septemberto January). These figures are much higher than those for Red River delta and for Bangladesh. Snakehead accounted for 26-34% of total fish consumption. Unlike Bangladesh, capture fish was the major source of fish consumed contributing around 60-77% of total fish consumption **(Table 45).**

Table 45 : Per Capita Fish Consumption in Lean Months (g/month), Mekong River, Southern Vietnam

Species	Source				Total	
	Captured		Purchased			
	Quantity	%	Quantity	%	Quantity	%
Clarias catfish	34	2.19	149	14.72	183.0	7.15
Climbing perch	271	17.50	115	11.36	386.0	15.07
Labeobarbus	35	2.26	0	0	35.0	1.37
Spiny eel	90	5.81	0	0	90.0	3.51
Marine fish	0	0	185	18.28	185.0	7.22
Nandus nandus	20	1.29	0	0	20.0	0.78
Snakehead	530	34.22	340	33.60	870.0	33.97
Puntius altus	15	0.97	0	0	15.0	0.39
Puntius leiacanthus	18	1.16	0	0	18.0	0.70
Pseudogobiopsis	8	0.52	0	0	8.0	0.31
River catfish	222	14.33	117	11.56	339.0	13.24
Silver barb	35	2.26	0	0	35.0	1.37
Silver carp	26	1.68	0	0	26.0	1.02
Trichogaster trichopterus	146	9.43	17	1.68	163.0	6.36
Others	100	6.46	90	8.89	190	7.42
Total	**1549**	**100.0**	**1012**	**100.0**	**2561**	**100.0**
Percent of all	**60.48**	-	**59.52**	-	**100**	-

Table 46 : Per Capita Fish Consumption During Peak Months (g/month), Mekong River, Southern Vietnam

Species	Source				Total	
	Captured		Purchased			
	Quantity	%	Quantity	%	Quantity	%
Common carp	2	0.07	0	0	2	0.05
Clarias catfish	237	7.70	106	11.75	343	8.62
Climbing perch	768	24.97	112	12.42	880	22.12
Fluta alba	0	0	7	0.78	7	0.18
Giant gourami	13	0.42	0	0	13	0.33
Labeobarbus	19	0.62	0	0	19	0.48
Spiny ell	173	5.62	0	0	173	4.35
Marine fish	0	0	53	5.88	53	1.33
Mystus	261	8.49	161	17.85	422	10.61
Snake head	680	22.11	350	38.80	1030	25.89
Puntius leiacanthus	*14*	*0.46*	*0*	*0*	*14*	*0.35*
Pseudogobiopsis	*0*	*0*	*0*	*0*	*0*	*0*
River catfish	144	4.68	23	2.55	167	4.20
Silver barb	37	1.2	23	2.55	60	1.51
Silver carp	40	1.3	10	1.11	50	1.26
Trichogaster trichopterus	687	22.33	57	6.32	744	18.70
Tilapia	1	0.03	0	0	1	0.03
Total	**3076**	**100.0**	**902**	**100.0**	**3978**	**100.0**
Percent of all	**77.33**	-	**22.67**	-	**100**	-

2.6.3.2 Share of Fish in Total Household Food Consumption

Around 34% of the respondents spent more than 20% of their total food expenditure on fish. Half of the remaining 64% of the respondents spent 10-20% percent of the total food expenditure on fish. In general, the share of fish expenditure to total food expenditure was higher among low-income households **(Table 47).**

Table 47 : Share of Fish in Total Household Food Consumption, Mekong River, Southern Vietnam.

Expenditure class (US$/year/capita)	Share of fish in total food consumption (%)						Total	
	<10		10-20		>20			
	No.	%	No.	%	No.	%	No.	%
<148 (Very low)	5	10	3	6	2	4	10	20
148-222 (Low)	7	14	9	18	13	26	29	58
222.1-296 (Medium)	2	4	4	8	2	4	8	16
>296 (High)	2	4	0	0	1	2	3	6
All	**16**	32	**16**	32	**17**	34	**50**	**100**

2.6.3.3 Annual Per Capita Fish Consumption by Expenditure Class

Although the share of fish expenditure to total food expenditure was higher among low-income households, they consumed lesser quantities of fish as compared to the households of higher expenditure classes (Table 48).

Table 48 : Annual Per Capita Fish Consumption by Expenditure Class, Mekong River, Southern Vietnam

Expenditure class (US$/year/capita)	Annual per capita fish consumption (Kg)						Total	
	<10		10-20		>20			
	No	%	No	%	No	%	No	%
<148 (Very low)	5	50.0	4	40.0	1	10.0	10	20.0
148-222 (Low)	4	13.8	11	37.9	14	48.3	29	58.0
222.1-296 (Medium)	1	12.5	4	50.0	3	37.5	8	16.0
>296 (High)	-	-	1	33.3	2	66.7	3	6.0
All	**10**	**20.00**	**20**	**40.0**	**20**	**40.0**	**50**	**100.0**

3. ALTERNATIVE TECHNICAL AND INSTITUTIONAL OPTIONS

3.1 Bangladesh

Generally, three rice-fish culture systems can be established in flood-prone areas: (i) alternating culture of dry season rice followed by stocked fish only during the flood season (that is, without rice) in the enclosed area (for example, as in a fish pen); (ii) concurrent culture of deepwater rice (with submergence tolerance) with stocked fish during the flood season followed by dry season rice in shallow flooded areas; and (iii) concurrent culture of deepwater rice (with elongation ability) with stocked fish during the flood season, followed by dry season non-rice crops. On the basis of group discussions between different stakeholders and researchers, it was decided to test the alternating rice and fish culture (option (i) above; Fi.g 4) in the deep-flooded areas (namely, in Kuliarchar and Brahman Baria) and to test concurrent rice-fish culture (option (ii) above; Fig. 5) in the shallower flooded areas (namely in Narail and Muktagacha).

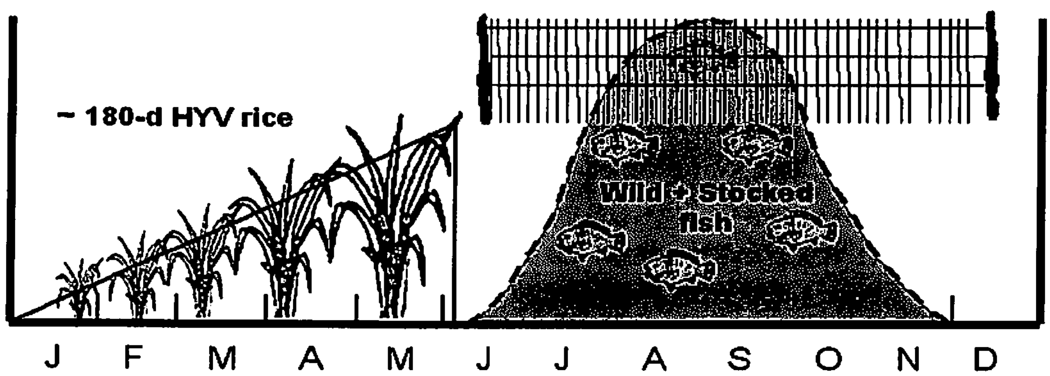

Fig 4. Proposed farming system for community based fish culture (MV rice – Deepwater rice + fish) in deep-flooded areas of Bangladesh.

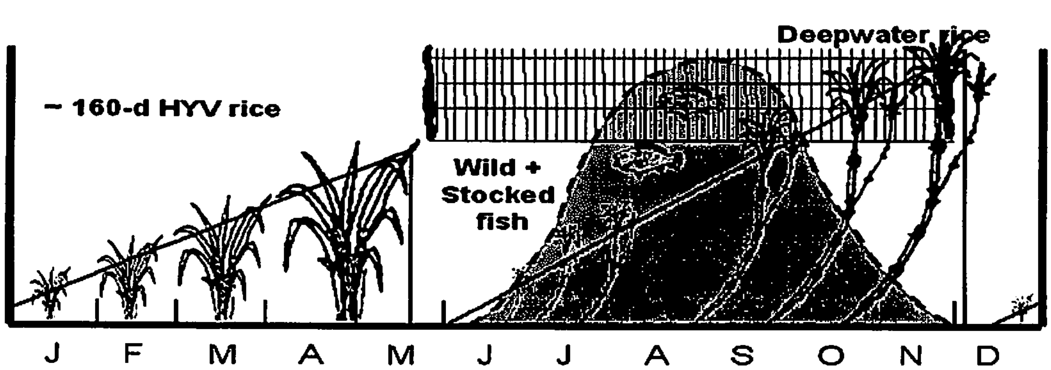

Fig 5. Proposed farming system for community based fish culture (MV rice – fish) in deep-flooded areas of Bangladesh.

The group members executed the trials with technical backstopping from different research partners. The Bangladesh Fisheries Research Institute (BFRI) provided technical advice on fish culture, Bangladesh Rice Research Institute (BRRI) provided technical advice on rice production and Proshika (a national NGO) organized the participants and facilitated the implementation of the trials. A Project Implementation Committee (PIC) was formed at each site. The PIC was composed of a chairman, a secretary and the rest as members. The PIC helped group members in performing each and every activity required for successful implementation of the project. The project provided financial support, as seed money, during the first two years to cover the material costs. Group members deposited part of the proceeds from the trials (for example, fish sale) to cover future project expenditures.

3.1.1 Study Location and Technical Options, 1998

During the first year of project activities, experiments on community-based fish culture in the seasonally flooded rice ecosystem were initiated at four sites: two sites in Kuliarchar (Monoharpur and Baghpara) and one site each in Brahman Baria and Narail. But due to the unprecedented flood of 1998, the experiments in Brahman Baria and Narail were destroyed and had to be abandoned. Though the experiments in the other two sites (Monohorpur and Baghpara of Kuliarchar) were also damaged to some extent by the flood, the experiments were completed, the results of which are presented here. The technical option tested in these two sites is sequential culture of rice and fish (fish culture in the rainy season and irrigated Boro rice culture during the dry season).

The fish culture period in both sites was about six months (fourth week of June to third week of December). At Monoharpur, seven species of fish were stocked with a stocking density of $0.65/m^2$. While at Baghpara, eight species of fishes were stocked with a stocking density of $0.505/m^2$. Average weight of fingerlings at release was 7 to 10 g at Monoharpur and 7 to 12 g at Baghpara. During the stocking period monitoring was done on various aspects like fish growth, water quality and fish health. The total costs of operating the sites were also recorded. Total fish weight and returns were recorded. The benefits were distributed to the beneficiaries on the basis of the contract made during stocking.

3.1.2 Institutional Options, 1998

This action research on fish culture was implemented through a group approach. After selecting the sites, Proshika arranged a general meeting with the landowners and the landless group members (formed by Proshika), as a result of which certain guidelines related to project implementation were agreed upon. Subsequently an agreement was signed between three parties: Proshika (first party), landowners (as second party) and the landless people (as third party). At Monoharpur site, out of 30 participants, 19 were landowners and the remaining 11 were landless fishers. The sharing arrangement of the expected sales of cultured fish was 30% for the landowners and 70% for the landless fishers. At Baghpara, there were 132 beneficiaries of whom 58 were landowners and 74 were poor fishers/group members. The sharing agreement was 30% for landowners and 70% for the poor fishers/group members.

3.1.3 Results and Discussion, 1998

The survival rate was 33% at Monoharpur and only 12% at Baghpara. The survival of ruhi was higher (61%) at Monoharpur than Baghpara (24.29 %). Highest fish growth rates were observed in case of silver carp at Monoharpur and silver carp and pangas at Baghpara. An amount of 793 kg/ha fish was harvested from Monoharpur and 498 kg/ha from Baghpara **(Table 49).** The fish survival was poor at Baghpara due to flood and a considerable number of fish escaped. However, the yield can be considered satisfactory which was possible due to higher weight gain of fish.

Table 49 : Fish Species, Stocking Density, Survival and Fish Yield (Kg/ha), Bangladesh, 1998

Site	Technical option tested	Fish culture period (days)	Species	At stocking: Density (no/m^2)	At stocking: Mean weight (g)	At harvest: No	At harvest: Mean weight (g)	At harvest: Survival (%)	At harvest: Yield (Kg/ha)
Monoharpur, Kuliarchar	Alternate rice-fish	175	S. carp	0.125	8.1	458	650	37	298
			Sarpunti	0.125	8.1	648	150	52	97
			C. carp	0.125	10.1	146	500	12	73
			Katla	0.125	7.1	144	400	12	58
			Ruhi	0.05	8.1	307	300	61	92
			Mrigal	0.05	8.1	350	300	70	105
			G. carp	0.05	8.1	94	750	19	71
			Total	**0.65**	-	**2147**	-	**33**	**793**
Baghpara, Kuliarchar	Alternate rice-fish	175	S. carp	0.123	8.1	238	750	19	179
			Sarpunti	0.148	6.8	62	150	10	93
			C. carp	0.123	10.1	202	600	16	121
			Katla	0.049	6.8	85	500	17	43
			Ruhi	0.025	6.8	60	250	24	15
			Mrigal	0.025	6.8	34	250	14	9
			G. carp	0.123	10.1	51	700	4	36
			Pangas	0.012	15.2	5	750	4	4
			Total	**0.505**	-	**737**	-	**12**	**498**

3.1.4 Study Location and Technical Options, 1999

During 1999 the project activities were conducted at five sites: two sites each in Kuliarchar (Kishorganj) and Brahman Baria and one site in Narail. The sites are Monoharpur and Char Kamalpur in Kuliarchar, Uzanisher and Urshiura in Brahman Baria, and Sadhukhali in Narail. The sites in Kuliarchar and Brahman Baria represent deep-flooded areas and the dominant cropping pattern in these areas is Boro-Fallow-Fallow. The Sadhukhali site in Narail represents the medium flooded environment (with maximum flooding depth of about 1 m) and the dominant cropping pattern in this area is Boro-Fallow–transplanted local Aman or transplanted deepwater Aman. The technical option tested in the deep-flooded areas (Kuliarchar and Brahman Baria) was alternating Boro rice and fish culture, and that in the shallower flooded area (Narail) was concurrent fish and deepwater rice culture. The fish culture period was about six months in Kuliarchar and Brahman Baria, and about five months in Narail. Altogether nine different fish species were tested; among them silver carp, common carp, silver barb and katla were common in all five sites.

3.1.5 Institutional Options, 1999

The technical options were tested under community based management (that is, group approach). The group included both landowners as well as landless/poor fishers who live in the vicinity of the project area and have customary access rights for fishing in the area during the rainy season. These beneficiaries consisted of both members of Proshika groups and Proshika non-members (Table 50). In Monoharpur the benefit sharing agreement was 30% for landowners and the remaining 70% was for participating group members. In Charkamalpur, landowners did not receive any share of the benefit for the contribution of their land. The total profit was equally distributed among all the group members. In Urshiura and Uzanisher, the group members received the whole profit of the project but they paid the irrigation cost to the landowners in lieu of the lease value of the land. In both these sites, 5% of the profit was deposited as group fund and the rest was equally distributed among the group members. In Sadhukhali, 60% of the profit was distributed among landowners and the rest (40%) among the group members.

Table 50: Number of Participants by Site, Bangladesh, 1999

Site	Landowners		Landless		Total beneficiaries
	Proshika Member	Proshika Non-member	Proshika Member	Proshika Non-member	
Urshiura (B. Baria)	3	16	25	5	49
Uzanisher (B. Baria)	18	34	-	30	82
Monoharpur (Kuliarchar)	15	4	4	7	30
Charkamalpur (Kuliarchar)	16	3	24	3	46
Sadhukhali (Narail)	7	27	15	11	60
Total	**59**	**84**	**68**	**56**	**267**

3.1.6 Results and Discussions, 1999

The average stocking density was 1 fingerling/m^2, which is considered very high given the fact that no feed was applied. Average weight of fingerlings at stocking was 14 g **(Table 51).** The average yield of fish was 730 kg/ha, ranging from 301 kg/ha in Sadhukhali to 1795 kg/ha in Uzanisher. Fish recovery rate was also highest in Uzanisher and lowest in Sadhukhali **(Table 52).**

Table 51 : Stocking Period, Species, Weight of Fingerlings at Stocking and Stocking Density, Bangladesh, 1999.

Site	Tested technical option	Species	Average weight at stocking (g)	Stocking density (n/m²)
Urshiura	Alternate rice-fish	Sarpunti,s. carp, katla,g. carp, rui, gonia & carpio	11.42	1.79
Uzanisher	Alternate rice-fish	Sarpunti, katla,s. carp,g. carp, rui, mrigal, gonia & carpio	10.16	1.31
Monoharpur	Alternate rice-fish	S. carp, sarpunti, carpio, G. carp, katla, rui & pangas	19.71	0.75
Charkamalpur	Alternate rice-fish	S. carp, sarpunti, carpio,g. carp, katla & rui	20.33	0.87
Sadhukhali	Concurrent rice-fish	Sarpunti, carpio & S. carp	10.00	0.63
Average		-	**14.32**	**1.07**

Table 52 : Fish Yield, Recovery and Fish Weight at Harvests, Bangladesh, 1999.

Site	Tested technical option	Area (ha)	Fish culture period (Months)	Fish yield (kg/ha)	Recovery %	Average fish weight kg)
Urshiura	Alternate rice-fish	3.2	6	673	23	0.211
Uzanisher	Alternate rice-fish	18.3	6	1795	56	0.116
Monoharpur	Alternate rice-fish	2.2	6	405	32	0.116
Charkamalpur	Alternate rice-fish	2.8	6	480	42	0.129
Sadhukhali	Concurrent rice-fish	3.1	5	301	20	0.098
All average		-	6	**730**	**34.6**	**0.134**

3.1.7 Study Location and Technical Options, 2000

During the year 2000 experiments were conducted in eight sites: Agarpur and Konapara in Kuliarchar (Kishorganj), Uzanisher and Urshiura in Brahman Baria, Halida and Kuripara in Muktagacha (Mymensingh), and Sadhukhali and Maizpara in Narail. In Agarpur, Konapara, Uzanisher and Urshiura, the technical intervention was to culture fish after harvesting of Boro rice (that is, alternating rice and fish culture). On the other hand, concurrent culture of fish with transplanted Aman/broadcast Aman rice after Boro rice was tested in Halida, Kuripara, Sadhukhali and Maizpara sites. The fish culture period ranged from five to seven months.

3.1.8 Institutional Options, 2000

In 2000, as in previous years, the technical options were also tested under the community based management approach (group approach). Beneficiaries included both landowners (participating and non-participating) and landless/poor fishers. The distribution of beneficiaries according to status is presented in **Table 53**. The terms and conditions and sharing arrangements for all the eight sites are described below individually.

Table 53 :Total Number of Beneficiaries According to Sites, Bangladesh, 2000.

	Landowner			Landless	Total
Site	**Participating**	**Non-participating**	**Total**		
Agarpur	3	13	16	17	33
Konapara	6	11	17	9	26
Uzanisher	31	30	61	17	78
Urshiura	12	9	21	15	36
Halida	5	0	5	15	20
Kuripara	2	0	2	15	17
Sadhukhali	33	0	33	16	49
Maizpara	32	0	32	15	47
Total	**124**	**63**	**187**	**119**	**306**

3.1.8.1 Agarpur, Kuliarchar

There were 33 beneficiaries in this site. Sixteen were landowners and the remaining 17 were landless. Out of the 16 landowners, 3 were directly involved with the project and enjoyed the benefits. The 13 landowners who were not directly involved in the project received a compensation package of BDT 3 (US$0.06) for each decimal (1/100 of an acre) of land in the project area for the monsoon season. Out of the six ditches within the project area, the owners of two ditches received BDT 2,000 (US$38) from the project in lieu of the one third of the natural fish in the ditch. The remaining two thirds of fish were taken by the landowners. Four ditch owners did not allow fishing in their ditches by the project beneficiaries. They did not take any money from the beneficiaries. After deducting all costs, the remaining amount was shared equally by the beneficiaries.

3.1.8.2 Konapara, Kuliarchar

A total of 26 beneficiaries were involved in this site consisting of 6 participating landowners, 11 non-participating landowners and 9 landless. The non-participating landowners were not allowed to claim any benefit for the use of their land and were not allowed to catch fish from the area. The project provided fingerlings and a partial share of feed needed in the first year. The project beneficiaries provided all materials and labor for fence preparation and installation, guarded the fish and provided a partial share of the feed. They obtained credit from Proshika for this purpose. The beneficiaries preserved the fences and poles after the harvest of fish for the next year. A joint account of Proshika and the beneficiaries was opened for handling expenditures. All the sales proceeds were deposited in the joint account, and after deducting all the expenditure benefits were distributed.

3.1.8.3 Uzanisher, Brahmanbaria

In the project area there were 78 beneficiaries. Out of the 78 beneficiaries, there was a seven-member Project Implementation Committee (PIC). This Committee declared 32 shares. Most of the landless group members are laborers and only two are fishers. Some of the landowners are big landowners owning about 30 acres of land and are involved in big businesses. Some of them opined that this fish stocking for them was not for business but to help others and for their personal satisfaction.

Sharing arrangements were as follows:

Out of the 32 shareholders, 15 have full shares and 34 own 17 shares. Each full share costs about BDT50,000 (US$962).

Some shareholders had more than one partner. Some members had unofficially shared their expenditure with those who were not members but who had money. Those people would get a share of the profit unofficially from the shareholders who took money from them.

With proceeds from the sale of their share, an adjacent borrow pit was leased from the Roads and Highways department for a fee of BDT 72,000 (US$1385) for three years in the name of a local religious educational institute, Forkania Madrasha. They also leased the adjacent road from the District Council for an annual fee of BDT 33,200 (US$638). They elevated this road in 1999 and planted trees along its side as a barrier for the rice-fish. They also maintained the road.

In addition to the official agreement between Proshika and the direct project beneficiaries (landowners and landless), another agreement was signed between the PIC and other landowners.

According to this agreement the PIC would provide irrigation facilities to the other landowners who were not directly involved in the project activities or who were not shareholders. In lieu of this facility the project beneficiaries would culture fish during the monsoon on their land. Landowners would not claim any money from fish culture. Shareholders would receive an equal share of any proceeds.

From the sales of the fish from the canal, an amount of BDT 100,000 (US$1923) was separately kept for the fish culture activity in coming year. The money (BDT 110,000) (US$2115) provided by the project was deposited in the bank account for future use in the project activities. The project provided the group with BDT 50,000 (US$962) during the year 1999 and BDT 60,000 (US$1154) in 2000 for fish feed only.

3.1.8.4 Urshiura, Brahmanbaria

The total number of beneficiaries in this project site was 36. Twenty one (21) landowners had land in the project area, and 12 of them were directly involved in the project activities. The remaining members used to fish in the same area before the project started and they were also members of the four Proshika groups. Out of these 15 members 7 had land in the project area. Seven farmers owned five *kuas* (deep depression) in the project area. Previously they had been selling fish from those *kuas* as their business. These *kuas* were leased by the project beneficiaries. An agreement was signed between Proshika as the first party and all the beneficiaries including active landowners as the second party on non-judicial stamp.

Sharing arrangements were as follows:

The area was used under the supervision of Proshika from 1999 to 2001.

Each of the members contributed BDT 2,000 (US$38) to start the project activities.

Landowners other than those involved in the project area did not take any money for their land and allowed the other landowners and the landless people involved in the project activities to culture fish during the monsoon season.

There are seven ditches in the project area. Owners of these ditches received BDT 41,000 (US$788) as lease value and did not claim any harvested fish from the ditches.

Ninety five (95) percent of the benefit was distributed directly among the landowners and landless participants and the remaining 5% was deposited in the group account.

The subsequent year's input costs are being derived from the money that was deposited in the joint account in the preceding year after the harvest. Every year the same amount will be deposited in the joint account after the final harvest for subsequent year's input cost.

3.1.8.5 Halida, Muktagacha

All the 20 beneficiaries actively participated in the project. The 15 Proshika group members agreed to pay for fencing materials, a net and a portion of the feed cost. An agreement was signed between Proshika as the first party, landowners as second party and the landless group members as the third party on non-judicial stamp.

Sharing arrangements were as follows:

The second party cultivated monsoon season paddy (Aman) and they used organic fertilizer and biological pest control rather than using chemical fertilizer and pesticides. Chemical pesticides were not to be used at all.

In the first year, the project paid costs of fingerlings, and part of the feed cost.

The total sales proceeds were deposited in the joint bank account maintained by Proshika for the beneficiaries. The benefit was calculated after deducting all the input costs incurred by Proshika and the beneficiaries. The input costs deposited in the bank account were used in the subsequent year.

The total benefits were distributed among the landowners and the landless members. The sharing arrangement was 60% for the landowners and 40% for the members. Landowners divided their share according to the amount of land within the project area while landless members received equal shares of the benefits.

3.1.8.6 Kuripara, Muktagacha

The 17 members consisted of 2 participating landowners and 15 landless Proshika group members. An agreement stating the role and responsibilities as well as the sharing arrangements was signed between Proshika being the first party, landowners as the second party and the landless people as the third party.

Sharing arrangements were as follows:

The second party cultivated monsoon season paddy (Aman) and they used organic fertilizer and biological pest control rather than using chemical fertilizer and pesticides.

In the first year, the project paid the costs of fingerlings, and part of the feed costs.

The total sales proceeds were deposited in the joint bank account of Proshika and the beneficiaries. The benefit was calculated after deducting all the input costs shouldered by Proshika and the beneficiaries. The inputs costs deposited in the bank account were used in the following year.

The total benefits were distributed among the landowners and the landless members. The sharing arrangement was 60% for the landowners and 40% for the other members.

Landowners divided their share according to the amount of land within the project area and landless members received equal shares of the benefits.

3.1.8.7 Sadhukhali, Narail

This project site was in operation for three years (1997-2000). In the first year the project provided costs of fingerlings and other costs related to the operation. Among its 49 members, 33 were participating landowners and 15 were landless Proshika group members.

Almost one third of the members were involved in Proshika activities. None of the farmers were Proshika group members. They had been fishing in the same flooded rice field before but this was the first time they had stocked fish in the rice field. Most of the landless were laborers and some of them were rickshaw or van drivers. An agreement stating the role and responsibilities as well as the sharing arrangements was signed between Proshika being the first party, landowners as the second party and the landless people as the third party.

Sharing arrangements were as follows:

The second party cultivated monsoon season paddy (Aman) and they used only organic fertilizer and biological pest control rather than chemical fertilizer and pesticides. Chemical pesticides were not to be used at all.

In the first year, the project paid the costs of fingerlings, and part of the feed costs.

The third party guarded the fish in rotation and performed other jobs needed.

The total sales proceeds were deposited in the joint bank account of Proshika and the beneficiaries. The benefit was calculated after deducting all the input costs incurred by Proshika and the beneficiaries. The inputs costs deposited in the bank account were used in the following year.

The total benefits were distributed among the landowners and the landless members. The sharing arrangement was 50% for the landowners and 30% for the landless guard members and the remaining 20% benefit was deposited in the joint account for future use. This money was kept as risk management money for the landless people.

Landowners divided their share according to the amount of land within the project area and the landless members received equal shares of the benefits.

3.1.8.8 Maizpara, Narail

The 47 members consisted of 32 participating landowners and 15 landless. An agreement stating the role and responsibilities as well as the sharing arrangements was signed between Proshika being the first party, landowners as the second party and the landless people as the third party.

Sharing arrangements were as follows:

The second party cultivated monsoon season paddy (Aman) and they used only organic fertilizer and biological pest control rather than chemical fertilizer and pesticides. Chemical pesticides were not to be used at all.

In the first year the project paid the costs of fingerlings, and part of the feed costs.

The total sales proceeds were deposited in the joint bank account maintained by Proshika for the beneficiaries. The benefits were calculated after deducting all the input costs incurred by Proshika and the beneficiaries. The input costs deposited in the bank account were used in the following year.

The total benefits were distributed among the landowners and the landless members. The sharing arrangement was 50% for the landowners and 50% for the members.

Landowners divided their share according to the amount of their land located within the project area while the landless members received equal shares of the benefits.

3.1.9 Results and Discussion for Year 2000 Activities

Under the alternating rice and fish system, a total of nine species were tested in different polycultures: five species in Agarpur, and seven species each in Konapara, Uzanisher and Urshiura. Stocking densities were 1.00, 0.89, 1.24 and 1.41 fish per m^2 at Agarpur, Konapara, Uzansher and Urshiura, respectively (**Table 54**). Among the four sites, the survival rate and yield was poorest at Agarpur due to a sudden storm and strong current, which washed away all the fences together with the fish stocked. At Konapara, there was a disease problem but the loss was minimal due to the adoption of control measures at the early stages. Among the four shallow flooded sites where concurrent culture of fish with deepwater Aman rice was tested, 7 species were tested at Halida, 5 species at Kuripara and 4 species each at Sadhukhali and Maizpara with a stocking density of 0.74, 0.95, 1.34 and 1.03 fish per m^2, respectively. The yield was very poor at Halida due to turbid water, low natural fish feed in the water and shading effect of the trees around the site which further inhibited productivity. The farmers in Kuripara achieved the highest yield (617 kg/ha) followed by farmers in Sadhukhali. In all the sites, the number of fish stocked was much higher than the recommended rate. Due to smaller size fingerlings and expectations of higher mortality, farmers preferred to stock more. But this practice did not produce any better result (**Tables 54 and 55**). It may be concluded from the above results that farmers in the beginning need extensive training on fish species selection, species composition, appropriate stocking density and proper size of the fingerlings. The transfer of non-marketable sized fish harvested from the rice field to a pond for further on growing to marketable size may increase the income of the farmers.

Table 54 : Fish Stocking Density, Recovery and Yield in the Alternating Rice and Fish Culture System, Bangladesh, 2000.

Site	Fish culture period (days)	Species	Stocking density (no/m^2)	At harvest			
				No	Mean Weight	Recovery rate (%)	Yield (kg/ha)
Agarpur	150	Rohu	0.09	88	0.26	9.27	23
		Mrigal	0.09	60	0.29	6.37	17
		C. carp	0.19	153	0.17	8.05	27
		S. carp	0.05	399	0.22	84.07	87
		Sarputi	0.57	198	0.12	3.48	24
		Total	**1.00**	**899**	**0.20**	**9.02**	**178**
Konapara	161	Rohu	0.06	97	0.34	16.80	33
		Katla	0.01	56	0.36	38.80	20
		Mrigal	0.06	200	0.30	34.80	59
		C. carp	0.11	639	0.24	55.60	151
		S. carp	0.11	882	0.70	76.75	619
		G. carp	0.11	74	0.49	6.45	37
		Sarputi	0.34	1,621	0.15	47.00	247
		Total	**0.82**	**3,568**	**0.33**	**43.57**	**1,165**
Uzanisher	160	Rohu	0.11	940	0.28	86.17	263
		Katla	0.08	109	0.88	13.27	95
		Mrigal	0.11	277	0.65	25.45	180
		C. carp	0.22	456	0.47	20.90	214
		S. carp	0.14	850	0.84	62.38	718
		G. carp	0.05	98	0.89	17.92	87
		Sarputi	0.55	17	0.14	0.31	2
		Total	**1.25**	**2,746**	**0.57**	**21.90**	**1,559**
Urshiura	145	Rohu	0.11	226	0.53	20.06	120
		Katla	0.06	442	0.40	78.61	177
		Mrigal	0.11	914	0.22	81.25	205
		C. carp	0.23	729	0.27	32.42	199
		S. carp	0.01	998	0.31	88.67	309
		G. carp	0.11	61	0.52	5.42	32
		Sarputi	0.68	189	0.20	2.80	38
		Total	**1.41**	**3,559**	**0.30**	**25.31**	**1,079**

Table 55 : Fish Stocking Density, Recovery and Yield in the Concurrent Rice and Fish Culture System, Bangladesh, 2000

Site	Fish culture period (days)	Species	Stocking density (no/m²)	At harvest: No	Mean Weight	Recovery (%)	Yield (kg/ha)
Halida	210	Rohu	0.06	271	0.17	42.75	45
		Katla	0.06	317	0.21	49.85	68
		Mrigal	0.06	306	0.18	48.25	55
		C. carp	0.16	329	0.10	20.74	31
		S. carp	0.02	136	0.07	85.40	9
		Sarputi	0.32	724	0.08	22.82	58
		Gift	0.06	103	0.05	16.25	6
		Total	**0.75**	**2,187**	**0.12**	**29.31**	**272**
Kuripara	181	Rohu	0.09	361	0.23	39.67	83
		Mrigal	0.09	382	0.24	42.00	92
		C. carp	0.23	463	0.38	20.37	174
		Sarputi	0.45	1,460	0.14	32.12	198
		Gift	0.09	344	0.20	37.83	70
		Total	**0.95**	**3,009**	**0.21**	**31.52**	**617**
Sadhukhali	191	Rohu	0.12	1,189	0.15	97.63	175
		Mrigal	0.12	1,062	0.15	87.21	160
		C. carp	0.37	206	0.87	5.55	179
		Sarputi	0.73	452	0.22	6.19	100
		Total	**1.34**	**2,910**	**0.21**	**21.72**	**614**
Maizpara	176	Rohu	0.09	841	0.17	89.67	144
		Mrigal	0.09	720	0.18	76.83	132
		C. carp	0.28	412	0.24	14.63	98
		Sarputi	0.56	790	0.15	14.04	117
		Total	**1.03**	**2,762**	**0.18**	**26.78**	**491**

3.1.10 Monitoring of Water Qualityin Year 2000 Activities

During 2000, water depth, transparency, water temperature and pH were measured from July to November. The results are presented in **Tables 56 - 59.** The results showed that except for water depth at Kuripara and transparency at Halida, all other water parameters were suitable for fish growth.

Table 56 : Average Water Depth (m), at the Project Sites, Bangladesh, 2000

Month	Site							
	Agarpur	Konapara	Halida	Kuripara	Sadhukhali	Maizpara	Uzanisher	Urshiura
July	0.94	0.85	0.89	0.41	1.21	1.55	2.64	1.44
August	1.43	1.82	0.90	0.75	2.00	1.98	2.38	2.13
September	1.08	1.48	1.31	0.77	0.93	0.91	2.56	1.77
October	0.67	1.11	1.14	0.35	0.90	0.93	1.65	0.80
November	0.48	0.92	1.05	0.29	0.59	0.42	0.79	0.73

Table 57 : Average Water Temperature (^{0}c), at the Project Sites, Bangladesh, 2000

Month	Site							
	Agarpur	Konapara	Halida	Kuripara	Sadhukhali	Maizpara	Uzanisher	Urshiura
July	31.5	32.5	29.9	29.7	30.0	30.2	31.0	31.5
August	32.1	32.0	28.5	28.2	30.7	30.7	31.9	32.6
September	28.7	30.7	28.9	29.8	30.2	31.1	30.9	30.9
October	30.7	30.8	28.1	28.0	32.3	32.4	32.2	32.5
November	28.4	28.2	28.0	28.2	28.2	28.0	27.2	27.4

Table 58 : Average Transparency of Water (cm) at the Project Sites, Bangladesh, 2000

Month	Site							
	Agarpur	Konapara	Halida	Kuripara	Sadhukhali	Maizpara	Uzanisher	Urshiura
July	25	27	32	16	20	28	25	38
August	46	29	5	23	30	33	25	28
September	34	28	6	12	63	34	33	40
October	27	29	6	10	88	90	50	48
November	21	34	5	9	40	35	45	55

Table 59 : Average pH of Water at the Project Sites, Bangladesh, 2000

Months	Sites							
	Agarpur	Konapara	Halida	Kuripara	Sadhukhali	Maizpara	Uzanisher	Urshiura
July	7.6	8.0	6.5	6.2	7.9	7.6	8.1	7.9
August	7.4	7.9	7.2	6.9	8.0	8.0	8.4	8.4
September	7.7	8.0	6.8	6.2	7.9	7.3	8.1	8.1
October	8.1	7.8	6.7	6.1	7.7	7.4	8.4	8.3
November	8.3	7.5	6.2	6.1	7.8	8.0	8.1	8.1

3.2 Red River Delta, Northern Vietnam

In flood-prone areas of the Red River delta in northern Vietnam, farmers generally grow high yielding irrigated rice during the dry season, and a tall-growing local rice variety during the rainy season. Based on group discussions with all the stakeholders, it was decided to test the concurrent culture of fish with deepwater rice (with submergence tolerance) during the rainy season, followed by irrigated dry season rice.

3.2.1 Study Location, and Technical and Institutional Options

Trials for three years (1998 to 2000) on concurrent rice-fish culture in flooded rice fields were conducted in two project sites: Hien Khanh commune with an area of 5 ha and Tan Khanh commune with an area of 1 ha. Similar technical design and institutional arrangements were followed during the entire three-year period.

In early March, selected rice fields at two sites were prepared carefully for conducting the experiment. The dikes of the rice fields were raised to protect against flooding. Two sluice gates were constructed for draining water during the rainy season. The deepwater area and the canals inside the rice fields were converted into the rearing area. A watch house was also constructed on the dike of the rice fields.

Two weeks after transplanting the rice, the water level in the fields was increased to 20 cm above the seedbed giving more space for fish. Organic/inorganic fertilizers were applied for the growth of rice and natural food for fish. There was no supplementary feeding given to fish for the whole culture period. The minimum level of water in the rice fields was kept at 40 cm. The maximum level of water during flooding was 1.0 m. Data on input used, yield of rice and fish, and price of inputs and outputs were recorded for comparisons.

At the Hien Khanh site there were 19 households sharing 5 ha of land for rice production. Out of 19 households, only three households were involved in fish culture in these rice fields under technical assistance from the project, adopting a group approach. The three fish farmers invested their own resources for field preparation, fingerlings, feed and fertilizers. The benefits were divided among the participating farmers on the basis of their contribution. At Tan Khanh, only one farmer was involved. He invested his own resources and received all the benefits. The project personnel only provided technical support.

3.2.2. Results and Discussions for Year 1998 Activities

A polyculture system of fish farming was tested: species combination was common carp, tilapia, silver barb, silver carp and rohu. Stocking density was 3000 fingerlings/ha at Hien Khanh and 3800 fingerlings/ha at Tan Khanh Common carp dominated total fish stocked accounting for as much as 40 to 50% of the total amount of fingerlings stocked but were of smaller size (5.3 g). On the other hand grass carp fingerlings were of larger size, at 143.3 g, as shown in Hien Khanh **(Table 60)**. The growing period was from April to December.

A submergence tolerant rice variety (BM 90) obtained from the Vietnam Agricultural Science Institute (VASI) was used for the first rice crop, and hybrid rice variety No. 4 was used for the second rice crop.

Multiple and total harvests were applied to fish culture in rice fields. Multiple harvest was undertaken once per month during September to November. Before harvesting, the water level above the rice bed was drained off to cause the fish to accumulate in the canals. Marketable sized fish were netted and small fish were released back into the rice fields. Total fish harvest was done in December. There was no significant variation of fish survival observed between the two sites but the yield was more than 2.5 times higher at Hien Khanh, which might be due to the bigger size of fish at harvest at Hien Khanh than at Tan Khanh (Table 60). In general, the growth rate of common carp was highest among all the species.

Table 60 : Fish Survival and Fish Yield (kg/ha), Red River Delta, Northern Vietnam, 1998

Site	Species	At stocking		At harvest			
		Stocking density (no/m²)	Mean weight (g)	No	Mean weight (g)	Survival (%)	Yield (Kg)
Hien Khanh	Common carp	0.15	5.3	801	611.3	53	498.7
	Tilapia	0.03	7.5	181	188.2	60	34.1
	Silver carp	0.03	15.2	190	625.0	63	118.8
	Rohu	0.06	12.1	425	560.6	71	238.3
	Grass carp	0.27	143.3	177	1375.7	59	243.5
	Total	**0.30**	-	**1774**	-	**59**	**1133.4**
Tan Khanh	Common carp	0.15	5.3	911	208.0	61	189.5
	Tilapia	0.03	7.3	197	126.4	66	24.9
	Silver carp	0.03	10.9	185	355.7	62	65.8
	Rohu	0.14	17.5	672	286.2	48	192.3
	Total	**0.38**	-	**1965**	-	**56**	**472.5**

3.2.3 Results And Discussions for Year 1999 Activities

The same trial was conducted in 1999 but with minor modifications of species composition, stocking density and rice variety. In addition to the species used in 1998, silver barb at the rate of 300 fingerlings/ha was used. Both sites stocked 3000 fingerlings/ha of which common carp accounted for 50% of the total number of fingerlings stocked **(Table 61)**. The previous hybrid rice variety No 4, was replaced by BM 90.

The survival rate was 60%. The average yield was higher (713 kg/ha) at Tan Khanh compared to Hien Khanh (647 kg/ha). The mean weight of harvested fish was higher at Tan Khanh than at Hien Khanh.

Table 61 : Fish Survival and Fish Yield (Kg/ha), Red River Delta, Northern Vietnam, 1999

		At stocking			At harvest		
Site	**Species**	**Stoking density (no/m^2)**	**Mean weight (g)**	**No per rice field**	**Mean weight (g)**	**Survival (%)**	**Yield (Kg)**
Hien Khanh	Common carp	0.15	12.70	1083	323.00	72.00	350
	Tilapia	0.03	12.10	79	189.00	26.00	15.00
	Silver carp	0.03	14.20	176	625.00	57.00	111.00
	Silver barb	0.03	3.20	204	280.00	68.00	57.00
	Rohu	0.06	14.70	248	460.00	45.00	114.00
	Total	**0.30**	-	**1790**	-	**59.66**	**647.00**
Tan Khanh	Common carp	0.15	5.30	949	318.00	63.00	302.00
	Tilapia	0.03	7.5	160	210.00	53.00	34.00
	Silver carp	0.03	15.20	230	656.00	78.00	152.00
	Silver barb	0.03	12.10	246	251.00	82.00	62.00
	Rohu	0.06	12.10	227	713.00	37.00	163.00
	Total	**0.30**	-	**1812**	-	**60.40**	**713.00**

3.2.4 Results and Discussions for Year 2000 Activities

The same trial was conducted in 2000. Five species were tested in both sites. The same stocking density (3000 fingerlings/ha) as in 1999 was used.. Average length and weight of the fingerlings was greater at Hien Khanh compared to Tan Khanh **(Table 62)**. The same rice variety was used as in 1999.

The survival rate and total yield were lower at Hien Khanh compared to Tan Khanh although the mean weight of fingerlings was higher at Hien Khanh compared to Tan Khanh for the same species and at the same stocking rate **(Table 62)**. This might have been due to a more favorable fish growing environment at Tan Khanh compared to Hien Khanh.

Table 62: Fish Survival and Fish Yield (Kg/ha), Red River Delta, Northern Vietnam in trials in 2000

		At stocking		At harvest			
Site	Species	Stocking density (no/sm)	Mean weight (g)	No per rice fields	Mean weight (g)	Survival (%)	Yield (Kg)
Hien Khanh	Common carp	0.15	12.70	801	323.00	53.40	258.70
	Tilapia	0.03	12.10	72	218.00	24.00	15.70
	Silver carp	0.03	14.20	190	625.00	63.30	118.80
	Silver barb	0.03	13.20	210	280.00	70.00	58.80
	Rohu	0.06	14.00	425	460.00	70.80	195.50
	Total	**0.30**	-	**1698**	-	**56.60**	**647.50**
Tan Khanh	Common carp	0.15	8.30	945	318.00	63.00	300.50
	Tilapia	0.03	6.50	126	270.00	42.00	34.00
	Silver carp	0.03	14.20	210	656.00	70.00	137.80
	Silver barb	0.03	10.10	213	251.00	71.00	53.50
	Rohu	0.06	12.10	348	513.00	58.00	178.50
	Total	**0.30**	-	**1842**	-	**61.40**	**704.3**

3.2.5 Spontaneous Adoption of Concurrent Fish and Deepwater Rice Technology

The result of the experiments in 1998 at Hien Khanh and Tan Khanh sites encouraged farmers in neighboring communes of Vu Ban district to adopt the technology. In early 1999, 4 groups of farmers consisting of 18 households in 4 communes of this district were involved in fish culture on 33 ha of deepwater rice fields. In 2000, 12 farmer groups implemented the technology with project assistance, which resulted in an average fish yield of 652 kg/ha in 1999 and 564 kg/ha in 2000.

The institutional arrangements that farmers agreed upon in Vu Ban are similar to those of project sites (that is, a cooperative group, a fish culture group and private households).

3.3 Mekong River Delta, Southern Vietnam

Given the existing biophysical characteristics of the flood-prone areas of the Mekong delta in Vietnam and the existing land use pattern in the area, the researchers and the stakeholders agreed to test the culture of fish during the flooding season in between two rice crops.

3.3.1 Study Location, and Technical and Institutional Options

Trials on concurrent rice-fish culture in flooded rice fields were conducted in Hau Bac village of Tien Giang province for four years (1997-2000). The total land area used and the total number of household participants varied from year to year. During the first 1year of the project, there was only one household participant. All the costs involved for the study was shouldered by the farmer and he received all the benefits. During the successive years, groups of farmers were involved in the community-based fish culture in seasonally flooded rice ecosystem experiment. The aims of forming the group were to operate and maintain the culture system more effectively and also to reduce the cost of production. The benefits were shared among the members on the basis of land holding and contribution of operating costs.

Nylon net was used to enclose the fish growing area. Three-meter bamboo poles were placed and the lower part of the net was placed under the soil. The height of the net was about 1.5 to 2 m above the water level.

Besides recording of information on input used and yield of rice and fish, and prices of input and output, water quality parameters such as water depth, transparency, water temperature, dissolved oxygen and pH were quantified four times during stocking. The summary of water parameter quality is presented in **Table 63.** The results showed that except for dissolved oxygen all other water parameters were suitable for fish growth. During 2000 only water depth was recorded six times during stocking when it was observed that flood water started to increase from August and reached a very high peak of 240 cm at the end of October, and was reduced to 55cm at the third week of January.

Table 63. Water Quality Parameters, Mekong River Delta, Southern Vietnam, 1997-1999.

	1997		1998		1999	
	Range	Optimum range	Range	Optimum range	Range	Optimum range
Water depth (m)	0.6 - 1.30	> 0.30	0.10 - 0.30	> 0.30	0.40-1.20	>0.30
Transparency (cm)	10 - 30	25 - 35	7 - 50	25 - 35	10 - 60	25-35
Temperature (0c)	26 - 28	25 - 35	25 - 29	25 - 35	26-31	25-35
Dissolved oxygen (ppm)	2.8 - 3.1	5 - 8	3 - 4	5 - 8	1-2.5	5 - 8
PH	6.5 - 6.6	6.5 - 8.5	6.24 - 7.0	6.5 - 8.5	6.30-6.50	6.5-8.5

3.3.2 Results and Discussions, 1997 and 1998

Trial on fish culture in flooded rice field was conducted on the land of one household at Hau My Bac village of Tien Giang province. The farmer was actively involved in the study. The Research Institute for Aquaculture No. 2 provided all the technical support for conducting the experiment.

A polyculture system of three species, common carp, tilapia and mud carp, was tested with a stocking density of $0.43/m^2$. The sizes of the fingerlings were 5.97, 5.75 and 14.7 g for common carp, tilapia and mud carp, respectively **(Table 64).**

The fish was harvested after 70 days of stocking (September to November). The survival rate of common carp was 93% percent followed by tilapia (80%). On the other hand, the survival rate of mud carp was very poor. The fish yield was 236.84 kg/ha, which was mostly contributed by common carp as the growth of the other two species was not satisfactory.

Table 64 : Fish Survival and Fish Yield (Kg/ha), Mekong River, Southern Vietnam, 1997

	At stocking		At harvest			
Species	Stocking density (no/m^2)	Mean weight (g)	No	Mean weight (g)	Survival (%)	Yield (Kg)
Common carp	0.15	5.97	1400	130.67	93.30	182.94
Tilapia	0.13	5.75	1040	49.83	80.00	51.82
Mud carp	0.15	14.70	30	69.50	2.00	2.08
Total	**0.43**		**2470**	-	**57.44**	**236.84**

In 1998, the stocking duration was 80 days starting from September to November. Due to the poor performance of mud carp in terms in terms of growth, only common carp and tilapia were released with a stocking density of 0.20 fingerlings/ha with a ratio of 3 :1 (common carp: tilapia), and average size of 8.24 and 5.83 g, respectively, which are bigger in size, compared to 1997. **(Table 65).**

Results showed a total fish yield of 202 kg/ha of which 70% was contributed by common carp. Both species showed survival rate of 66%. Investigation of food content in the digestive system, showed that food contents of common carp was lower compared to tilapia. This might be due to reduction of food at the bottom due to higher stocking density of common carp. The fat content of the cultured fish was higher indicating there was no shortage of food at the stocking site.

Table 65 : Fish Survival and Fish Yield (Kg/ha), Mekong River, Southern Vietnam, 1998

	At stocking		At harvest			
Species	Stocking density (no/m^2)	Mean weight (g)	No	Mean weight (g)	Survival (%)	Yield (Kg)
Common carp	0.15	8.24	995	174.10	66.30	173.23
Tilapia	0.05	5.83	332	87.27	66.40	28.97
Total	**0.20**		**1327**	-	**66.35**	**202.20**

3.3.3 Results and Discussions, 1999

During the third year of project activities, experiments on community-based fish culture in seasonally flooded rice ecosystem were conducted in three areas with different levels of water depths and water flows. All the areas were located in Hau My Bac village of Tien Giang province. Each area corresponded to a group of households with a total number of 11 households.

In the first group, the rice fields are located outside the dike system and along the provincial highway. This area has the highest flooding depth and strongest water flow. In the second group, the rice fields are located between two channels and inside a dike system, far from the provincial highway. This area has medium flooding depth and water flow. Finally, in the third group, the rice fields are located inside a dike system. Most of the rice fields have low dikes and a surrounding trench. This area is the farthest from the provincial highway, thus has medium flooding depth and water flow.

Due to different levels of water depth, the fish culture duration varied across the groups (145 days for group 1, 136 days for group 2, and 126 days for group 3, all from August 1999 to January 2000). The stocking duration was long because after the flood water receded, the fish were kept in the pond until the time when the market price was high.

Groups 1 and 2 stocked grass carp in addition to common carp and tilapia. Stocking density was higher (0.33 fingerling/m^2 for group 1 and 0.25 0.33 fingerling/m^2 for group 2) compared to last year's stocking density. Common carp still accounted for most of the fingerlings stocked (around 45%). The size at stocking of grass carp was bigger (9.79 g) than that of common carp (5.32 g) and tilapia (4.82 g) **(Table 66)**.

Group 3 stocked silver barb and snakeskin gourami in addition to common carp and tilapia with a stocking density of 0.28 fingerlings/m^2. Tilapia accounted for almost 50% of the total fish stock. The average size of fingerling was much bigger than that of group 1 and 2, ranging from 8.57 g for snakeskin gourami to 11.41 g for tilapia.

Grass carp performed well in terms of survival rate compared to common carp and tilapia in groups 1 and 2 while the performance of tilapia was the lowest. The survival rate of grass carp in group 1 was 25% compared to 8% of common carp and 1% of tilapia. In group 2, the survival rate of grass carp in was 78% compared to 56% of common carp and 8% of tilapia. The survival rate of silver barb was very high (90%) in group 3. On an average, the recovery rate and fish yield were highest in group 3 where flooding depth and water flow is minimal, followed by group 2. With the most contribution to total fish stocked, common carp also accounted for most of the yield.

Table 66 : Fish Survival and Fish Yield (Kg/ha), Mekong River Delta, Southern Vietnam, 1999

Group	Species	At stocking		At harvest			
		Stocking density (no/m^2)	Mean weight (g)	No	Mean weight (g)	Survival (%)	Yield (Kg)
1	Common carp	0.165	5.32	130	812	7.86	105.56
	Grass crap	0.099	9.79	139	558	24.85	91.51
	Tilapia	0.066	4.82	164	91	1.40	12.65
	Total	**0.33**		**433**	-	**13.12**	**209.72**
2	Common carp	0.125	5.32	697	316	55.76	220.25
	Grass carp	0.075	9.79	390	325	77.95	126.75
	Tilapia	0.050	4.82	62	91	8.30	5.64
	Total	**0.25**		**1149**	-	**45.96**	**352.64**
3	Common carp	0.099	9.74	736	455	74.31	334.88
	Tilapia	0.132	11.41	238	203	18.00	48.31
	Silver barb	0.049	10.85	442	175	90.20	77.35
	Snakeskin gourami	0.0495	8.57	124	91	25.00	11.28
	Total	**0.2805**		**1540**	-	**46.66**	**471.82**

3.3.4 Results and Discussions, 2000

During the final year of project activities, an experiment was conducted in four areas with different levels of water depths and water flows, all in Hau My Bac village of Tien Giang province. Each area corresponded to a group of households with a total number of 18 households. The total area was 14.28 ha.

All the four groups stocked common carp, grass carp and silver carp with a stocking density of 0.25 fingerlings/m^2 and a stocking ratio of 7:2:1. The size of common carp at stocking (11.15 g) was also bigger compared to that of grass carp (6.60 g) and silver carp (3.71 g).

The stocking period was much longer (from September 2000 to March 2001 with a total of 6.5 months or around 195 days) compared to last year based on the same reason that after the flood water receded, the fish were kept in the pond until the time when t the market price was high.

Out of 18 farmers, only four farmers were able to preserve fish during the abnormal flood, which started to increase from August and reached a very high peak of 240 cm at the end of October and receeded down to 55 cm only in the third week of January.

The low recovery was due to loss of fish during the abnormal flood. The farmers received only 23.7 to 174.41kg/ha fish yield. Group No IV received the lowest fish yield due to poor recovery. Most of the sites, common carp exhibited the highest growth rate and survival rate **(Table 67).**

Table 67 : Fish Recovery and Fish Yield (Kg/ha), Mekong River Delta, Southern Vietnam, 2000

Group	Species	At stocking		At harvest/ha			
		Stocking density (no/m²)	Mean weight (g)	No	Mean weight (g)	Recovery (%)	Yield (Kg)
	C. carp	0.175	11.15	287	463	16.4	132.88
1	G. carp	0.050	6.60	63	180	12.5	11.34
	S. carp	0.025	3.71	42	353	16.9	14.82
	Total	**0.25**	-		-	-	**159.04**
	C. carp	0.175	11.15	193	427	11.0	82.41
2	G. carp	0.050	6.60	50	200	10.0	10.00
	S. carp	0.025	3.71	250	328	100.0	82.00
	Total	**0.25**	-		-	-	**174.41**
	C. carp	0.175	11.15	193	464	11.0	89.55
3	G. carp	0.050	6.60	50	178	10.0	8.90
	S. carp	0.025	3.71	50	345	20.0	17.25
	Total	**0.25**	-		-	-	**115.7**
	C. carp	0.175	11.15	35	400	2.0	14.00
4	G. carp	0.050	6.60	15	180	3.0	2.70
	S. carp	0.025	3.71	10	700	4.0	7.00
	Total	**0.25**	-		-	-	**23.7**

3.4 Concluding Remarks

From the results of the three-year experiment on community-based fish culture in seasonally flooded rice ecosystems in three different environmental situations, it can be concluded that fish culture along with rice or during the fallow period is productive and socially acceptable. The main problem is to save the stocking during abnormal flood and to ensure the sincere participation of the parties involved.

4 PROFITABILITY OF FISH CULTURE IN THE SEASONALLY FLOODED RICE ECOSYSTEM

4.1 Bangladesh

During the experiment in 2000, a heavy storm at the Agarpur site caused floods which washed away the stocked fish. The Halida site proved to be not technically suitable site for fish culture due to high water turbidity. Consequently, these two sites were excluded from the subsequent analyses.

4.1.1 Results of 1998

The results showed that fish culture was very profitable at Monoharpur. The farmers gained a return of around 27% of their investment within a period of six months. The farmers of Agarpur made a net loss of US$52/ha as a flood destroyed the fencedisrupted made for fish culture resulting in high losses of stocked fish and low recovery rates at harvest.(**Table 68**). The cost of fencing was high as farmers had to protect the trials from an unprecedented flood using high fences.

Table 68 : Profitability (US$/ha) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Bangladesh, 1998

Particulars	Location	
	Monoharpur	Agarpur Baghpara
Returns	**712**	**363**
Rice	-	-
Fish:		
Culture	669	342
Wild	43	21
Input cost: ish		
Fingerlings	271	228
Fencing	240	150
Harvesting	33	21
Transportation	17	16
All input	**561**	**415**
Net benefit	**151**	**-52**

4.1.2 Results of 1999

Utilizing the knowledge gained in 1998, the experiment was extended and more sites were included in 1999. During 1999, project activities were performed in five locations. The research results were analyzed using the same principle as used in 1998. The analysis showed that fish culture was profitable in three sites out of five (**Table 69**). Due to stunted growth and low recovery the net return was negative at Monoharpur and Sadhukhali.

Table 69 : Profitability (US$/ha) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Bangladesh, 1999

Particulars	Sites				
	Monoharpur	Char Kamalpur	Uzanisher	Urshiura	Sadhukhali
	Alternate rice-fish	Alternate rice-fish	Alternate rice-fish	Alternate rice-fish	Concurrent rice-fish
Returns	**252**	**595**	**1187**	**789**	**118**
Fish					
Culture	212	549	1183	748	100
Wild	40	46	4	41	18
Input cost: Fish					
Fingerlings	165	198	617	371	240
Fencing	214	47	92	183	12
Feed	78	46	195	66	0
Harvesting	23	22	63	26	6
Transportation	28	18	30	25	3
Total	**508**	**331**	**997**	**671**	**261**
Net benefit	**-256**	**264**	**190**	**118**	**-143**

4.1.3 Results of 2000

In 2000, research activities were further expanded. Experiments were conducted at eight sites. Every cost related to fish culture as well as rice cultivation and benefits was analyzed. The specific cropping patterns followed at the specific sites were considered in analyzing the data. For example, only one rice crop (boro) was grown at Agarpur, Konapara, Uzanisher and Urshiura and two crops (boro and transplanted aman) were grown at the remaining four sites.

The highest net benefit from rice was obtained from Uzanisher. The net return from fish at Uzanisher was highest due to better fish growth and higher recovery. The farmers of Uzanisher received the highest total net return and also highest net return from rice as well as fish culture **(Table 70).** Therefore, it can be concluded that after harvesting boro rice in the areas where it is not possible to grow transplanted aman rice due to higher water depth during the monsoon, fish can be cultured for higher income. It is also profitable to culture fish along with transplanted aman/broadcast aman rice where water levels remain for a period of three to four months with a minimum water depth of 0.3m.

Table 70 : Profitability (US$/ha) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Bangladesh, 2000

	Konapara (A)	Kuripara (C)	Sadhukhali (C)	Maizpara (C)	Uzanisher (A)	Urshiura (A)
Returns:						
Rice:						
Boro	817	676	641	578	1131	1040
Transpl. aman	-	213	319	346	-	-
Total rice	**817**	**889**	**960**	**924**	**1131**	**1040**
Fish:						
Culture	890	366	430	321	1186	797
Wild	49	26	29	37	153	6
Total fish	**939**	**392**	**459**	**358**	**1339**	**803**
Total return	**1756**	**1281**	**1419**	**1282**	**2470**	**1843**
Input costs:						
Rice: (boro & transpl. aman)	**420**	**379**	**328**	**380**	**587**	**661**
Fish:						
Fingerlings	333	217	109	148	189	218
Fencing	17	5	18	6	40	52
Feed	141	10	0	0	241	55
Harvesting	29	6	27	8	142	11
Transport	8	16	22	7	13	8
Guard	40	0	63	20	115	18
Total fish	**569**	**253**	**239**	**188**	**740**	**363**
All input	**1020**	**763**	**871**	**732**	**1327**	**1024**
Net benefit from rice	**397**	**510**	**632**	**544**	**544**	**379**
Net benefit from fish	**371**	**138**	**220**	**169**	**599**	**440**
Total net benefit	**768**	**648**	**852**	**713**	**1143**	**819**

(A) – Alternate rice-fish
(C) – Concurrent rice-fish

4.1.4 Cost of community based fish culture: an overall analysis

Table 71 shows the overall cost of community base fish culture in flooded rice fields in Bangladesh, based on trials conducted during 1998 to 2002. Per hectare cost of community base fish culture in flooded rice field varies from US$ 168 to US$ 811. It varies from site to site due to the variation in area of site, management options followed and type of enclosure required. The trial sites in Bangladesh can be categorized into 3 types: (type 1) small area (<5 ha), 30 to 60 % perimeter fence required, minimal feeding; (type 2) small area (<5 ha), less than 30 % perimeter fence required, minimal feeding; and (type 3) large area (10-20 ha), less than 30 % perimeter fence required, moderate feeding. It was observed that fingerling cost is the main operational cost, representing 49% to 75% of the total cost. Fence cost would be minimal (about 4 to 33% of the total cost) if less than 30% of the perimeter requires to be fenced (Table 72, Figures 6a and 6b).

Table 71. Cost of community based fish culture in seasonally flooded rice fields in Bangladesh.

Area	Area (ha)	Year of operation	Fingerling cost(US $/ha)	Fence cost (US $/ha)	Feed cost (US $/ha)	Other cost (US $/ha)	Total cost (US $/ha)
Monoharpur	2.22	98/99	218.0	227.0	39.0	50.5	534.5
Uzanisher	18.34	99/00	403.0	66.0	218.0	124.0	811.0
Urshiura	3.20	99/00	294.5	117.5	60.5	35.5	508.0
Sadhukhali	3.12	99/00	174.5	15.0	27.5	1.5	218.5
Konapara	1.74	2000	333.0	17.0	141.0	38.0	529.0
Kuripara	1.32	2000	217.0	5.0	10.0	21.0	253.0
Maizpara	3.20	2000	148.0	6.0	0.0	14.0	168.0

Table 72. Cost of community based fish culture in seasonally flooded rice field by type and site, Bangladesh, 1998-2000.

Site and management type	Fingerling Cost (US $/ha)	Fence cost (US $/ha)	Feed cost (US $/ha)	Other cost (US $/ha)	Total cost (US $/ha)
Enclosure/management Type 1	256	172	50	43	521
Enclosure/management Type 2	218	11	45	19	292
Enclosure/management Type 3	403	66	218	124	811

Enclosure/management Type 1: small area (<5ha), 30 to 60% perimeter need fence, minimal feeding
Enclosure/management Type 2: small area (<5ha), less than 30% perimeter need fence, minimal feeding
Enclosure/management Type 3: large area (10-20ha), less than 30% perimeter need fence, moderate feeding

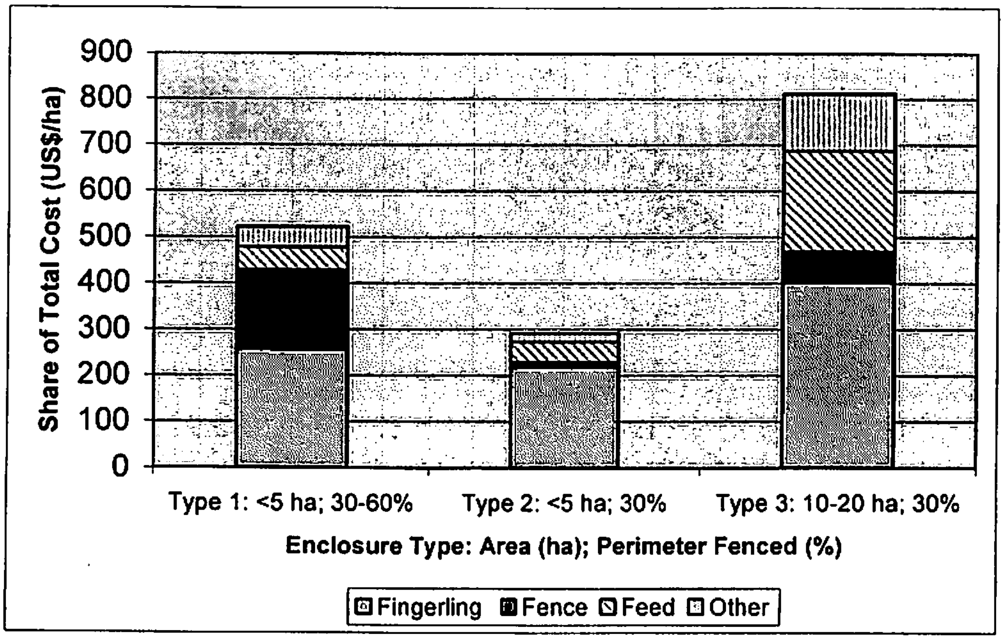

Fig. 6a. Operational cost (US$/ha) of Community Based Fish Culture in Seasonally Flooded Rice Fields in Bangladesh (trials from 1998 to 2000)

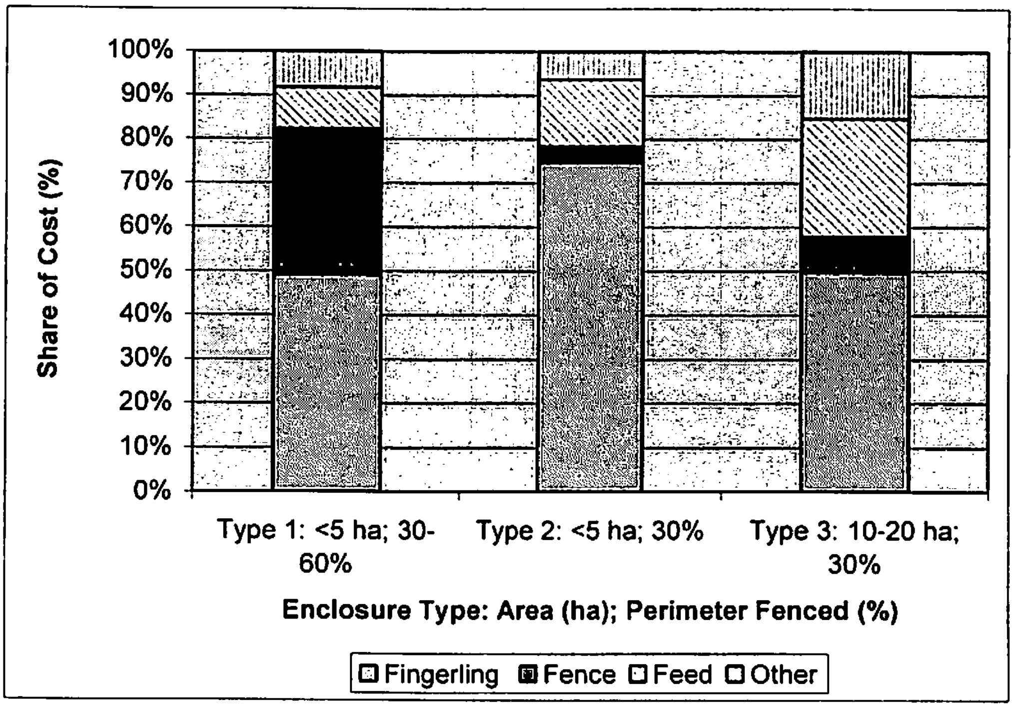

Fig. 6b. Operational cost (%) Community Based Fish Culture in SeasonallyFlooded Rice Fields in Bangladesh (trials from 1998 to 2000)

4.2 Red River Delta, Northern Vietnam

4.2.1 Results of 1998

In 1998, experiments were conducted at two sites and fish were cultured concurrently with rice. All the costs involved in growing rice as well as fish and returns from rice and fish were recorded and converted to US Dollars using the prevailing exchange rate. The results showed that the return from rice was higher at Tan Khanh site but the return from fish was lower compared to Hien Khanh site. Total input costs for fish were higher at Hien Khanh. The farmers of Hien Khanh received about five times more net return from fish compared to the farmers of Tan Khanh site (Table 73). From the first year's result it can be concluded that growing fish along with rice is profitable at both the sites but it is more profitable at the Hien Khanh site than at Tan Khanh site.

Table 73 : Profitability (US$/ha) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Red River, Northern Vietnam, 1998

Particulars	Location	
	Hien Khanh	Tan Khanh
Outputs		
Rice	735	779
Fish	628	270
Total output	**1364**	**1050**
Input	-	-
Seedling	35	35
Fertilizer	128	128
Land preparation	52	51
Seedling transplanting	79	79
Management cost	60	60
Harvesting cost	52	52
Other expenses	17	17
Irrigation cost	22	22
Fingerlings	184	105
Trench digging	74	74
Labor for fish culture	22	221
Total inputs	**725**	**646**
Total net return	**639**	**401**
Net return from fish	**349**	**70**

4.2.2 Results of 1999

The same experiment was also conducted at the same two sites in 1999 with minor modifications in the design of the experiment. The stocking rate was increased from 0.27

fingerling/m^2 to 0.3 fingerling/m^2 and silver barb was added in addition to the previous species. Hybrid rice variety No 4 was replaced with BM 90. The return from rice was high compared to 1998 and slightly higher at Tan Khanh than Hien Khanh. Input cost was almost the same at both the sites. Total net return was higher at Tan Khanh compared to Hien Khanh which is opposite of the result obtained the previous year (1998). Similarly the net return from fish was higher at Tan Khanh **(Table 74).** Therefore, it also can be concluded that fish culture with rice is profitable at both the sites.

Table 74 : Profitability (US$/ha) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Red River, Northern Vietnam, 1999

Particulars	Location	
	Hien Khanh	Tan Khanh
Outputs		
Rice	1441	1471
Fish	354	399
Total output	**1795**	**1869**
Input		
Seedling	33	33
Fertilizer	92	112
Land preparation	55	55
Seedling transplanting	74	74
Management cost	59	59
Harvesting cost	51	51
Other expenses	11	15
Irrigation cost	25	25
Fingerlings	110	85
Net cost	37	37
Labor cost for fish	44	44
Total input	**591**	**589**
Total net return	**1204**	**1295**
Net return from fish	**162**	**233**

4.2.3 Results of 2000

The same experiment was also conducted at the two sites in 2000 using the same rice variety, fish species and stocking density that were used in 1999. The return from rice as well as fish was almost the same as it was in 1999 at both the sites. The total input cost was lower compared to 1999. In 2000 the total net return was also higher at Tan Khanh compared to Hien Khanh. Similarly the net return from fish was higher at Tan Khanh **(Table 75).** Therefore it can also be concluded that fish culture with rice is profitable at both the sites.

From the above results of the three-year experiment, it can be concluded that fish culture with rice is profitable at both the sites and the technology can be adopted in other areas of the country with similar agroecological conditions.

Table 75 : Profitability (US$/ha) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Red River, Northern Vietnam, 2000

Particulars	Location	
	Hien Khanh	Tan Khanh
Outputs		
Rice	1314	1457
Fish	347	386
Total output	**1662**	**1843**
Input		
Seedling	33	33
Fertilizer	86	107
Land preparation	54	54
Seedling transplanting	71	71
Management cost	57	57
Harvesting cost	50	50
Other expenses	11	14
Irrigation cost	24	24
Fingerlings	107	70
Net cost	-	-
Labor cost for fish	46	48
Total input	**539**	**535**
Total net return	**1123**	**1308**
Net return from fish	**194**	**261**

4.2.4 Results on the Spontaneous Adoption of Concurrent Fish and Deepwater Rice Technology, 1999 and 2000, Red River Delta, Northern Vietnam

As stated earlier, the result of the experiments in 1998 at Hien Khanh and Tan Khanh sites immediately encouraged farmers in neighboring communes of Vu Ban district to adopt the technology. Results on profitability of adopting farmers during 1999 and 2000 are presented in **Tables 76 and 77**, respectively.

On an average, fish yield was around 652 kg/ha and 564 kg/ha during 1999 and 2000, respectively. These yields are on the same level with the yields in project sites. The profits from fish however were much less than that of the project sites (US$135 /ha in 1999 and US$158/ha in 2000). The average input cost during 1999 (US$682 /ha) was higher than the average input cost during 2000 (US$528 /ha). Overall profit was US$991/ha and US$958/ha during 1999 and 2000, respectively. Therefore, it also can be concluded that fish culture in flooded rice fields is profitable in these sites.

Table 76 : Profitability (US$/ha/year) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Red River, Vu Ban District, Northern Vietnam, 1999

Particulars	Tan Khanh	Hien Khanh	Minh Thuan	Dai Thang	Average
Project area (ha)	2.70	12.00	3.00	15.50	8.30
No of households	3	5	3	7	5
Input cost for rice crop	450.00	435.71	464.29	428.57	444.64
Input cost for fish culture	228.57	264.29	250.00	207.14	237.50
Rice productivity (t/ha/yr)	9.50	9.00	8.90	9.10	9.13
Fish productivity (kg/ha)	700.00	650.00	650.00	610.00	652.50
Total net profit	**1,078.57**	**957.14**	**928.57**	**1,000.00**	**991.07**
Net profit from fish	**171.43**	**107.14**	**121.43**	**141.43**	**135.36**

Table 77 : Profitability (US$/ha/year) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Red River, Vu Ban District, Northern Vietnam, 2000.

Site No	Field area (ha)	Input cost (US$/ha/year)	Rice yield (t/ha/yr)	Fish yield (kg/ha/yr)	Profit from rice (US$ /ha)	Profit from fish (US$ /ha)
1	5.0	557	8.8	674	879	207
2	6.5	557	8.9	544	893	132
3	3.0	557	9.6	525	993	121
4	2.3	557	9.7	662	1,007	200
5	0.8	557	10.2	706	1,079	225
6	3.8	557	8.4	571	821	148
7	2.2	557	9.8	704	1,021	224
8*	2.2	383	5.4	1320	539	576
9	2.1	557	8.7	360	864	27
10	5.5	557	6.6	403	564	52
11	4.0	557	6.7	427	579	65
12*	2.0	383	4.1	1053	353	423
Average	**3.3**	**528**	**8**	**564**	**799**	**158**

* one crop of rice and two crops of fish

4.3 Mekong River Delta, Southern Vietnam

4.3.1 Results of 1997

The experiment on fish culture in seasonally flooded rice fields in the Mekong Delta started in 1997 at Mekong River Delta at only one site. The species cultured were common carp, tilapia, and mud carp. The stocking density was $0.45/m^2$. From the experiment, 251 kg/ha fish was harvested. Except for mud carp whose survival rate was very poor, the survival rate of the other two species was higher than 80%. Due to the lack of data on cost and return, it was not possible to make a valid analysis of profitability.

4.3.2 Results of 1998

The same experiment was conducted in 1988 at one site but with only common carp and tilapia species. The stocking density was $0.20/m^2$. The survival rate of both the species was higher than 66%. A total of 200 kg/ha was harvested from the experiment. Similar to year 1997, due to the lack of data on cost and return data, it was not possible to make a valid analysis of profitability.

4.3.3 Results of 1999

In 1999, experiments were conducted at three sites. The species were common carp, grass carp and tilapia in two sites and common carp, tilapia, silver barb and snakeskin gourami at the third site. On the basis of input-output data, a profitability analysis was made and compared with a control site. Income from rice and fish were added together for the control as well as for the project site. At the control area, the value of wild fish was considered. After deducting all the costs (fish culture and rice cultivation) the net return was estimated. The results showed that with an additional investment of 208 US$/ha, the farmers received a net benefit of US$126.45/ha,, a rate of return about 60% within a period of six to seven months **(Table 78)**. Therefore it can be concluded that integrating fish in the flooded rice field is more profitable compared to producing rice only in the same field.

Table 78 : Profitability (US$/ha) of Fish Culture in the Seasonally Flooded Rice Ecosystem, Mekong River, Southern Vietnam, 1999.

Particulars	Location	
	Control Site	Project Site
Returns		
Rice	701.87	720.59
Fish	86.67	276.31
Total returns	**788.54**	**996.89**
Input costs: Rice		
Land preparation	1.93	2.54
Fertilizer	72.76	78.84
Weeding	24.21	23.86
Pesticides	52.02	54.16
Other	90.92	88.57
Total input cost: Rice	241.83	247.97
Total input cost: Fish	-	75.76
Total input cost	**241.83**	**323.73**
Net benefit	**546.71**	**673.16**
Increase in net return due to the technology	-	**126.45**

4.3.4 Results of 2000

In 2000, experiments were conducted at four sites. The cultured species were common carp, grass carp and silver carp with an average stocking density of $0.25/m^2$. On an average, 119.4 kg/ha fish was harvested. The survival rate was very poor at only 11.9%.

Data on input use and value of output was not available. Therefore, it was not possible to make a valid analysis on profitability.

4.4 Conclusion

Based on the results of four years' action research on community-based fish culture in seasonally flooded rice ecosystems in two different countries with diversified agroecological I situations, it can be concluded that the technology is profitable and socially acceptable. If the technology is adopted in similar agroecological situations, the resources in particular the labor of the landless or marginal farmers will be utilized properly because during this period of the year, no agricultural activities are available to engage their labor.

5 RECOMMENDED TECHNICAL AND INSTITUTIONAL OPTIONS

5.1 Bangladesh

Action research for community-based fish culture in seasonally flooded rice ecosystems in Bangladesh was undertaken in two types of environment: shallow and medium flooded (50-150 cm deep) area and deep flooded (1500 -250 cm) area. In the shallow flooded areas the dominant cropping pattern is two rice crops grown per year and in the medium flooded areas the dominant cropping pattern is only one rice crop grown during the dry period per year. In the case of shallow flooded areas fish was cultured along with the second rice crop In the medium flooded areas only fish was cultured during the monsoon when land remained fallow. On the basis of three year's results of experiments the following technical and institutional recommendations were made.

5.1.1 Technical

Selection of Areas: Sites should be selected to meet the following criteria: (i) they should be of adequate size, that is, 5 to 20 ha (smaller groups and areas are considered less effective); (ii) natural topography (such as saucer-shaped natural depressions, or existing artificially elevated lands through homesteads, road/train, dams,) enclose the area on two to three sides to allow fencing off at low cost; (iii) the prevailing social conditions should be such that all stakeholders of a waterbody can be involved in a shared management arrangement, including landowners, leaseholders, landless fishers (who may have customary rights to fish in the flooded waterbody but are restricted from access during the dry season).

Enclosure: The enclosure should be designed and built by the cooperating farmers. Usually a fence is made of locally available materials such as bamboo, reed, wood or crab-resistant netting (the latter can be cheaper as it is longer lasting). The mesh size should be small enough to prevent stocked fingerlings from escaping, but still be large enough to permit natural small indigenous species to enter with the floods.

Stocking Density: Stocking density is to be determined on the basis of size of fingerling, stocking duration, water quality and availability of natural feed in the water. Results of this project show that the use of bigger size fingerlings gives higher survival rate and growth. For relatively bigger sized fingerlings (usually 15 to 20 g per piece), an average stocking density of 2000 to 4000 fingerlings / ha is recommended. On the other hand, the availability of such larger fingerlings in a sufficient quantity can pose a problem and should be planned for, for instance, through arrangements with one or more hatcheries, nurseries or fingerling suppliers. Likewise, the need for considerable numbers of large fingerlings poses demands on transport and handling capacity in order to avoid serious losses at stocking. A possible cost-reducing strategy is to raise fry (which are much cheaper) to fingerlings within the rice field in the preceding rice culture period in the dry season. However, this was not tested within this project.

Species Combination: A polyculture system with fast growing species like silver carp, common carp and, silver barb is recommended for the concurrent systems and along with the above species, grass carp and catla can be added for the alternate systems.

5.1.2 Institutional

For fish culture in seasonally flooded rice ecosystems, a group-based approach should be adopted. The group should comprise landowners and fishers / landless laborers of the community, who have customary access rights for fishing in the area during the flood season. Landowners comprise participating (active) and non-participating (passive) persons. Landowners who participate actively in the group activities also receive an additional share of benefits for their role as group members in addition to the share they already receive through mere provision of their land.

Before stocking, group members will have to negotiate and agree on cooperative sharing arrangements, rules, technical details and schedules for the operation. Any delay in the finalization of the agreement may delay the period of stocking, which will reduce yield. In the absence of any financial help from outside sources, the general sharing agreement could be as follows: landowners 30%, labor group members 30%, working capital 30%, and savings/ institution building 10%.

For financial and administrative support, an NGO can be involved. For technical support, respective research organizations should be included. The local personnel of the Department of Fisheries can also be involved.

5.2 Red River Delta, Northern Vietnam

5.2.1 Layout of the Field

The plot of flooded rice fields used for deepwater rice-fish culture should be enclosed by strong dikes, at least 1.2 m high above the rice bed. There should be an inlet and outlet connecting to irrigation canals that will serve as reservoir for filling in and draining out water in/from the field. Surrounding the field (inside the dikes), a trench should be dug to generate a refuge area for fish during hot weather. The trench/canals are also used as fry/fingerling rearing area. The trench area should be 10-15% of the rice fields. During the rainy season, sufficient netting should be fixed enclosed on all the enclosing dikes to prevent fish from escaping from the field.

5.2.2 Species Composition

Common carp is the most suitable species in rice fields and should be stocked at a rate of 50% of the total amount of fingerlings stocked. Rohu should account for 20%, and 10% each for silver carp, silver barb and tilapia. The fingerling size of all species at stocking should be over 10 g.

5.2.3 Stocking Density

The stocking density is to be 3,000–3,500 fingerlings/ha.

5.2.4 Time of Stocking and Fish Harvest

Stocking is to be done in March, 10 to15 days after transplanting of the first rice crop. No supplemental feeding will be required. One intermediate harvest is to be done between September and November (in case of multiple harvests) and the total harvest is to be undertaken in December.

5.2.5 Rice Variety

In the first rice crop (March-June), HYV should be used and a shallow water level is to be maintained in the field. In case of the second rice crop (July to November), which is cultured in the rainy season, only flood tolerant rice varieties, suitable to deepwater conditions should be used.

5.3 Mekong River Delta, Southern Vietnam

5.3.1 Rice Field Design

Nylon netting is recommended for making the boundary of the rice field. The net's width should vary based on the height of the dike: 1.4 m if the height of the dike is 0.5-0.7 m , and 1.8 m for dikes lower than 0.5 m. Bamboo sticks of 2-3 m in height are to be installed at 2-3 intervals and should be embedded into the dike 0.5 m deep. The upper edge of the net is to be lined with a strong nylon line. The lower edge is to be fixed by bamboo hem and is to be embedded 0.2 m deep into the dike. The bamboo hem is to be fixed by piles at 0.5 m intervals.

5.3.2 Species Composition

The following three species combinations are suggested for fish culture in flooded rice fields, with common carp and grass carp being the major species throughout:

(1) (i) Common carp 50 % : grass carp 30 % : tilapia 20 %
(2) (ii) Common carp 50 % : grass carp 30 % : tilapia 10 % : silver carp 10 %
(3) (iii) Common carp 50 % : grass carp 30 % : silver carp 20 %.

5.3.3 Stocking Density

A stocking density of 0.2 /m^2 is recommended, which ensures sufficient natural food for the stocked fish without any supplementary feed. The suitable size of fingerlings at stocking is 5 g (common carp, tilapia) and 10 g (grass carp, silver carp).

5.3.4 Time of Stocking and Harvesting

Fish should be stocked into the rice field one month before arrival of the flood, and is to be kept for one month in a pond after the recession of the three-month long flood. Thus the average culture duration should be five months, which is sufficient for fish to reach marketable size.

5.3.5 Feeding

The stocked fish should feed on the available natural food in the rice field. At the same time macrophytes (for example, grasses, leaves) which are eaten by grass carp can be added. As an option to further increase fish production, fish can be fed with rice bran during the first month of culture and with available on-farm resources during the last month.

5.3.6 Other Technical Issues

The net wall and net base should be regularly checked and any holes should be repaired. Aquatic macrophytes, which are stuck outside the net and block the net's mesh, should be removed frequently. Night patrol should be carried out, in order to prevent poaching. The flood regime should be monitored every year so that preventive measures can be undertaken in the years with abnormal flood.

5.3.7 Management Options

Due to the specific characteristics of the farmers in the Mekong Delta, collaboration cannot be obligatory. The participation of each farmer in a group should be on a volunteer basis. During group management, the sharing arrangement should be based on a negotiation among the participating farmers. In general the sharing of outputs should be on the basis of input and labor contribution of each group member.

6. IMPACT AND ADOPTION OF THE TECHNOLOGY

6.1. Impact on the Level and Distribution of Income

The impact of community based fish culture in seasonally flooded rice ecosystems was estimated by comparing the total farm income (that is, total net benefits from rice and fish production) in project sites (with fish culture) to that in control sites (without fish culture). The total farm income in the project sites comprises net benefits obtained from rice production, cultured fish production and wild fish catch, while that in control sites comprises net benefits obtained from rice production and wild fish catch only.

6.1.1. Bangladesh

In Bangladesh, detailed monitoring of control and project sites was undertaken in 2000. Results show that, on an average, concurrent and alternate systems of community-based fish culture in seasonally flooded rice ecosystem generated an additional annual income of US$169/ha/year and US$506/ha/year, respectively, in Bangladesh (**Table 79**). The increase in total net benefit was higher in areas where the alternate system is applied. Alternating fish and boro rice farming is usually followed in deep-flooded areas which are more conducive for fish culture and give higher fish yield.

Table 79: Total Net Benefit (US$/ha) Obtained by the Project and Control Farmers, Bangladesh, 2000

System	Site	Project				Control			Total increased in income (US$/ha)
		Rice	Cultured fish	Wild fish	Total	Rice	Wild fish	Total	
Concurrent	Kuripara	510	139	26	675	508	22	530	145
	Sadhukhali	632	220	29	881	624	37	661	220
	Maizpara	544	170	37	751	547	62	609	142
	Average	**562**	**176**	**31**	**769**	**690**	**40**	**600**	**169**
Alternating	Konapara	397	370	49	816	467	50	517	299
	Uzanisher	544	599	153	1296	417	12	429	867
	Urshiura	379	440	146	965	415	198	613	352
	Average	**440**	**470**	**116**	**1026**	433	**87**	**520**	**506**
	All Average	-	-	-	**897**	-	-	**560**	**338**

The impact of community based fish culture in seasonally flooded rice fields on the distribution of farm income among landowners and landless households was calculated based on the pre-agreed sharing arrangement between these two social groups. Results show that with the introduction of community based fish culture under the alternating fish and rice system, the annual household income could be increased by as much as 23% for landless farmers and 26% for landowners (**Table 80**). The magnitude of the increase depends on the size of the culture area, number of beneficiaries involved in the operation and the performance of the technology. When there are fewer beneficiaries, the net benefit will be divided among a smaller number of households. In most areas, the increase in household income as a proportion of total income is negligible since aquaculture or agriculture is not the major source of income. In general, the results show that the community based fish culture in flooded rice fields has the potential for generating income for landless poor. If the information generated and experience gained through this project are properly utilized in the future through community-based fish culture in seasonally flooded rice ecosystems, both landowners as well as landless participants will be benefited.

Table 80: Impact of Fish Culture in Seasonally Flooded Rice Fields on Income, Bangladesh, 2000.

System	Sites	Tenure status	Base income (US $/household)	Increase income due to the technology (US$/household)	Percent Increase income due to the technology (%)
Concurrent					
	Kuripara	Participating Landowner	1,442	61.92	4.29
		Landless	709	3.97	0.56
	Sadhukhali	Participating Landowner	381	15.34	4.03
		Landless	326	4.22	1.30
	Maizpara	Participating Landowner	1,207	11.89	0.98
		Landless	490	4.94	1.01
	Average	Participating Landowner	**814**	**29.72**	**3.65**
		Landless	**517**	**4.38**	**0.85**
Alternating					
	Konapara	Participating Landowner	1,408	24.07	1.71
		Non - Participating Landowner	1,408	5.18	0.37
		Landless	612	12.35	2.02
	Uzanisher	Participating Landowner	1,223	319.06	26.09
		Non - Participating Landowner	1,223	45.06	3.68
		Landless	1,191	274.01	23.01
	Urshiura	Participating Landowner	1,550	61.77	3.99
		Non - Participating Landowner	1,550	12.62	0.81
		Landless	466	18.11	3.89
	Average	Participating Landowner	**1,326**	**128.18**	**9.67**
		Non - Participating Landowner		**8.23**	**0.62**
		Landless	**1,032**	**44.15**	**4.28**

6.1.2. Red River Delta, Northern Vietnam

During the three years of trials, detailed information on cost and return of agricultural activities were collected from both the control and project sites in Hien Khanh and Tan Khanh communes, Red River delta, Vietnam. Results show that on an average, fish culture in seasonally flooded rice ecosystems generated an additional annual income of US$346/ha (**Table 81**).

Table 81: Total Net Benefit (US$/ha) Obtained by the Project and Control Farmers, Red River Delta, Northern Vietnam

Particulars	Sites		Total increase
	Experiment	Control	Income (US$/ha)
Yield (kg/ha/yr)			
Rice yield	10	10	
Wild fish production	35	20	
Culture fish yield	677	-	
Input costs (US$/ha/yr)			
Production costs	577	480	
Pesticides and spraying costs	-	18	
Returns (US$/ha/yr)			
Profit from rice	1,001	888	114
Profit from both wild and cultured fish	247	14	233
Total net profit	**1,249**	**902**	**346**

The Impact of the technology (that is, fish culture in seasonally flooded rice fields) on household income was estimated based on equal sharing of the total net benefit among the three farmers in Hien Khanh commune who were involved in the experiment for three years (1998-2000). Results show that average annual increase in income of each farmers household was US$392, which is 42% of their income prior to the adoption of the technology (**Table 82**).

Table 82: Impact of Fish Culture in Seasonally Flooded Rice Fields on Income, Red River Delta, Northern Vietnam

Year	Base income (US$/household)	Increase in income due to the technology (US$/household)	Percent increase in due to the technology %
1998	943	581	61.65
1999	943	271	28.69
2000	943	323	34.26
Average		**392**	**41.54**

6.1.3. Mekong Delta, Southern Vietnam

Detailed agricultural activities and the profitability were monitored in both the project and control sites in Trap Muoi district, southern Vietnam, during 1999. Results show that, on an average, fish culture in the seasonally but flooded rice ecosystem generated an additional annual income of US$211/ha (**Table 83**).

Table 83 : Total Net Benefit (US$/ha) Obtained by the Project and Control Farmers, Mekong River Delta, Southern Vietnam, 1999

Particulars	Location	
	Control Site	Project Sites
Returns	**788.54**	**996.89**
Rice	701.87	720.59
Fish capture	86.67	84.31
Fish culture		276.31
Input costs	**241.83**	**323.73**
Rice	241.83	247.97
Fish	-	75.76
Net benefit	**546.71**	**757.48**
Increase in Income	-	**210.77**

6.2. Impact of Fish Culture in Seasonally Flooded Rice Fields on Fish Consumption

6.2.1. Bangladesh

In this project, food (including fish) consumption of different types of households (landowners and landless) was monitored in all sites (both control and project sites). Daily food consumption was recorded every other week for eight months (Tables 39-42). From these tables, however, one cannot determine the impact of the technology (that is, community based fish culture in seasonally flooded rice fields) on fish consumption, as variations in fish consumption could be due to the influence of several factors (such as income, household size, price of fish and other fish substitutes). We conducted a tobit regression analysison fish consumption as a function of these hypothesized variables including dummy variables on sites, months and types of respondents. Results of the regression (not presented here) show that fish consumption is positively related to household income and price of meat increase and negatively related to price of fish. The individual effects of other variables like month, site and respondent type are not significant. This implies that fish culture in seasonally flooded rice ecosystems affects household fish consumption only through income changes.

We estimated the income elasticity of fish consumption (that is percentage change in fish consumption due to percentage change in income) from the result of the tobit regression, which is equal to 0.66. This means that if household income increases by 10%, fish consumption will increase by 6.6%. Earlier, we also estimated the impact of the technology on increase in income (**Table 80**). Using the estimated income elasticity of fish consumption and the estimated increase in income due to technology (community based fish culture in seasonally flooded rice fields) adoption, we computed the impact of the technology on fish consumption and the results are presented in **Table 84**. Since the households following the alternating rice and fish system have greater increase in income, as expected, they also have greater increase in per capita fish consumption compared to households following the concurrent rice and fish culture system. For the participating landowners, per capita fish consumption increased by 6.4% and 2.4% due to the adoption of the alternating and the concurrent system of rice-fish farming in seasonally flooded ecosystems, respectively. For the landless beneficiaries, the increase in per capita fish consumption due to adoption of the alternating and the concurrent system of rice-fish farming were 2.8% and 0.6%, respectively.

Table 84: Impact of Fish Culture in Seasonally Flooded Rice Fields on Fish Consumption, Bangladesh, 2000.

System	Sites	Tenure status	Base consumption of fish (kg/capita/year)	Increase In income due to the technology (%)	Increase in fish consumption due to the technology (%)
Concurrent					
	Kuripara	Participating Landowner	1.16	4.29	2.83
		Landless	0.8	0.56	0.37
	Sadhukhali	Participating Landowner	2.03	4.03	2.66
		Landless	3.08	1.30	0.85
	Maizpara	Participating Landowner	1.32	0.98	0.65
		Landless	1.02	1.01	0.66
	Average	Participating Landowner		**3.65**	**2.41**
		Landless		**0.85**	**0.56**
Alternate					
	Konapara	Participating Landowner	1.05	1.71	1.13
		Non - Participating Landowner		0.37	0.24
		Landless	1.25	2.02	1.33
	Uzanisher	Participating Landowner	2.57	26.09	17.22
		Non - Participating Landowner		3.68	2.43
		Landless	1.67	23.01	15.18
	Urshiura	Participating Landowner	1.25	3.99	2.63
		Non - Participating Landowner		0.81	0.54
		Landless	2.01	3.89	2.56
	Average	Participating Landowner		**6.25**	**6.38**
		Non - Participating Landowner		**0.62**	**0.41**
		Landless		**5.10**	**2.82**

In the Vietnam sites (both in the Red river delta and the Mekong river delta), some of the relevant information needed to estimate a fish demand function are not available, which restricted us from determining the impact of the technology on fish consumption.

6.3. Impact on Landless Labor

The adoption of community based fish culture in seasonally flooded rice fields will increase the demand for labor in fish production, harvesting and post-harvest operations. The landless farmers will earn money as profit through their participation in the community-based culture system. Results from trials conducted in Bangladesh during 1998 to 2000 show that incremental income to landless labor due to community based fish culture in seasonally flooded rice fields would be about US $ 77 /ha for the concurrent system and about US$ 218 /ha for the alternating system (Fig. 7). Very few agricultural activities can generate this much of incremental income for landless labor.

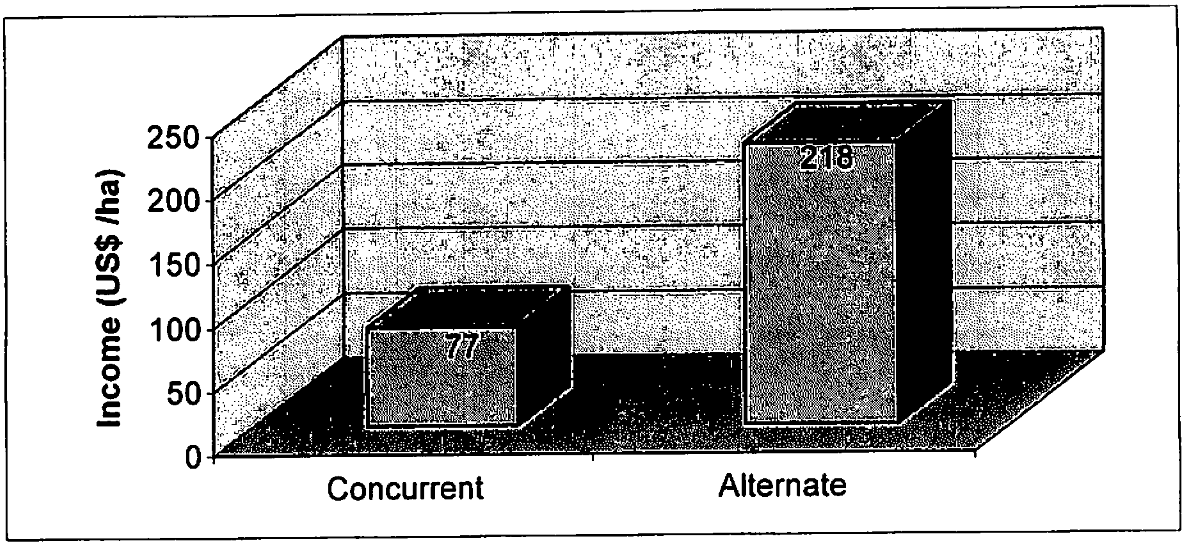

Fig 7. Increase in Income to Landless Labor due to Community based Fish Culture in the Seasonally Flooded Rice Ecosystem, Bangladesh

6.4. Adoption of the Technology

6.4.1. Bangladesh

The local population in Bangladesh is convinced of the benefit of this technology. Communities neighboring the trial and demonstration sites have copied the technology for their situation. These established group arrangements seem more harmonious and longer lasting than those orchestrated by external organizations (follow-on monitoring is planned).

The ongoing Agricultural Development and Improvement Project (ADIP) of the Department of Agricultural Extension (DAE), which is funded by an IFAD loan, has adopted this technology for extension to farmers in project areas in Tangail district. Proshika, the participating NGO in this project, has established the technology as part of its rural development program and is planning to disseminate this technology in 30 sub-districts in Bangladesh.

6.4.2. Red River Delta, Northern Vietnam

Earlier, it was reported that the result of the fish culture on flooded rice fields experiment in 1998 at Hien Khanh and Tan Khanh sites had encouraged farmers in neighboring communes of Vu Ban district to adopt the technology. The profitability was presented in Tables 74-75.

The technology was also adopted by the farmers in other provinces (Bac Ninh, Yen Bai and Hanoi) in 1999 with technical assistance from the project. The project staff advised the farmers in designing the fields, selecting fish species, rice variety and management of the farm, but no financial support was provided. The area and number of households that adopted the rice-fish culture technology are presented in **Table 85.**

Table 85 : Adoption of Fish Culture in Shallow Flooded Rice Area in 1999-2000, Red River Delta, Northern Vietnam

Locality	Area (ha)	Number of household
Bac Ninh	102	300
Yen Bai	12	25
Hanoi	80	44
Total	**194**	**369**

6.4.3 Mekong River Delta, Southern Vietnam

In total there are 28 households in the study area which have already adopted the fish farming technology in deep-flooded rice fields during the three years of project implementation (1998 to 2000). In addition, 7 out of 11 interviewed non-participating households have a high interest to participate in fish culture in deep-flooded rice fields (**Table 86**).

Table 86 : Farmer's Willingness to Participate in Fish Culture in Seasonally Flooded Rice Fields, Mekong River Delta, Southern Vietnam

Rate	Type of Respondents			
	Non-participants		Participants	
	No	%	No	%
High	7	63.64	9	81.82
Medium	1	9.09	2	18.18
Low	3	27.27	-	-
Total	**11**	**100**	**11**	**100**

In addition, about 60 – 70 % of farmers who have small ponds for culturing fish have applied the technology for keeping the fish in the pond during the flooding season.

Most of the participating as well as non-participating farmers have confirmed the viability of the culture system developed by the project. In the first year of the project's implementation (1997), there was hardly any person who believed in the feasibility of the project. Therefore, it was very difficult to find farmer cooperators.

After three years of project implementation, many farmers are now convinced of the technical feasibility and economic viability of this technology. They are surprised to see that such a fairly simple technology can bring about a good yield of 300 – 400 kg fish/ha. The only constraint is the vulnerability of the system during heavy floods. On the other hand, some farmers are still hesitating to adopt the technology; there are several reasons for this, and the most important one is the lack of money (25% of total responses) **(Table 87).**

Table 87 : Reasons for Not Culturing Fish in Deep-flooded Rice Fields in the Control Site, Mekong River Delta, Southern Vietnam

Response	Respondents	
	Number	%
Still considering technology	1	12.5
Risk of flood	1	12.5
Risk of theft	1	12.5
Water in pond for keeping fish is poor	1	12.5
Insufficient money	2	25.5
Insufficient labor	1	12.5
Conflicts with other owners	1	12.5

Several Centers for Agricultural Extensions of the provinces located in the flood-prone area (Dong Thap, An Giang) have voiced suggestions to adopt fish culture in the seasonally flooded rice ecosystem. Other development agencies, such as Farmers' Union and the Veterans' Union, have requested to be supported technically. The public broadcasting system of Dong Thap province often broadcasts news about this technology.

Appendix 1

Publications resulting from the project

Dey, M. and Prein, M. 2000. Case 3: Fish in deepwater ricelands. P. 19-20 *In* PRGA Program (eds.) Equity, wellbeing, and ecosystem health: participatory research for natural resources management. CGIAR Program on Participatory Research and Gender Analysis, CIAT, Cali, Colombia. 62 p.

Equity, Well-Being, and Ecosystem Health

Participatory Research for Natural Resource Management

CGIAR Program on Participatory
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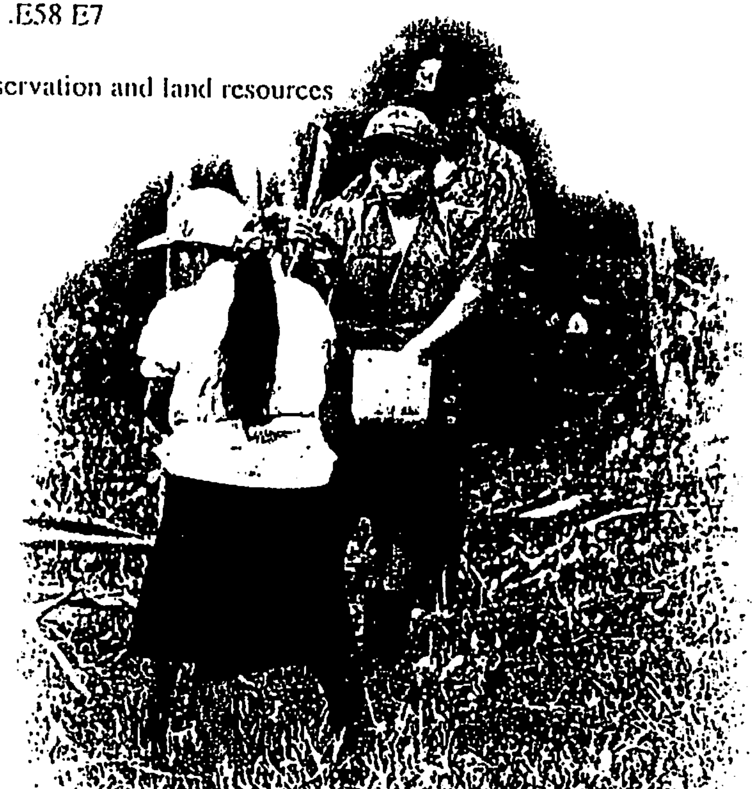
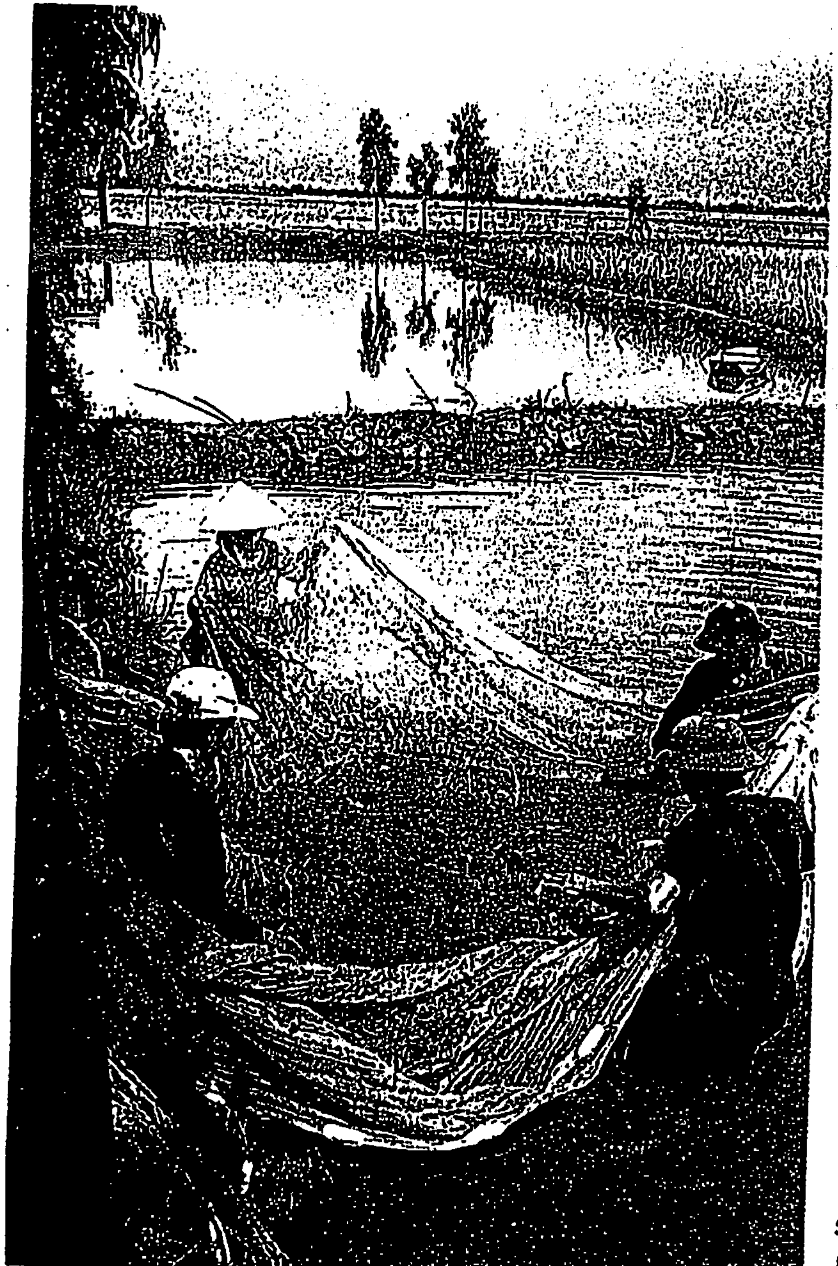


Contents

Case 3: Fish in deepwater ricelands



Key dimensions	Tools and methods
Agroecosystem health	Farmer-designed experiments
Fish	Group interviews
Institutional innovations	Participatory rural appraisal
Partnerships	Researcher-designed experiments
Poverty alleviation	Wealth ranking
Technological innovations	
User sensitivity	
Wetlands	

In Asia over 10 million hectares of riceland (10 percent of the region's total rice area) are affected by uncontrollable seasonal flooding. During the dry season, ownership of land is fixed according to tenure arrangements. But during the rainy season, when farmers grow deepwater rice and fish in flooded areas, fish are treated as a common resource, and community members are traditionally granted access to private property for fishing.

With a view to increasing and sustaining the productivity of rice and fish in such areas, the International Center for Living Aquatic Resources Management (ICLARM) and the International Rice Research Institute (IRRI) are collaborating with local communities, government organizations, and NGOs in a participatory action research project. Begun in 1997, the project seeks to improve household incomes in the seasonally flooded agroecosystems of Bangladesh and Vietnam. The project's strategy combines indigenous approaches to resource management with semi-intensive fish culture and management technologies.

The project's unit of analysis is the resource management domain (RMD) at the landscape level. The RMD encompasses the environmental, social, and economic characteristics of a recognizable unit of land and takes into account its inherent natural variability. Project clients include landowners and other local residents who rely on fishing during the rainy season. To identify its clients, the project convened meetings with farmers from different wealth groups as well as with landless laborers and members of local organizations. A team of researchers and representatives from local organizations conducted diagnostic surveys to identify the needs of each group. The results were presented and discussed during group meetings. The survey data provide a baseline for analyzing project impact over time.

A project implementation committee was established at each project site, with representatives from each user group. The committee oversees implementation of the project, prepares budgets, manages project accounts, negotiates sharing agreements, settles conflicts, supervises fish sales, and distributes the proceeds from experiments. With support from researchers and NGO staff, different user groups have designed their own organizational arrangements for testing technical innovations in fish culture.

The concept of managed fish culture in deepwater rice fields is new. So, researchers designed technical options in close consultation with users and based on information about their needs, knowledge, and current practice. Technical options were tested locally in small-scale experiments, and the options were fine-tuned on the basis of feedback from users. Currently, users are testing options themselves, with minimum support from researchers. Users provide labor, manage experiments, and collect data. During its first 2 years, the project provided seed money to cover the costs of materials. Users deposit a part of the proceeds from the sale of fish produced in experiments to cover future project expenditures.

Researchers are monitoring water and soil quality, profitability, input use, fish consumption, group performance, and sharing arrangements. Based on this information, the project will analyze the impact of technological innovations and project processes.

CIMMYT Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center), Mexico, D.F., Mexico

CIP Centro Internacional de la Papa (International Potato Center), Lima, Peru

CSIRO Commonwealth Scientific and Industrial Research Organisation

DFID Department for International Development, UK

FAO Food and Agriculture Organization

FFS Farmer Field School

GTZ Deutsche Gesellschaft für Techniche Zusammenarbeit (German Agency for Technical Cooperation)

ICARDA International Center for Agricultural Research in the Dry Areas, Aleppo, Syria

ICLARM International Center for Living Aquatic Resources Management, Penang, Malaysia

ICRAF International Centre for Research in Agroforestry, Nairobi, Kenya

ICRISAT International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India

IDRC International Development Research Centre, Ottawa, Canada

IFAD International Fund for Agricultural Development

ILRI International Livestock Research Institute, Nairobi, Kenya

IPGRI International Plant Genetic Resources Institute, Rome, Italy

IPM Integrated Pest Management

IRRI International Rice Research Institute, Los Baños, Laguna, Philippines

IWMI International Water Management Institute, Colombo, Sri Lanka

LI-BIRD Local Initiatives for Biodiversity, Research, and Development

LTM Long-term monitoring

NARC Nepal Agricultural Research Council

NGO Nongovernment organization

NRI Natural Resources Institute

NRM Natural resource management

OPEC Organization of Petroleum Producing Countries

OXFAM Oxford Committee for Famine Relief

PAM Participatory Agroecosystem Management

PPB Participatory plant breeding

PRGA Participatory research and gender analysis

RDC Rural District Council

RMD Resource management domain

RMP Risk Management Project

SDC Swiss Agency for Development and Cooperation

WARDA West Africa Rice Development Association, Côte d'Ivoire

WUA Water Users Association

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Analysis and writing:
Ann Braun, Paideia Resources,
P.O. Box 462,
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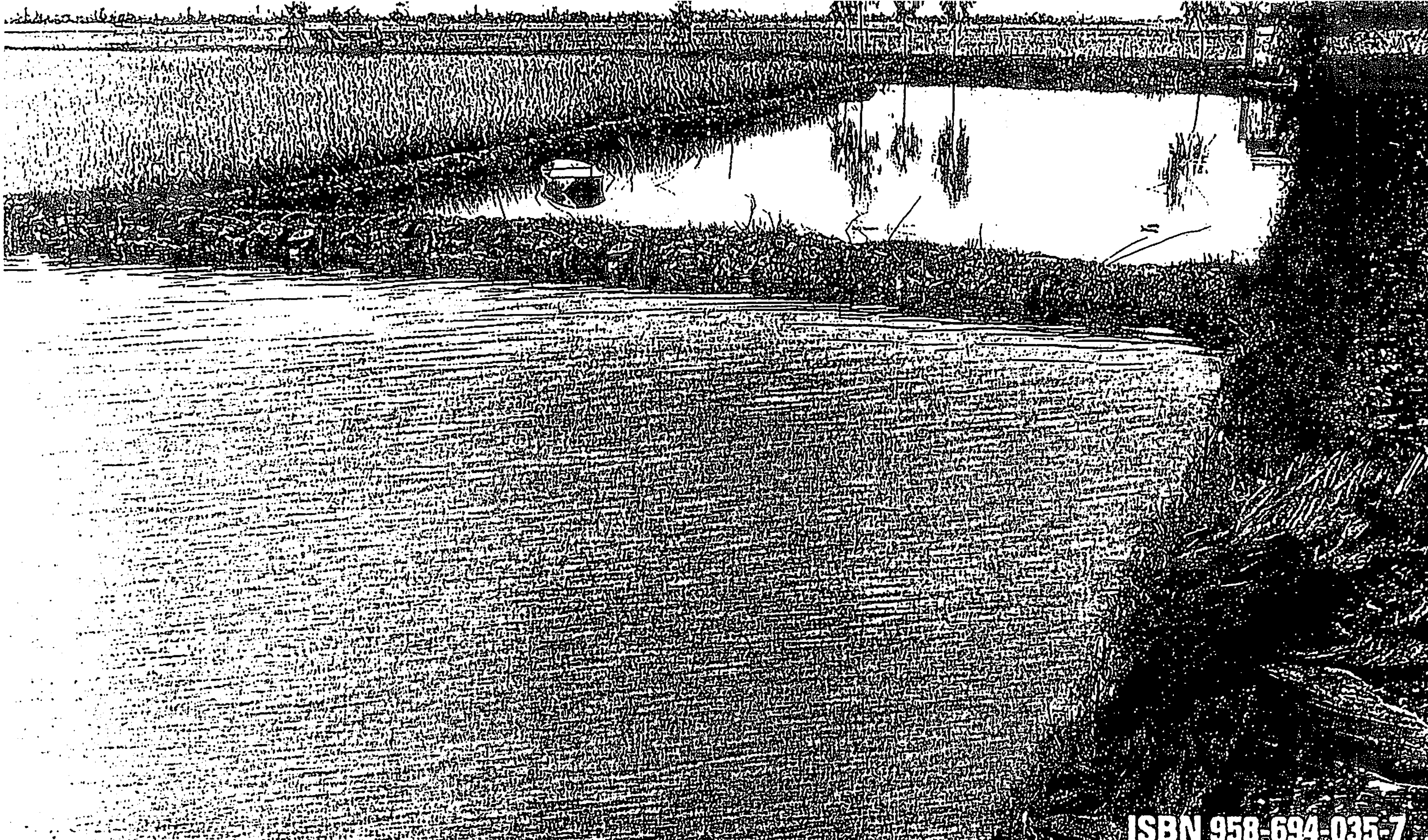

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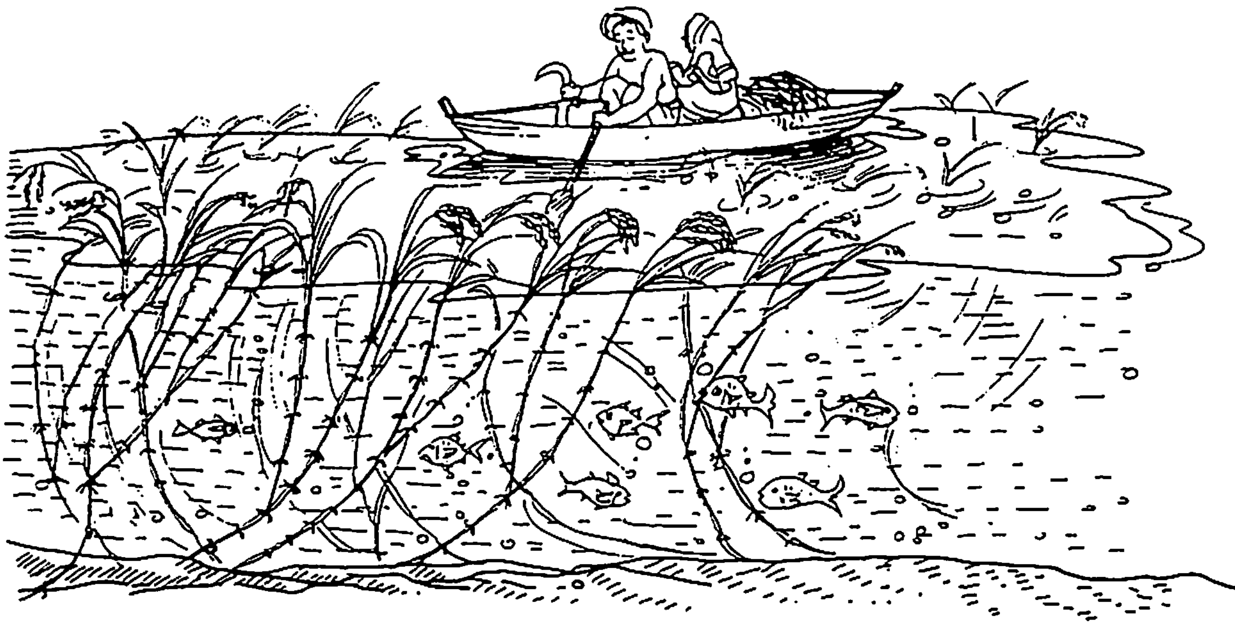
Rice and Fish Culture in Seasonally Flooded Ecosystems

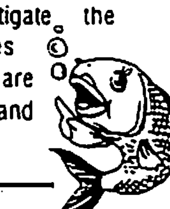


Farming in a flood-prone environment

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.

Rice and fish in flood-prone areas in Bangladesh

Bangladesh relies heavily on flood-prone rice ecosystems. In Bangladesh, for example, about 10% of the country's seven million hectares of arable land is flooded to depths of more than 50 cm during the rainy season. These areas are flooded during the monsoon and remain submerged for four to six months. The vast water bodies and rice canopies provide natural habitats for various aquatic resources including wild fish and shrimp. The abundance of natural organisms favors the cultivation of fish for four to five months either in a deepwater rice environment in a fenced-off waterbody, or in the same area without deepwater rice. Increased food production in the flood-prone ecosystem using any of the two options for rice-fish culture could play a vital role in reducing malnutrition, increasing household income and promoting food security. It would also help mitigate the trend of declining capture fisheries production. Similar opportunities are seen for deltaic systems in India and Vietnam, among other countries.



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 thee 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

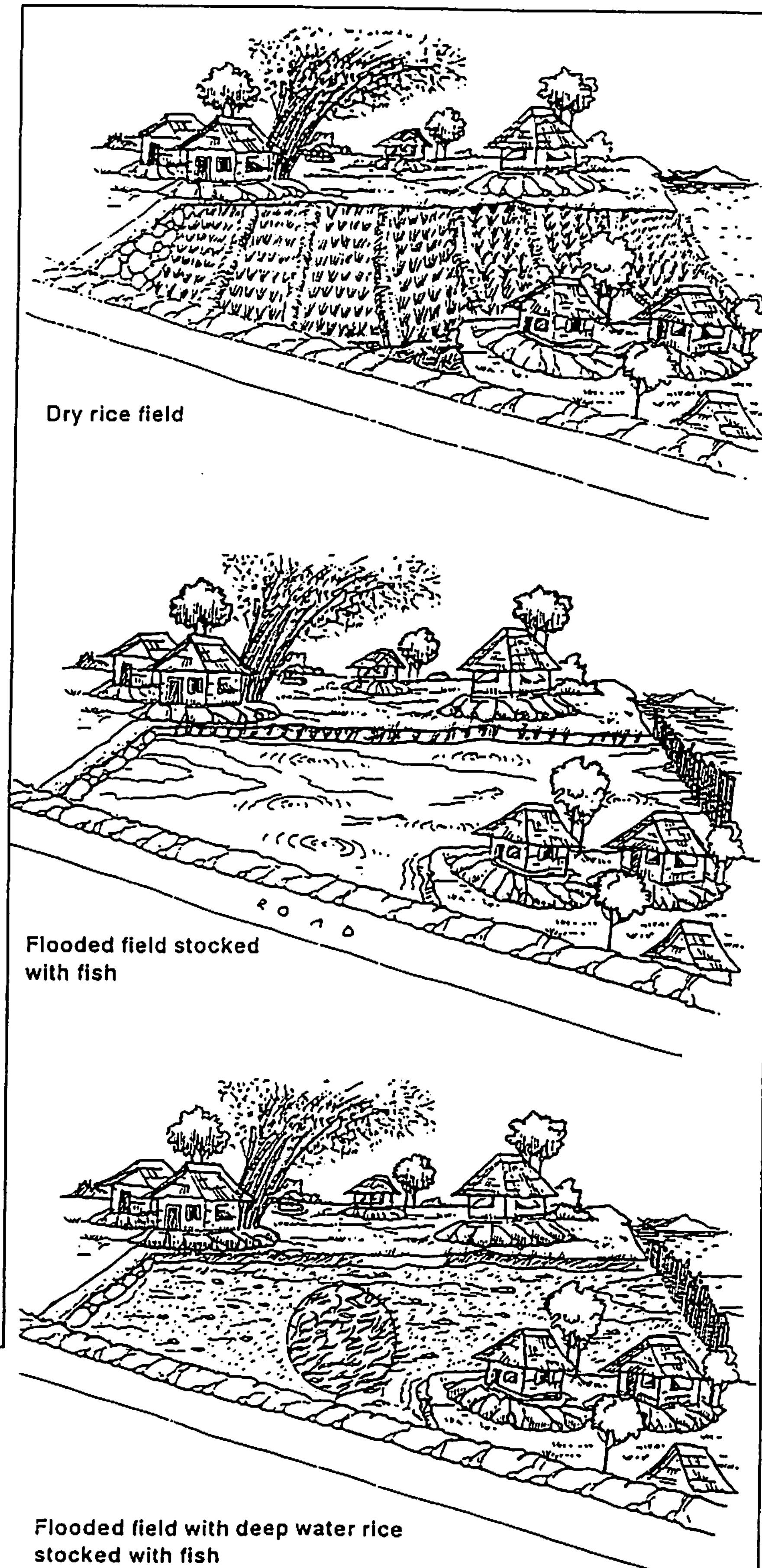
After the cultivation of dry season rice, when fields are flooded to a depth at which individual ricefield boundaries (i.e., bunds) cannot be distinguished, floods form a water body for 4 to 6 months. The farm is usually left as flooded fallow, but it can be used to grow deepwater rice and/or fish. Given 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.



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.

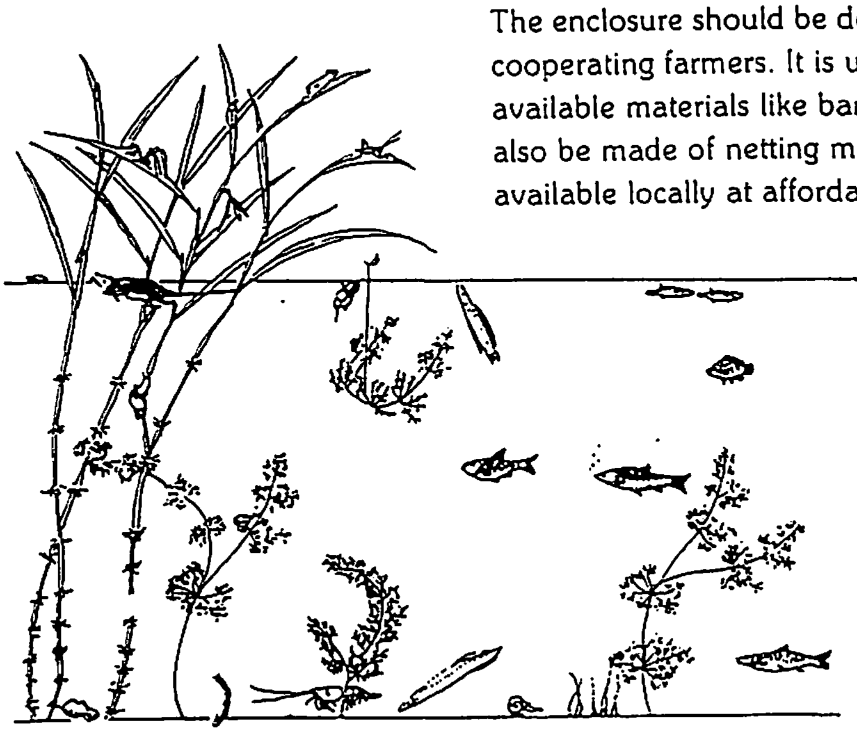
Farmers groups will have to negotiate and agree on cooperative sharing arrangements, rules, technical details and schedules of operation. These may be influenced by other existing agreements and ongoing conflicts.

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.



Natural flora and fauna in a deepwater/ floating rice field, i.e., without additionally stocked fish species for culture.

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

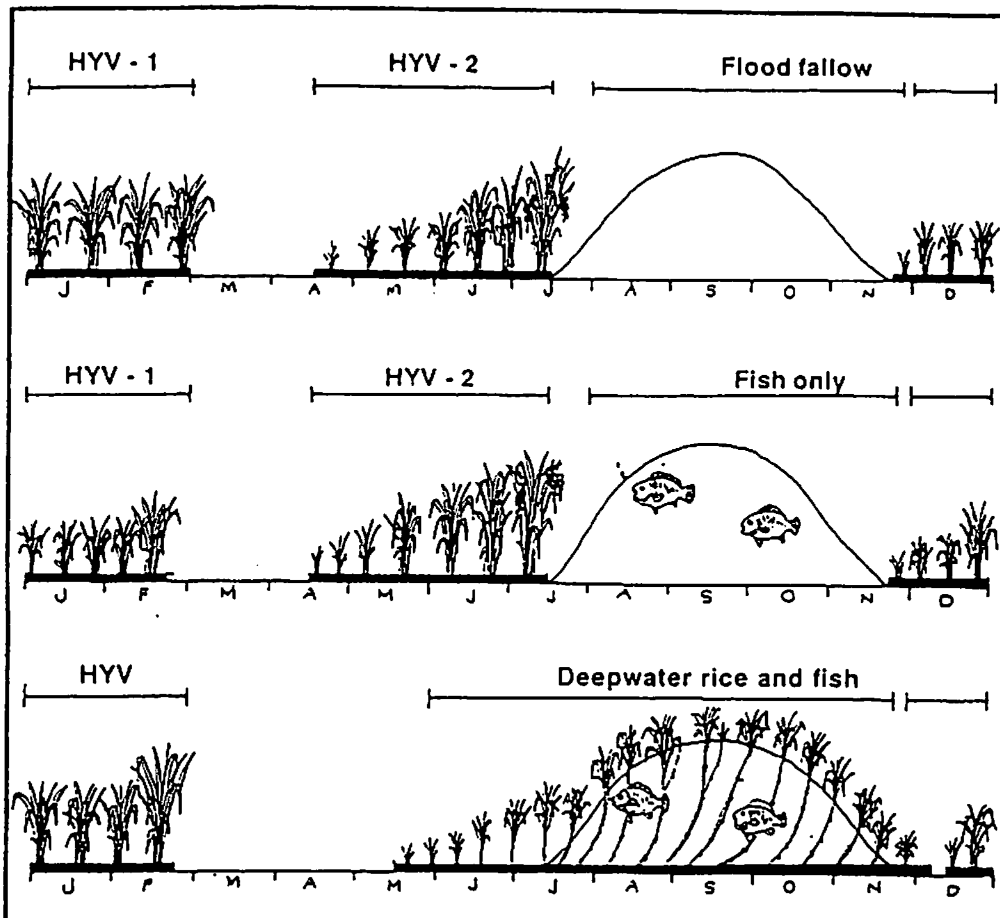
Availability of fingerlings of species (desired by farmers) in appropriate sizes and quantities for stocking can pose problems and should be planned for.

• 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.



General schematic annual calendar representation of comparison of culture system with two high-yielding rice culture periods without utilization of the flooded area for fish culture during the flood season (upper calendar) with two options for cultivation in flooded fields: 1. Flooded field stocked with fish only between two HYV culture periods (middle calendar); 2. Flooded field planted with deepwater/ floating rice stocked with fish with only one HYV cropping cycle as deepwater rice requires earlier sowing or transplanting and has a longer culture period (lower calendar). Intermittent crops could be grown in the period between the HYV and the deepwater rice cycles.

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.

Prepared by:
Mark Prein and
Madan Mohan Dey

Resource book produced through a participatory writeshop 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 Centers in Asia-Pacific (NACA), International Center for Living Aquatic Resources Management (ICLARM), Asian Institute of Technology (AIT), The Netherlands Embassy in the Philippines, German Agro Action (GAA) and Southeast Asian Fisheries Development Center (SEAFDEC)

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Utilizing Different Aquatic Resources for Livelihoods in Asia

A RESOURCE BOOK

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Fulltext book, abbrev. 2-p case studies; No. 15:
http://web.idrc.ca/ev_en.php?ID=33998_201&ID2=DO_TOPIC

Fulltext case study, p. 29-33:
http://www.prgaprogram.org/download/chatham99_case_studies.pdf

Reflections

The evaluation meetings confirmed that the expected benefits to both animals and herders had been realized. The women revealed that before the water trough came into use their husbands tended to be tired, irritable and argumentative when they returned home in the evenings. Since then they had been less irritable, and if there was a disagreement between husband and wife it could be resolved amicably.

The use of participatory problem tree analysis proved highly useful. It reveals how farmers or livestock-keepers perceive problems and relationships, which may be different from how outsiders see them. For example, livestock scientists tend to focus on how constraints affect the animals, whereas these livestock-keepers were also concerned about the impact of water scarcity on themselves.

There were some problems with the collection and analysis of monitoring data. First, the design of the monitoring system was researcher-dominated: the Rabaris themselves did not consider it necessary to collect such detailed quantitative data. Second, the BAIF field staff were not used to conducting research and did not analyse the data themselves. As a result, they were unaware of puzzling differences in milk production trends that could have been usefully discussed with the Rabaris. This highlights the need for field staff to be proficient in simple techniques for analysing and inspecting monitoring data.

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15 Participatory research at landscape level: Flood-prone ecosystems in Bangladesh and Vietnam

Madan M Dey and Mark Prein, International Center for Living Aquatic Resources Management (ICLARM – The World Fish Center), Penang, Malaysia, m.dey@cgiar.org

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Bangladesh Fisheries Research Institute (BFRI), Mymensingh, Bangladesh; Proshika Manobik Unnayan Kendra, Dhaka, Bangladesh; Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh; Research Institute for Aquaculture No 1 (RIA1), Bac Ninh, Vietnam; Research Institute for Aquaculture No 2 (RIA2), Ho Chi Minh City , Vietnam; Vietnam Agriculture Science Institute (VASI), Hanoi, Vietnam; International Rice Research Institute (IRRI), Los Banos, Philippines; International Fund for Agricultural Development (IFAD), Rome, Italy.

Background

Uncontrollable seasonal flooding affects over 10 million hectares, or 15 per cent, of the total rice land in south and south east Asia. During the dry season, land ownership is fixed according to tenure arrangements. In the rainy season, farmers grow deepwater rice and capture fish in the flood-prone areas. At this time, fish are considered a common resource, and community members are traditionally allowed access to private property for fishing.

Since 1997, ICLARM and the International Rice Research Institute (IRRI) have been undertaking an interdisciplinary and PAR project. The project is being implemented in collaboration with various governmental organizations and NGOs. The aim is to increase and sustain the productivity of rice and fish in the seasonally flooded ecosystem in Bangladesh and Vietnam as a demonstration for the entire region. The project strategy combines indigenous resource management techniques with semi-intensive fish culture and management technologies for the increased income of normal households.

Approach

The unit of analysis used is the resource management domain (RMD) at the landscape level. The RMD covers the environmental, social and economic characteristics of a recognizable unit of land and takes into account its inherent natural variability.

The steps followed in the participatory problem analysis are to:

- collect and analyse secondary data;
- conduct a diagnostic field survey;
- conduct baseline socioeconomic, biophysical and institutional surveys;
- analyse data;
- present data;
- hold group discussions involving users, researchers and NGO representatives;
- identify problems and potential solutions.

The users/stockholders include landowners and other community members, at all levels, reliant on the landscape for fishing during the rainy season. To identify its clients, the project held meetings with farmers from different wealth groups, landless labourers and members of local organizations. The steps followed in assessing users' needs were (a) scientists and representatives from local-level organizations conducted a diagnostic survey, (b) baseline surveys were made of socioeconomic, institutional and biophysical conditions, and (c) group discussions were held with users. A main objective of the baseline survey is to later enable analyses of the project impact over time.

The concept of managed fish culture in deepwater rice fields is new. Thus, researchers designed technical options consulting users on their needs and taking into consideration their indigenous knowledge. Small-scale experiments were first initiated in Vietnam to show the potential of the technical options. These initial trials were then used to generate discussions between researchers and users about various aspects of trials to fine-tune the technical options. Users tested site-specific technical options with minimum support from researchers during 1997–2000. The project provided financing support, as seed money, during the first two years to cover material costs. Users deposited part of the proceeds from the experiments (eg, fish sales) to cover future project expenditures.

Researchers monitored water and soil quality, profitability, input use, fish consumption, group performance and sharing arrangements. Based on this information, the project analysed the impact of the technological innovations and the project processes. The results indicate that community-based fish culture in flood-prone ecosystems in Bangladesh and Vietnam is technically feasible, economically profitable, environmentally non-destructive, and socially acceptable. For the overall system, an additional income of US$150 per hectare in southern Vietnam to US$690 per hectare per year in Bangladesh is achieved, which is an increase of 20 to 160 per cent over the previous profitability.

Reflections

Deficiencies of the process are that it is researcher-initiatied and -dominated and not very participatory in areas where users have only a limited knowledge of the subject. On the other hand, in subsequent years the technology has been copied by neighbouring communities but often with differing arrangements. The approach does not work well in areas where group action is not viewed positively.

The experiments are on an appropriate scale for representing the real world situation, and thus may be used for up scaling. The design and testing of the technological options included user participation. As regards sustainability, the community is less dependent on the project for funds and has an arrangement for group saving.

Problem analysis using the landscape-level resource management domain (RMD) as a unit has provided a better understanding of the integration of the biophysical and socioeconomic factors. A project implementation committee was established at each project site, including representatives from each user group. The committee oversees project implementation, prepares budgets, manages project accounts, negotiates sharing agreements (including participating members, responsibilities, access to the wild fish in the flood period, necessary guarding duties, etc), settles conflicts, supervises fish sales and distributes the proceeds from experiments. With support from researchers and NGO staff, different user groups have designed their own organizational arrangements for community-based fish culture in flood-prone rice ecosystems.

Reference

Prein, M and Dey, M (2001) 'Rice and Fish Culture in Seasonally Flooded Ecosystems', in IIRI, IDRC, FAO, NACA & ICLARM *Utilizing Different Aquatic Resources for Livelihoods in Asia: A Resource Book*, International Institute of Rural Reconstruction, Philippines, pp207–214

Managing Natural Resources for Sustainable Livelihoods

Uniting Science and Participation

Edited by
Barry Pound, Sieglinde Snapp,
Cynthia McDougall and Ann Braun

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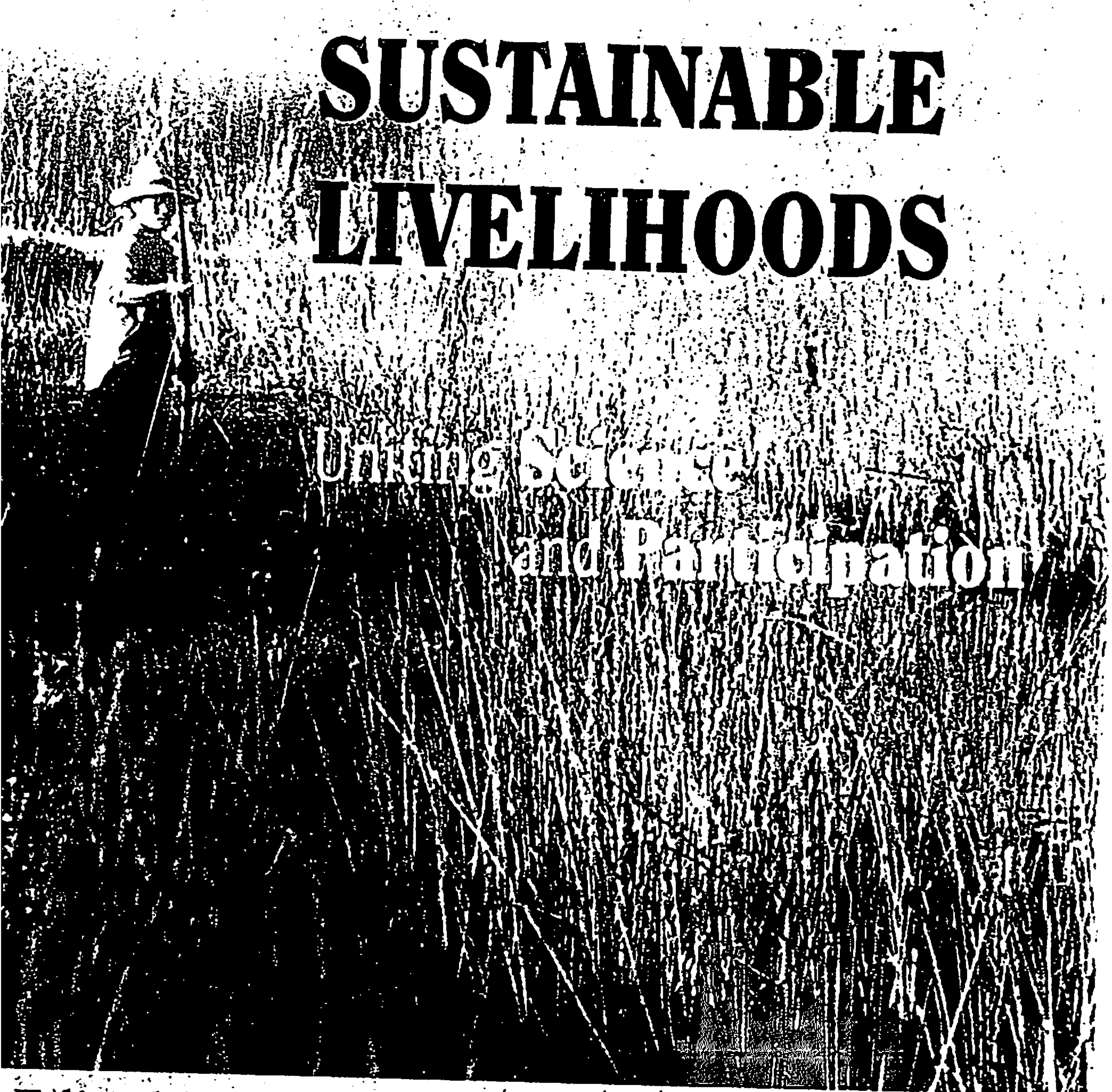
Managing NATURAL RESOURCES for SUSTAINABLE LIVELIHOODS



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Dey, M.M. and Prein, M. 2003. Community-based fish culture in seasonally deep-flooding ecosystems [Agriculture Technologies for Rural Poverty Alleviation]. IFAD Technical Knowledge Notes Number 1, Aquaculture Series, IFAD, Rome

Draft of 10 March 2004

Advisory Notes

α AGRICULTURAL TECHNOLOGIES FOR RURAL POVERTY ALLEVIATION

Aquaculture Series December 2001 NUMBER 1

Community-based fish culture in seasonally shallow-flooding ecosystems

Source of technology/funding:	WorldFish Center (formerly ICLARM-The World Fish Center) conducted research in collaboration with NARS (Bangladesh Fisheries Research Institute, Bangladesh Rice Research Institute, Proshika; Research Institute for Aquaculture No. 1 in Hanoi, Vietnam Institute of Agricultural Science – VASI, Hanoi) and IRRI, funded by IFAD through a Technical Assistance Grant (TAG-350).
Expected benefits:	Income from fish crop; increased income to landless poor; strengthening of local capacity towards community-based natural resource management; no loss in rice yield; no reduction in natural fish catch; no negative effects on fish biodiversity; no need for pesticide on rice; fertilization of soil through aquatic detritus; human nutritional benefits from increased consumption.
Crops and enterprises:	Rice-based farming systems susceptible to shallow and medium (50-150 cm) flooding in South and Southeast Asia.
Agro-ecological zones:	Lowland floodplains of South and Southeast Asia.
Targeted region & countries:	South and Southeast Asia - Bangladesh, eastern India, Vietnam, Cambodia, Thailand.

KEY WORDS: Rice-fish culture; deepwater rice ecosystem; floodplain agriculture; community-based management

In many tropical and subtropical regions there are extensive river floodplains and deltaic lowlands where rice is the traditional dry season crop, but seasonal flood inundation renders the land unavailable for crop production for several months each year. This raises the opportunity to enclose parts of these floodwater areas to produce a crop of wild and specifically-stocked aquatic organisms (e.g. fish, prawns, etc.), resulting in more high-quality, nutrient-dense food production and enhanced farm income. On-farm demonstrations in Vietnam and Bangladesh already confirm the feasibility of such approaches.

In South and Southeast Asia, over 10 million hectares or 15 percent of rice land suffer from uncontrollable seasonal flooding, of which about 56 percent are in the Indian subcontinent, mainly in Bangladesh and eastern India, and 44 percent are in Southeast Asia, chiefly in Myanmar, Thailand, Vietnam and Cambodia. These areas are home to more than 100 million farmers and their dependents, which are among the poorest in Asia.

More than half of Bangladesh's 10.2 million hectares of riceland and about 10 percent of Vietnam's 7.0 million hectares of arable land are flooded to depths of 30 to 180 centimeters during the rainy season.

These flood-prone areas are seasonally flooded during the monsoon and remain submerged for four to six months. The vast water bodies and the rice canopies provide natural habitats for various aquatic resources including wild fish and shrimp. The abundance of natural organisms (plant and animal matter) favors the cultivation of fish for four to five months in a deepwater rice environment. Increased food production in the flood-prone ecosystem from rice-fish culture could play a vital role in reducing malnutrition, increasing household income and promoting food security. It would also help mitigate the trend of declining capture fisheries production. In Bangladesh, about 2 million ha of shallow and medium flooded areas exist, of which 50% are estimated to be suitable for community-based fish culture, with a potential to yield 500,000 tons of fish per year (vs. only 43,000 tons of wild caught fish) at an approximate value of 375 million US$. Similar opportunities are seen for other floodplain and deltaic systems such as the Red river delta in Vietnam, among other countries. This TAN reports the results of studies conducted in Bangladesh and northern Vietnam, funded by IFAD through a Technical Assistance Grant (TAG-350) to WorldFish Center.

FARMING IN A SHALLOW-FLOODED ENVIRONMENT

Farming practices in the flood prone ecosystem are governed by a number of interacting physical factors, of which the chief ones are flooding regime (onset, depth, recession, variability), topography, rainfall pattern, soil texture and water management regime. Traditionally, farmers used to grow deepwater rice during the rainy/flood season and subsequently cultivate a wide range of crops (e.g. pulses, oil seeds, vegetables) during the post flood dry season.

During the last few decades, the flood-prone ecosystems in Bangladesh and Vietnam have undergone some dramatic changes because of the construction of Flood Control Drainage and Irrigation (FCDI) systems. Presently farmers are producing one or two rice crops depending on the flooding regime.

In Bangladesh, the dominant cropping pattern in shallow flooded areas is 'boro' rice in the dry season, followed by transplanted 'aman' rice during the rainy season. In Vietnam, farmers generally grow high yielding irrigated rice during the dry season, and a tall-growing local, or higher-yielding, variety during the rainy season.

The yield of rice during the rainy season is relatively low due to the unavailability of appropriate rice varieties and due to fluctuations in the flooding regime that has consequences on the ensuing rice culture period. The introduction of fish into rice fields during the rainy season has considerable potential for increasing the overall agricultural production.

At times of floods during the wet season, where land is not bounded, it is essential that rice-fish culture is undertaken by the rural community under a group approach.

The characteristics of the situation in Bangladesh are: existence of several user groups such as landless seasonal fishers, landless laborers, landowners, an openness to group formation, other involved stakeholders, opportunities for process facilitation by existing qualified NGOs.

The characteristics of the situation in Vietnam are: (a) in the north (Red River Delta): existence of flood control measures and ricefields protected by higher bunds, functioning of communal farms, the propensity to form groups and share in inputs, management efforts and outputs; and (b) in the south (Mekong River Delta): no effective flood control, ricefields in large open areas, individual land ownership, lower propensity by farmers to form groups under sharing arrangements.

TECHNICAL SUMMARY

Basic Principle. After the cultivation of dry season rice, when fields flood to a depth at which individual boundaries (i.e. bunds) of ricefield plots can no longer be distinguished, the floods establish a waterbody that lasts for 4 to 6 months. The area under this waterbody is usually left as flooded fallow, but can be used for growing a crop of deepwater rice and 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., it is possible to close off the open sides with a fence, and stock the enclosed waterbody with fish. In some locations such as in Bangladesh, areas with saucer-shaped topography lend themselves ideally to this approach, as additional enclosing structures such as fences are not required. In other areas, such as in northern Vietnam, existing flood-control systems physically modulate the effects of floods and provide ideal conditions for concurrent fish-in-rice culture.

Criteria for Choice of Managed Areas

Definition of Flood-prone Areas. The areas considered here flood annually during the rainy season and have shallow to medium (50-150 cm) flooding depths. These are usually cultivated with high yielding rice varieties in the post-flood (dry) season, with the availability of irrigated underground or surface water. Lands remain fallow during the flooding season. Depending on the onset and duration of the floods, a deepwater rice crop can be cultivated.

Selection of Areas

In order to be successful, sites selected as suitable should meet the following criteria: (a) they should be of adequate size, i.e. 3 to 20 ha (smaller groups and areas are considered less effective), (b) topography should be such that natural boundaries (e.g. saucer-shaped natural depressions, or existing artificial elevated lands for homesteads, dams, etc.) enclose the area on two to three sides to allow fencing off at low cost; (c) prevailing social conditions should be such that all stakeholders in a waterbody can be involved in a shared management arrangement, including landowners, leaseholders, landless fishers (who may have customary rights to fish in the flooded waterbody but would be restricted from access during the dry season).

Enclosure. The enclosure should be designed and built by the cooperating farmers. Usually a fence is made of locally available materials such as bamboo, reed, wood or crab-resistant netting (the latter can be cheaper as it is longer lasting). The mesh size should be small enough to prevent stocked fingerlings from escaping, but still be large enough to permit natural small indigenous species to enter with the floods.

Selection of Culture Systems. Generally three rice-fish culture systems can be established in floodprone areas: (1) alternating culture of dry season rice followed by the flooded season with stocked fish only (i.e. without rice) in the enclosed area (e.g. as in a fishpen); (2) concurrent culture of deepwater rice (with submergence tolerance) with stocked fish during the flood season followed by dry season rice in shallow flooded areas; (3) concurrent culture of deepwater rice (with elongation ability) with stocked fish during the dry flood season, followed by dry season non-rice crops. The second system is most suitable for shallow-flooded areas, which is described in detail here. These systems differ from the widespread system of culturing fish in irrigated rice paddies (i.e. not in floodprone areas).

Concurrent Deepwater Rice-Fish

Stocking Fingerlings. During the rainy season after transplanting of rice, fingerlings of bigger sizes, usually around 15 to 20 grams per piece, at 2000 to 4000 per hectare, depending on the size of fingerlings at stocking, are stocked into the ricefields. Fish are reared until the water dries up, which in most cases is after the harvest of rice. The bigger-sized fingerlings are costly, but this investment is usually made up for by the increased growth and survival (i.e. less escapes and losses to fish predators) and ensuing greater returns. On the other hand, the availability of such larger fingerlings in adequate sizes and quantities can pose a problem and should be planned for, e.g. through arrangements with one or more hatcheries, nurseries or fingerling suppliers, also to ensure good quality fingerlings. Likewise, the need for considerable numbers of large fingerlings poses demands for transport and handling capacity to avoid serious losses at stocking.

(2) Stocking Fry and Rearing them to Fingerlings. A cost-reducing strategy is to raise fry, which are much cheaper, to fingerlings within the rice field or in small nursery ponds in the preceding rice culture period in the dry season. This strategy was successfully applied in the project site in northern Vietnam.

Deepwater Rice Technologies

Rice Varieties. For the rice crop in the flood season, taller, usually traditional rice varieties have to be used which are characterised by a total plant height at harvest of more than 160 centimeters, a taller seedling height, and better tolerance of submergence. These are often referred to as deepwater rice varieties, although the varieties used in this project and referred to in this TAN are not of 'floating' type with high elongation ability. In some areas farmers may decide to grow high yielding varieties on outer, more shallow-flooded areas, and transplanted deepwater varieties in deeper flooded areas.

Fertilisation of Deepwater Rice. Fertilisers should be given, but only in form of a basal dose for deepwater rice.

Pesticides. No pesticides should be applied.

Fish Culture Technologies

Species Combinations. A polyculture system with fast growing species such as silver carp, common carp, silver barb, and Nile tilapia is recommended.

Naturally occurring fish species can enter into the enclosed areas with the flood and when these are of a size small enough to pass through the fence (e.g. fry and small fingerlings). Thereby, these indigenous species can grow, reproduce and can be fished by small scale fishers.

Further improvements in fish production with the target of doubling or even tripling fish production in these stocked areas are to be investigated in subsequent research activities.

Feeding of Fish. Essentially no feeding is required as fish can feed on natural food and byproducts available in the ricefield. However in case of slow growth, supplemental feed in the form of rice bran, azolla, duckweed, and other macrophytes may be given at a later stage.

Guarding. In many situations, guarding the areas is essential, as the stocked fish are valuable and are attractive to others who fish in adjacent flooded but non-stocked areas. The largest share of the total guarding time is usually done by the landless. This is also their largest contribution to the sharing arrangements. Children of the landless are also involved in the guarding activity.

Fence mending and raising. On occasion, fences can be damaged and need to be mended immediately to avoid escape of fish. Also, exceptionally high floods can require the urgent raising of the height of fences to a height above the maximum water level of the floods. The group members guarding the sites should be vigilant and on the outlook for such events and have adequate materials and manpower available for such emergency interventions.

Fishing for Wild Fish During the Culture Period. Fishing with traditional gears for small indigenous and other non-stocked species may be permitted to group members under the condition that stocked fish captured by the gear are immediately released unharmed. This will enable particularly the landless poor to continue to benefit from their traditional sources of food and income, which can be the most important income-generating activity for the landless over the entire year. If this access is not granted, these people will either not have any fish as food and income during the culture period or be forced to fish in other adjacent areas already occupied by members of other communities, which can lead to conflicts.

Harvesting and Marketing. Strategies of thinning fish crops and holding before marketing may be applied; staggered/partial harvests can provide greater economic and biological benefit as well as early and delayed harvests. Due to the large bulk of harvested fish, adequate labor and transport to markets has to be pre-arranged.

Additional Technical Options

With a short-duration dry season rice crop, an additional crop of pulses, mustard, soya bean, maize, green leafy vegetables, etc. can be grown in between two rice crops. However, this was not tested in the trials described here.

Institutional Arrangements

Arrangements between stakeholders are necessary as during the flooded season, when individual plots are not discernable, the water body becomes temporarily common property, in contrast to the dry season, when individual land holdings are clearly discernable and respected; this community approach is needed to exploit the resource effectively and equitably.

Group Approach. A group approach is used with around 20 households per group, comprising landowners, fishers of the community and landless laborers (with customary access rights for fishing in the flood season). Benefit arrangements are required to organize and consolidate the group. Landowners comprise participating (active) and non-participating (passive) persons. Of those landowners participating actively in the group activities, these also receive an additional share of benefits for their role as group members (on top of the share they already receive through mere provision of their land).

Knowledge. For communities used to fishing and handling fish, no sophisticated knowledge or formal training is required. Critical issues are the handling of fingerlings at stocking for highest possible survival, and the choice of optimal and not too high numbers of fingerlings to be stocked (to avoid overstocking).

Investments. The group will have to invest in fingerlings, materials and labor (for fence or dike construction and maintenance, feeding, harvesting) to successfully master the activity. Usually, the greatest investments in funds are for the labor and materials for the fence or dikes, followed by the purchase of fingerlings. As these investments have to be made at the beginning of the activity, the groups have to be able to generate the funds or obtain a loan.

Cooperation and Sharing in Activities. Farmer groups will have to negotiate and agree on cooperative sharing arrangements, rules, technical details and schedules for the operation. This may be influenced by other existing agreements and ongoing conflicts.

Sharing Arrangements. The group sets the rules of access, duties and rights of different parties involved (participating and non-participating landowners, fishers or landless laborers) and sharing of benefits among themselves.

In the trials conducted, the groups covered all costs from the proceeds from rice and/or fish sales; beyond which returns were shared at around 40% for landowners, and around 60% for group members. Investment costs for the following season are usually set aside by the group to avoid having to take a loan. In the absence of any financial help from outside sources, the general sharing agreement could be as follows: landowners 30%, labor group members 30%, working capital 30%, and savings/ institution building 10%.

Landowners are usually keen on joining the activity as they receive returns from land that would be otherwise fallow in the flooded season.

The landless poor members of the group usually perform most of the guarding and benefit from their share of added production from stocked fish. Compared to the landowners, this is of higher benefit to landless poor, based on their relative overall income. Therefore, this technology specifically benefits the landless poor.

Sustainability. In terms of technical factors, fence material may decompose after one or two seasons and needs to be replaced at occasionally high cost. Socioeconomic factors include setting aside part of the returns for reinvestment in the following year for the fence (mending, renewal, etc.) and for restocking (fish, rice). Social factors include the group mechanisms for enforcement of rules and establishment of elements of the agreement.

Role of External Support

Group Formation. Project support activities will include the identification and inclusion of NGOs or other local service institutions to provide local experience and facilitation of the necessary processes.

Strengthening of Groups. Through surveying of sites for selection together with the group, the capacity of groups to comprehend the underlying concepts will be strengthened. Discussions should be held with individuals and then groups of landowners, landless, etc. to broach the idea. This is followed by the facilitation of meetings to present the idea to the larger group, facilitate discussions towards consensus and the establishment of a 'management committee', facilitate negotiations and the formulation of an agreement over sharing arrangements. This includes the role of acting as credible provider of technology and acting as a witness and arbitrator. Additionally, it is necessary to assist in group discussions on selection of fish species and rice varieties, stocking densities, sourcing of fingerlings, and providing guidance on proper transport and stocking method to ensure high survival. Repeated visits are necessary to ensure smooth interactions among the group members and to facilitate meetings to solve/settle problems and any arising conflicts. Training is required for farmers/actors who will do the work (fence construction, stocking, feeding). Further, it is necessary to provide assistance to the group on financial accounting, harvest methods and equipment (nets), marketing of harvest, and the actual task of sharing of the yield both in terms of fish and cash.

Start-up Loans. The initial investment in the fence can be considerable and groups will be hesitant to the risk of investing their own funds on an activity which has not been demonstrated successfully to them. Likewise, farmer groups may be wary of the investment in fingerlings for stocked fish. Startup loans, to be repaid upon harvest, have been shown to enable the adoption process and provide the necessary assurance to the groups to embark on the activity.

BENEFITS

Fish Yield. 400 to 700 kg per hectare.

Rice Yield. The basic rice yield is about 6 to 10 t per hectare per year for two crops. With the introduction of fish the rice yield does not decrease. In fact, it has marginally increased by about 500 to 1000 kg per hectare per year.

Increase in Profitablity. US$225 to 340 per hectare per year, which is an increase of 35 to 60% over the previous profitability.

Impact on Landless Laborers. Household income was substantially increased. For example, in the trial sites in Bangladesh, annual per capita income increased by about 16%. Fish consumption increased marginally. For example, in Bangladesh, annual per-capita fish consumption increased by about 2%. This technology contributes to improved livelihoods through improved social status and linkages, established social capital, and reduced dependence on money lenders.

FACTORS INFLUENCING ADOPTION

Socioeconomics and Institutional Issues. Presence of, or possibility of forming, rural organisations and/or farmers groups, is essential. Homogeneity of households is a positive factor for adoption of this technology. Heterogeneity of households within the group will create problems for the operation.

Biophysical Factors. Fluctuations in the onset and duration of the rainy season, and average flooding depth affect the length of the rice-fish culture period. With longer duration rice and rising floods while rice has not yet been harvested, farmers cannot grow deepwater rice after dry season rice. In this case, farmers usually decide to adopt the alternating rice (dry season) and fish (flood season) system. Water turbidity should not be high, i.e. Secchi depth should not be less than 10 cm.

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.

EXTRAPOLATION DOMAIN / POTENTIAL APPLICATION AREAS

Shallow- and medium-flooded areas of Bangladesh, Mekong Delta of Vietnam, and eastern India can be brought under this technology. It seems possible that this technology can also be applied to similar environments in Africa and Latin America subject to further on-farm testing in those environments. These results refer only to non-flood-controlled areas.

For *ex ante* estimates of possible extrapolation domains for this technology, the attributes and agroecological characteristics to be considered are: flood arrival, flood recession, flood duration, flood depth, predictability of flood regime, pattern of gradual increase and decrease (i.e. not pulsed, short flash flood), cropping pattern, land tenure, and the attitude of potential users towards community-based farming in common property areas.

VALIDATION STATUS

Three years of field trials with two communities in the Red River Delta, and four communities in Bangladesh. In Bangladesh, the local population is convinced of the benefit of this technology: communities neighboring the trial and demonstration sites have copied the technology to suit their situation. These established group arrangements seem more harmonious and longer lasting than those orchestrated by external organizations (follow-on monitoring is planned).

In Bangladesh, the presently ongoing Agricultural Development and Improvement Project (ADIP; funded by an IFAD loan) of the Department of Agricultural Extension (DAE) has adopted this technology for extension to farmers in its two project areas in Narshindi and Tangail districts. Proshika, the participating country-wide operating NGO in this project, has established the technology as part of its rural development program and is planning to disseminate this technology in 30 sub-districts in Bangladesh.

This technology has been adopted in Vietnam by the local government and the Department of Science and Technology, which are providing considerable investment, and the approach is being disseminated among farmers.

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FOCAL POINT

Nigel Brett, Country Portfolio Manager, Asia and Pacific Division, International Fund for Agricultural Development (IFAD), 107 Via del Serafico, 00142 Rome, Italy • Tel. 39-06-54591 • Fax 39-06-5043463 • Email: IFAD@IFAD.ORG or n.brett@ifad.orgThe **Director, Technical Advisory Division**

OTHER INSTITUTIONAL REFERENCES

BFRI (Bangladesh Fisheries Research Institute), Headquarters at Freshwater Station, Mymensingh 2201, Bangladesh, Tel +880-91-54874, -54221, Fax +880-91-55259, -55221, Email frihq@bdmail.net

ICLARM - The World Fish Center, GPO Box 500, 10670 Penang, Malaysia. Tel +60-4-6261606, Fax +60-4-6265530. Email: iclarm@cgiar.org. URL: www.iclarm.org

IRRI (International Rice Research Institute), MCPO Box 3127, 1271 Makati City, Philippines. Tel +63-2-7620127, Fax +63-2-7612404, Email: irri@cgiar.org, URL www.irri.org

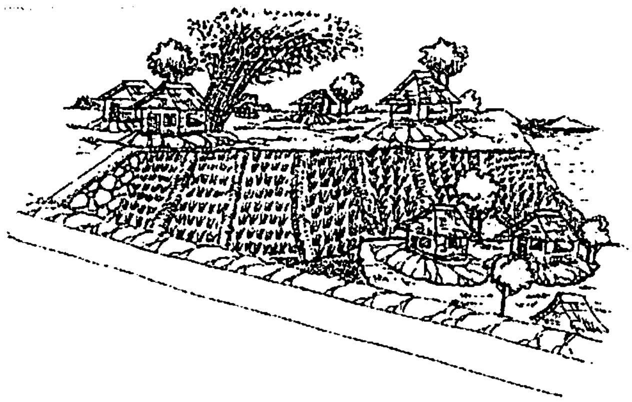
Proshika Manobik Unnayan Kendra, Fisheries Development Programme, I/1-GA, Section-2, Mirpur-2, Dhaka 1216, Bangladesh; Mail: GPO Box 3149, Ramna, Dhaka 1000, Tel +880-2-8013398, -9005795, Fax +880-2-8015811, Email fdp@proshika.bdonline.com , URL www.bdonline.com/proshika

RIA-1 (Research Institute for Aquaculture No. 1), Dinh Bang, Tien Son, Bac Ninh, Ha Bac, Hanoi, Vietnam. TEL +84-4-8780408, FAX +84-4-8273070, Email: ria1@hn.vnn.vn

Prepared by Dr. Madan M. Dey and Dr. Mark Prein, WorldFish Center (formerly 'ICLARM'), GPO Box 500, 10670 Penang, Malaysia. TEL +60-4-6261606, FAX +60-4-6265530, www.worldfishcenter.org , Email: m.dey@cgiar.org, m.prein@cgiar.org

Photo credits: Dr M. Prein

Figure captions:
(1) Drawing of lowland area under dry season rice cultivation, surrounded by raised lands on three sides (homesteads and road embankment) which is an ideal site for establishing fenced-in deepwater rice-fish culture in the flood season.
(2) Same area as (1) showing the situation in the flood season with a fence across the narrow side towards the open water, and fish stocked in the deepwater rice area.
(3) Sampling of fish in a communally managed concurrent deepwater rice-fish field plot in the Red River delta, northern Vietnam.
(4) Saucer-shaped concurrent deepwater rice-fish site in Narail district, Bangladesh.
(5) Harvested catla carp which was stocked at the beginning of the flood season into deepwater rice fields Narail, Bangladesh.
(6) Small indigenous species (i.e. 'wild' fish) from a concurrent deepwater rice-fish field, which are important for food and income to the rural poor in Bangladesh.



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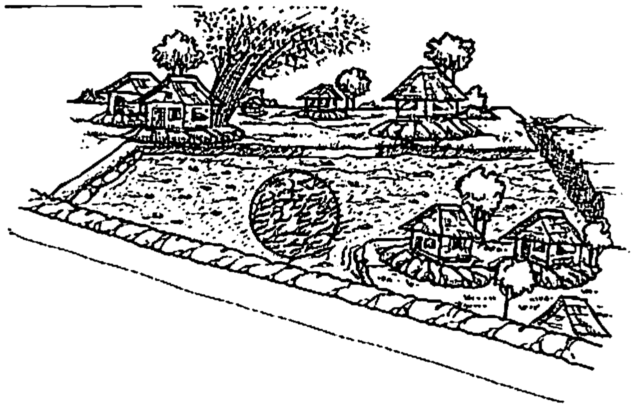

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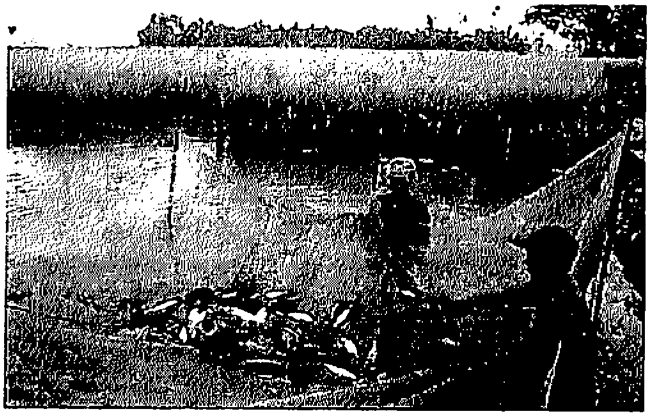

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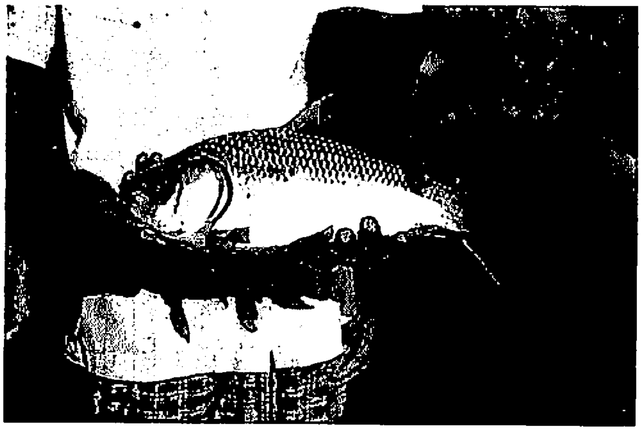
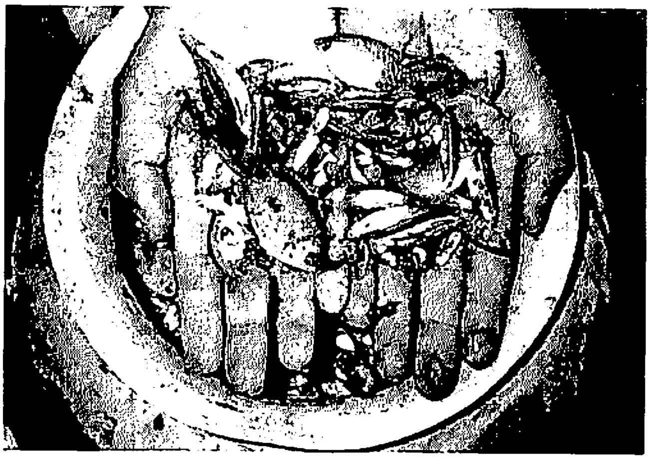


(5) Harvested catla carp which was stocked at the beginning of the flood season into deepwater rice fields in Narail, Bangladesh.



(6) Small indigenous species (i.e. 'wild' fish) from a concurrent deepwater rice-fish field, which are important for food and income to the rural poor in Bangladesh.

α *IFAD Advisory Notes are targeted at project designers, project implementers and subject-matter specialists/extension agents working with the rural poor. However, readers should consider the relevance of the information, and any recommendations made, within the context of their own socio-economic conditions, before adopting them.*

Dey, M.M. and Prein, M. 2003. Community-based concurrent rice-fish culture in seasonal moderately deep-flooding ecosystems [Agriculture Technologies for Rural Poverty Alleviation]. IFAD Technical Knowledge Notes Number 2, Aquaculture Series, IFAD, Rome.

AGRICULTURAL TECHNOLOGIES FOR RURAL POVERTY ALLEVIATION

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Community-based fish culture in seasonally deep-flooding ecosystems

Source of technology/funding:	ICLARM - The World Fish Center conducted research in collaboration with NARS (Bangladesh Fisheries Research Institute, Bangladesh Rice Research Institute, Proshika, Research Institute for Aquaculture No. 2 in Ho Chi Minh City) and IRRI, funded by IFAD through a Technical Assistance Grant (TAG-350).
Expected benefits:	Income from fish crop; increased income to landless poor; strengthening of local capacity towards community-based natural resource management; no loss in rice yield; no reduction in natural fish catch; no negative effects on fish biodiversity; no need for pesticide on rice; fertilizing of soil through aquatic detritus; nutritional benefits from increased consumption.
Crops and enterprises:	Rice-based farming systems susceptible to deep (150-250 cm) flooding in South and Southeast Asia.
Agro-ecological zones:	Lowland floodplains of South and Southeast Asia.
Targeted region & countries:	South and Southeast Asia - Bangladesh, eastern India, Vietnam, Cambodia, Thailand, Myanmar.

⊶ KEY WORDS: Rice-fish culture; deepwater rice ecosystem; floodplain agriculture; community-based management; pen aquaculture; fish farming

In many tropical and subtropical regions there are extensive river floodplains and deltaic lowlands where rice is the traditional dry season crop, but seasonal flood inundation renders the land unavailable for crop production for several months each year. This raises the opportunity to enclose parts of these floodwater areas to produce a crop of wild and specifically-stocked aquatic organisms, resulting in more high-quality, nutrient-dense food production and enhanced farm income. On-farm demonstrations in Vietnam and Bangladesh already confirm the feasibility of such approaches.

In South and Southeast Asia, over 10 million hectares or 15 percent of rice land suffer from uncontrollable seasonal flooding, of which about 56 percent are in the Indian subcontinent, mainly in Bangladesh and eastern India, and 44 percent are in Southeast Asia, chiefly in Myanmar, Thailand, Vietnam and Cambodia. These areas are home to more than 100 million farmers and their dependents, who are among the poorest in Asia.

These flood-prone areas are seasonally flooded during the monsoon and remain submerged for four to six months. The vast water bodies and the rice canopies provide natural habitats for various aquatic resources including wild fish and shrimp. The abundance of natural organisms favors the cultivation of fish for four to five months in a deepwater rice environment. Increased food production in the flood-prone ecosystem from rice-fish culture could play a vital role in reducing malnutrition, increasing household income and promoting food security. It would also help mitigate the trend of declining capture fisheries production. In Bangladesh, 1 million hectares of deep flooded areas (150 to 250 cm flood depth) exist, of which 40% are estimated to be suitable for community based fish culture, with a potential to yield 400,000 t of fish (vs. 76,000 t of wild fish caught) at an approximate value of 300 million US$. Similar opportunities are seen for floodplain and deltaic systems in Vietnam, among other countries. This TAN reports the results of studies conducted in Bangladesh and northern Vietnam, funded by IFAD through a Technical Assistance Grant (TAG-350) to ICLARM - The World Fish Center.

FARMING IN A DEEP-FLOODED ENVIRONMENT

Farming practices in the flood prone ecosystem are governed by a number of interacting physical factors, of which the chief ones are flooding regime (onset, depth, recession, variability), topography, rainfall pattern, soil texture and water management regime. Traditionally, farmers used to grow deepwater rice during the rainy/flood season and subsequently cultivate a wide range of crops (e.g. pulses, oil seeds, vegetables) during the post flood dry season.

During the last few decades, the flood-prone ecosystems in Bangladesh have undergone some dramatic changes because of the construction of the Flood Control Drainage and Irrigation (FCDI) systems. The sequential culture of rice and fish (rice in the dry season, and fish alone in the rainy season) has considerable potential for increasing the overall agricultural production.

In Bangladesh, the dominant cropping pattern in deep flooded areas is single-crop irrigated 'boro' rice in the dry season. Late harvest of boro rice does not allow timely establishment of a deepwater rice crop in the flood season. In southern Vietnam, where rice fields also are deeply flooded in the rainy season, two irrigated crops of high-yielding rice varieties are grown with a flood fallow period in between.

The characteristics of the situation in Bangladesh are: existence of several user groups such as landless seasonal fishers, landless laborers, landowners, an openness to group formation, other involved stakeholders, opportunities for process facilitation by existing qualified NGOs.

The characteristics of the situation in southern Vietnam (Mekong River Delta) are: no flood control, ricefields in large open areas, individual land ownership, lower propensity by farmers to form groups under sharing arrangements.

TECHNICAL SUMMARY

Basic Principle. After the cultivation of dry season rice, when fields flood to a depth at which individual boundaries (i.e. bunds) of ricefield plots can no longer be distinguished, the floods establish a waterbody that lasts for 4 to 6 months. The area under this waterbody is usually left as flooded fallow, but can be used for growing a crop of 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., it is possible to close off the open sides with a fence, and stock the enclosed waterbody with fish.

Criteria for Choice of Managed Areas

Definition of Flood-prone Areas. The areas considered here flood annually and have deep (180-300 cm) flooding depths. These are usually cultivated with high yielding rice varieties in the post-flood (dry) season with the availability of pumped well water or irrigated water.

Selection of Areas

Sites should be selected to meet the following criteria: (a) they should be of adequate size, i.e. 5 to 20 ha (smaller groups and areas are considered less effective), (b) natural topography (such as saucer-shaped natural depressions, or existing artificially elevated lands through homesteads, dams, etc.) enclose the area on three sides to allow fencing off at low cost; (c) the prevailing social conditions should be such that all stakeholders of a waterbody can be involved in a shared management arrangement, including landowners, leaseholders, landless fishers (who may have customary rights to fish in the flooded waterbody but be restricted from access during the dry season).

Enclosure. The enclosure should be designed and built by the cooperating farmers. Usually a fence is made of locally available materials such as bamboo, reed, wood or crab-resistant netting (the latter can be cheaper as it is longer lasting). The mesh size should be small enough to prevent stocked fingerlings from escaping, but still be large enough to permit natural small indigenous species to enter with the floods.

Selection of Culture Systems. Generally, three rice-fish culture systems can be established in floodprone areas: (1) alternating culture of dry season rice followed by stocked fish only during the flood season (i.e. without rice) in the enclosed area (e.g. as in a fishpen); (2) concurrent culture of deepwater rice (with submergence tolerance) with stocked fish during the flood season followed by dry season rice in shallow flooded areas; (3) concurrent culture of deepwater rice (with elongation ability) with stocked fish during the dry flood season, followed by dry season non-rice crops. The first system is most suitable for deep-flooded areas with the availability of irrigation during the dry season and is described in detail here. These systems differ from the widespread system of culturing fish in irrigated rice paddies (i.e. not in floodprone areas).

Sequential Dry Season Rice and Flood Season Fish

If farmers decide to maintain two crops of high yielding rice varieties and do not want to substitute the second crop with deepwater rice, specifically stocked fish species can be grown within an enclosure subsequently during the flooded period.

Alternating Dry Season Rice with Flood Season Fish

Stocking Fingerlings. During the rainy season, after the fence has been established, relatively large fingerlings, usually around 15 to 20 grams per piece are stocked, at 2000 to 4000 per hectare, depending on the size of fingerlings at stocking, and reared for several months until the water dries up. The bigger-sized fingerlings are more costly, but this investment is usually made up for by the increased growth and survival (i.e. less escapes and losses to fish predators) and ensuing greater returns. On the other hand, the availability of such larger fingerlings in quantity and sufficient can pose a problem and should be planned for, e.g. through arrangements with one or more hatcheries, nurseries or fingerling suppliers. Likewise, the need for considerable numbers of large fingerlings poses demands on transport and handling capacity to avoid serious losses at stocking.

Stocking Fry and their Rearing to Fingerlings. A cost-reducing strategy is to raise fry, which are much cheaper, to fingerlings within the rice field in the preceding rice culture period in the dry season. However, this was not tested within this project.

Fish Culture Technologies

Species Combinations. A polyculture system with 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.

Naturally occurring fish species can enter into the enclosed areas at the time of flood rise and when these are of a size small enough to pass through the fence (e.g. fry and small fingerlings). Thereby these indigenous species can grow, reproduce and are fished by small scale fishers.

Further improvements in fish production with the target of doubling or even tripling fish production in these stocked areas are to be investigated in subsequent research activities.

Feeding of Fish. Essentially no feeding is required as fish can feed on natural food and byproducts available in the ricefield. However in the case of slow growth, supplemental feed in the form of rice bran, azolla, duckweed and other macrophytes may be given at a later stage.

Guarding. In many situations, guarding the areas is essential, as the stocked fish are valuable and are attractive to others who fish in adjacent flooded but non-stocked areas. The largest share of the total guarding time is usually done by the landless. This is also their largest contribution to the sharing arrangements. Children of the landless are also involved in the guarding activity.

Fence mending and raising. On occasion, fences can be damaged and need to be mended immediately to avoid escape of fish. Also, exceptionally high floods can require the urgent raising of the height of fences to a height above the maximum water level of the floods. The group members guarding the sites should be vigilant and on the outlook for such events and have adequate materials and manpower available for such emergency interventions.

Fishing for Wild Fish during the Culture Period. Fishing with traditional gears for small indigenous and other non-stocked species may be permitted to group members under the condition that stocked fish captured by the gear are immediately released unharmed. This will enable particularly the landless poor to continue to benefit from their traditional sources of food and income, which can be the most important income-generating activity for the landless over the entire year. If this access is not granted, these people will either not have any fish as food and income during the culture period or be forced to fish in other, adjacent areas already occupied by members of other communities, which can lead to conflicts.

Harvesting and Marketing. Strategies of thinning fish crops through partial, staggered harvests in the final weeks, and holding before marketing may be applied; staggered/partial harvests can provide greater economic and biological benefit as well as early and delayed harvests. Due to the large bulk of harvested fish, adequate labor and transport to markets has to be pre-arranged.

Additional Technical Options

With a short-duration dry season rice crop, an additional crop of pulses, mustard, soya bean, maize, green leafy vegetables, etc. can be grown in between two rice crops. However, this was not tested in the trials described here.

Institutional Arrangements

Arrangements between stakeholders are necessary within the context that during the flooded season when individual plots are not discernable, the water body becomes a temporary a common property, in contrast to the dry season in when individual land holdings are clearly discernable and respected; this approach is needed to exploit the resource.

Group Approach. A group approach is used with around 20 households per group, comprising landowners, fishers of the community and landless laborers (with customary access rights for fishing in the flood season). Benefit arrangements are required to organize and consolidate the group. Landowners comprise participating (active) and non-participating (passive) persons. Landowners participating actively in the group activities receive an additional share of benefits for their role as group members (on top of the share they already receive through mere provision of their land).

Knowledge. No sophisticated knowledge or formal training is required for communities already skilled in fishing and handling fish. Critical issues are the handling of fingerlings at stocking for highest possible survival, and the choice of optimal and not too high numbers of fingerlings to be stocked (to avoid overstocking).

Investments. The group will have to invest in fingerlings, materials and labor (for fence or dike construction and maintenance, feeding, harvesting) to successfully master the activity. Usually, the greatest investments in funds are for the labor and materials for the fence or dikes, followed by the purchase of fingerlings. As these investments have to be made at the beginning of the activity, the groups have to be able to generate the funds or obtain a loan.

Cooperation and Sharing in Activities. Farmers' groups will have to negotiate and agree on cooperative sharing arrangements, rules, technical details and schedules for the operation. This may be influenced by other existing agreements and ongoing conflicts.

Sharing Arrangements. The group sets the rules of access, duties and rights of different parties involved (participating and non-participating landowners, fishers or landless laborers) and sharing of benefits among themselves.

In the trials conducted, the groups covered all costs from the proceeds from rice and/or fish sales; additional returns were shared at around 40% for landowners, and around 60% for group members. Investment costs for the following season are usually set aside by the group to avoid having to take a loan. In the absence of any financial help from outside sources, the general sharing agreement could be as follows: landowners 30%, labor group members 30%, working capital 30%, and savings/ institution building 10%.

Landowners are usually keen on joining the activity as they receive returns from land that would be otherwise fallow in the flooded season.

The landless poor members of the group usually perform most of the guarding and benefit from their share of added production from stocked fish. Compared to the landowners, this is of higher benefit to landless poor, based on their relative overall income. Therefore, this technology specifically benefits the landless poor.

Sustainability. In terms of technical factors, fence material may decompose after one or two seasons and needs to be replaced at occasionally higher cost. Socioeconomic factors include setting aside part of the returns for reinvestment in the following year for the fence (mending, renewal, etc.) and for restocking of fish. Social factors include the means by which the group enforces rules and establishes elements of the agreement.

Role of External Support

Group Formation. Project support activities should include the identification and inclusion of NGOs or other local service institutions to provide local experience and facilitation of the necessary processes.

Strengthening of Groups. If the surveying of sites for selection is conducted with the group, the capacity of groups to comprehend the underlying concepts will be strengthened. Discussions should be held with individuals and then groups of landowners, landless, etc. to broach the idea. This is followed by the facilitation of meetings to present the idea to the larger group; facilitation of discussions towards consensus and the establishment of a 'management committee'; facilitation of negotiations and the formulation of an agreement over sharing arrangements. This includes the role of acting as credible provider of technology and acting as a witness and arbitrator. Additionally, it is necessary to assist in group discussions on selection of fish species and rice varieties, stocking densities, sourcing of fingerlings, and providing guidance on proper transport and stocking method to ensure high survival. Repeated visits are necessary to ensure smooth interactions among the group members and to facilitate meetings to solve/settle problems and any arising conflicts. Training of farmers/actors who will do the work (fence construction, stocking, feeding) is required. Further, it is necessary to provide assistance to the group on financial accounting, harvest methods and equipment (nets), marketing of harvest, and the actual task of sharing of the yield both in terms of fish and cash.

Start-up Loans. The initial investment in the fence can be considerable and groups will be hesitant to risk investing their own funds on an activity which has not been demonstrated successfully to them. Likewise, farmer groups may be wary of the investment in fingerlings for stocked fish. Startup loans, to be repaid upon harvest, have shown to enable the adoption process and provide the necessary assurance to the groups to embark on the activity.

BENEFITS

Fish Yield. 350-500 kg per hectare in southern Vietnam, to 700-1500 kg per hectare in Bangladesh.

Rice Yield. The basic rice yield is about 11 t per hectare per year for two crops in southern Vietnam, and about 6 t per hectare per year for one rice crop in Bangladesh. With the introduction of fish the rice yield does not decrease.

Increase in Profitablity. For the overall system, an additional income of US$ 150 per hectare in southern Vietnam to US$ 690 per hectare per year in Bangladesh was achieved, which is an increase of 20 to 160 % over the previous profitability.

Impact on Landless Laborers. Income and per-capita fish consumption has been increased substantially. In Bangladesh, annual per capita income of landless laborers among the group members increased by about 60 %. Annual per capita fish consumption among this group increased by 25 to 60 %. Furthermore, this technology contributes to improved livelihoods through improved social status and linkages, established social capital, and reduced dependence on money lenders.

FACTORS INFLUENCING ADOPTION

Socioeconomics and Institutional Issues. Presence of, or possibility of forming, rural organisations and/or farmers groups, is essential. Homogeneity of households is a positive factor for adoption of this technology. Heterogeneity of households within the group will create problems for the operation.

Biophysical Factors. Fluctuations in the onset and duration of the rainy season, and average flooding depth affect the length of the fish culture period. Water turbidity should not be high, i.e. Secchi depth should not be less than 10 cm.

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.

EXTRAPOLATION DOMAIN

Medium- and deep-flooded areas of Bangladesh, Mekong Delta of Vietnam, and eastern India can be brought under this technology. In Bangladesh, the estimated suitable area for this technology is 440,000 ha with the potential to produce an estimated 400,000 t of fish per year (vs. 76,000 t of wild fish caught annually) at an approximate value of 300 million US$. It seems possible that this technology can also be applied to similar environments in Africa and Latin America subject to further on-farm testing in those environments.

VALIDATION STATUS

Three years of field trials with one community in the Mekong Delta, and four communities in Bangladesh. In Bangladesh, the local population is convinced of the benefit of this technology: communities neighboring the trial and demonstration sites have copied the technology to suit their situation. These established group arrangements seem more harmonious and longer lasting than those orchestrated by external organizations (follow-on monitoring is planned).

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FOCAL POINT

Nigel Brett, Country Portfolio Manager, Asia and Pacific Division, International Fund for Agricultural Development (IFAD), 107 Via del Serafico, 00142 Rome, Italy • Tel. 39-06-54591 • Fax 39-06-5043463 • Email: IFAD@IFAD.ORG or n.brett@ifad.org

OTHER INSTITUTIONAL REFERENCES

BFRI (Bangladesh Fisheries Research Institute), Headquarters at Freshwater Station, Mymensingh 2201, Bangladesh, Tel +880-91-54874, -54221, Fax +880-91-55259, -55221, Email frihq@bdmail.net

ICLARM - The World Fish Center, GPO Box 500, 10670 Penang, Malaysia. Tel +60-4-6261606, Fax +60-4-6265530. Email: iclarm@cgiar.org URL: www.iclarm.org or www.worldfishcenter.org

IRRI (International Rice Research Institute), MCPO Box 3127, 1271 Makati City, Philippines. Tel +63-2-7620127, Fax +63-2-7612404, Email: irri@cgiar.org, URL www.irri.org

Proshika Manobik Unnayan Kendra, I/1-GA, Section-2, Mirpur-2, Dhaka 1216, Bangladesh; Mail: GPO Box 3149, Ramna, Dhaka 1000, Tel +880-2-8013398, -9005795, Fax +880-2-8015811, Email fdp@proshika.bdonline.com (Fisheries Development Programme), URL www.bdonline.com/proshika

RIA-2 (Research Institute for Aquaculture No. 2), Ministry of Fisheries, 116 Nguyen Dinh Chieu St., District 1, Ho-Chi-Minh City, Vietnam. TEL +84-8-8229617, 8226496, FAX +84-8-8226807, Email: ria2@netnam2.org.vn or xuan@ria2.ac.vn

Prepared by Dr. Madan M. Dey and Dr. Mark Prein, WorldFish Center (formerly 'ICLARM'), GPO Box 500, 10670 Penang, Malaysia. TEL +60-4-6261606, FAX +60-4-6265530, www.worldfishcenter.org , Email: m.dey@cgiar.org, m.prein@cgiar.org

Photo credits: M. Prein

Figure captions:

(1) Drawing of lowland area under dry season rice cultivation, surrounded by raised lands on three sides (homesteads and road embankment) which is an ideal site for establishing fenced-in fish culture in the flood season.

(2) Same area as (1) showing the situation in the flood season with a fence across the narrow side towards the open water, and fish stocked in the enclosed waterbody.

(3) Fence built across mouth of area with elevated lands on three sides, creating temporary enclosure for fish culture during flood season. Costs for fencing and juvenile fish for stocking are shared by the community, and the maintenance to avoid fish escapes is done by the members according to agreed schedules.

(4) Cropping calendar of new technology for deep flooding areas with alternating rice in dry season (individual farmer owned and managed) and fish culture in flood season (community managed).

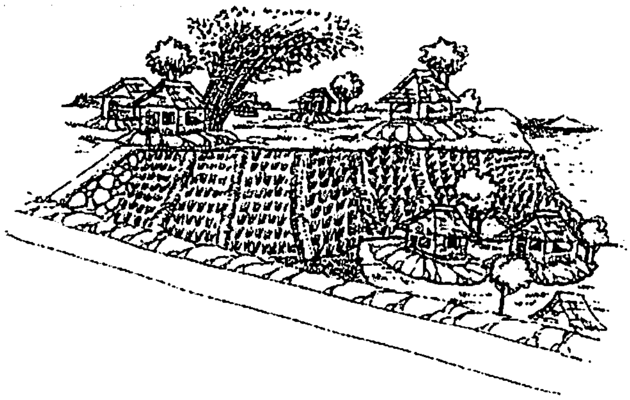
(5) Harvest of fish in a communally managed fenced-in waterbody in the flood season in Kuliarchar, Kishoregonj district, Bangladesh, where in the dry season high yielding rice is grown. Note fence in right background.

(6) Harvest of stocked fish after five months of culture in a fenced area under seasonal community management agreement in Urshiura, Brahmanbaria district, Bangladesh.

(7) Small indigenous species (SIS, i.e. 'wild' fish) from an enclosed waterbody additionally stocked with a polyculture of commercial

fish species, which are important for food and income to the rural poor in Bangladesh.
(8) Woman drying small indigenous fish species caught in fenced area, providing food and income to poor members while the culture of stocked fish was ongoing. Fishing for these SIS was specifically permitted by the group arrangement.

Figures



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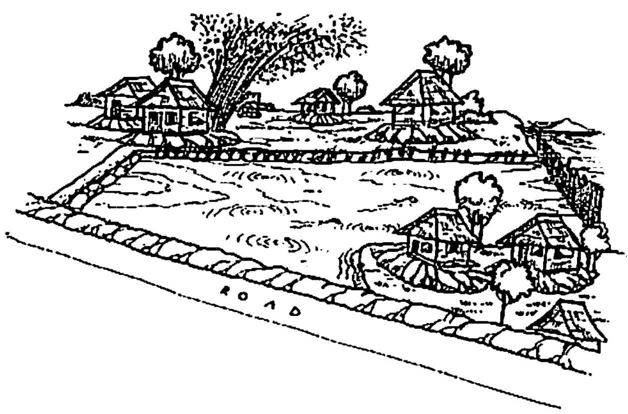

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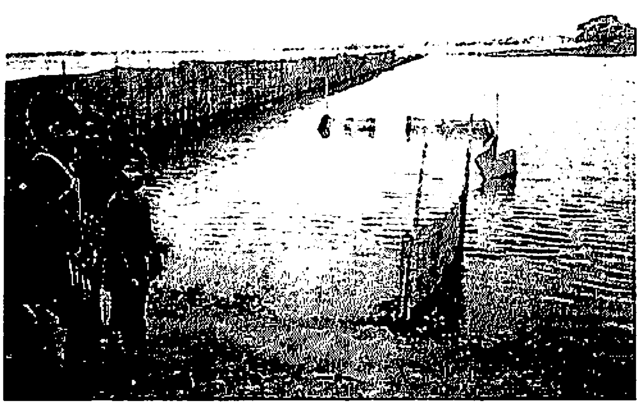
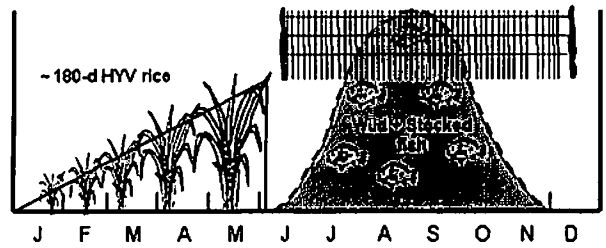


(3) Fence built across mouth of area with elevated lands on three sides, creating temporary enclosure for fish culture during flood season. Costs for fencing are shared by the community, and the maintenance to avoid fish escapes is done by the members according to agreed schedules. Mesh size of fence permits entry of juvenile wild fish, enabling them to reach maturity and reproduce with in the enclosed area.



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α *IFAD Advisory Notes are targeted at project designers, project implementers and subject-matter specialists/extension agents working with the rural poor. However, readers should consider the relevance of the information, and any recommendations made, within the context of their own socio-economic conditions, before adopting them.*

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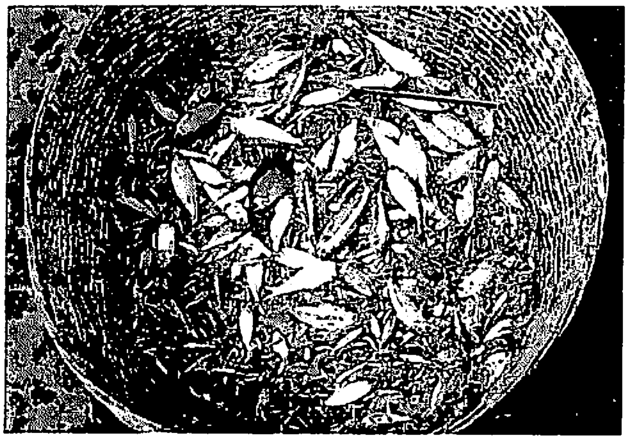
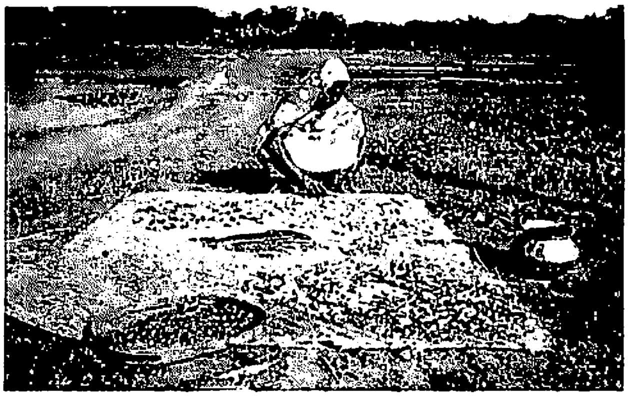


(7) Small indigenous species (i.e. 'wild' fish, = SIS) from an enclosed waterbody additionally stocked with a polyculture of commercial fish species, which are important for food and income to the rural poor in Bangladesh.



(8) Woman drying small indigenous fish species caught in fenced area, providing food and income to poor members while the culture of stocked fish was ongoing. Fishing for these SIS was specifically permitted by the group arrangement.

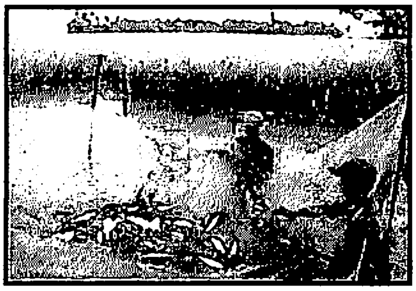
Appendix 2

Media impacts resulting from the project

New Agriculturist on-line
Reporting Agriculture for the 21st Century

Floating the idea of fish

Seasonal floodwaters rocked the cradle of civilisation encouraging men, or perhaps women, to make their first attempts at agricultural development. Countless seasons later, we are still attempting to make the most of natural floodwater.



Credit: Mark Prein, ICLARM

The people of the delta regions of Bangladesh and Vietnam made use of their annual floods by growing the tall-stemmed, 'deep water' rice that can keep its head above the rising water. The land was left fallow in the dry winter season. With the introduction of better irrigation and much higher-yielding, short-stemmed rice varieties, farmers switched growing seasons. Much of the land is now left fallow under the floodwaters. But is there any reason why better use should not be made of this otherwise wasted natural resource? Raising fish would seem to be an obvious idea except for the fact that fish, unless fenced in or caged, can swim from flooded field to flooded field regardless of who owns the land beneath. The only practical solution is for the local community to raise fish collectively. Putting aside for the moment the question of whether people are willing to work together, is it technically feasible? Several institutions, ICLARM-The World Fish Center, the Bangladesh Fisheries Research Institute (BFRI), Proshika (an NGO in Bangladesh), Research Institute for Aquaculture No. 1, Research Institute for Aquaculture No 2 and others* set out to discover whether growing fish would harm subsequent rice production, or vice versa.

Three years of research and the answers are very encouraging. There are two options for farmers, depending on the expected depth of floodwater. They can grow high yielding rice followed by fish or they can grow high yielding rice followed by fish and deep water rice. Fish yields of 1.5 t/ha can be achieved in Bangladesh although in South Vietnam, where the duration of flood is shorter, yields are nearer 400 kg/ha. Careful monitoring has revealed no ill effects on yields of rice. Indeed, the cost of rice production is actually reduced by about 10%, mainly because land preparation and weeding are easier, and because diseases and insect infestation are less of a problem. And there are no detrimental effects on wild fish stocks. Trials have shown that farmers are catching about 100kg of wild fish in both the experimental sites and the control sites. Introduced fish species are chosen to suit local taste, particularly silver barb, common carp and mirror carp and there is no difficulty in achieving marketable size.

Technical solutions are relatively straightforward but how would the idea of community based fisheries management appeal to the people involved? Again ICLARM and others (with funding from the UK Government's Department for International Development) set out to discover how such an approach might be managed.

The challenge was for the interested parties to create a system that was considered acceptable by all. There are three principal groups: landowners who want to take part in the scheme; landowners who do not, and landless fishers who had previously fished the floodwaters for wild fish. Each would get a certain percentage of the fish catch depending on their input. One can imagine that a compromise is not easy to achieve but very thorough consultation in the early stages paid off. In Bangladesh, all but one or two of the groups worked well. In those instances where there were problems, these arose because some felt they had not received a fair share of the benefits. In a few other cases there were problems with landless fishers coming into the community from outside the area, hoping to take advantage of the better fishing. In South Vietnam, farmers are generally more cautious but, after three seasons demonstrating the good returns that rice-fish culture brings, they are now convinced.

What has proved most encouraging for the researchers involved is that in both Bangladesh and Vietnam, government and NGOs have become very enthusiastic about community based fisheries management and are planning to introduce the idea to other districts. Even more gratifying is that some farmers in Bangladesh, outside the trial areas but hearing about them, have formed their own groups which, in many cases, seem to be doing even better. The researchers now want to see how the adoption process evolves and what modification to the technology may be needed to suit farmers not only in Bangladesh and Vietnam but also in the Indian States of West Bengal, Bihar and Uttar Pradesh where there is similar interest in the idea. Community collaboration must have been an essential element for early Man to take those first steps towards developing agriculture. Even in today's sophisticated civilisation, it still is.

* Funded by the International Fund for Agriculture Development (IFAD) and participating institutes

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WRENmedia
World Radio for the Environment

Fressingfield, Eye, Suffolk IP21 5SA, UK
FAX +44 1379 586755
Email: Post@wrenmedia.co.uk

AGFAX Resource: Water in agriculture

Interview: Dr Madan Dey
ICLARM
(International Center for Living Aquatic Resources Management)

Community based rice fish culture in flooded rice fields in South and South-East Asia

Transcript

Dey The problem was the adoption of the technology. In order to grow fish in the rainy season it has to be a community approach because during the rainy season all the plots get flooded. It's not possible to distinguish one plot from another.

Reynolds *So all the fish swim away!*

Dey Yes, from one plot to another. Now if they fence individual plots, the cost of fish cultivation goes very high and the small farmer cannot really grow fish.

Reynolds *And it would be an awful nuisance having fences.*

Dey Exactly. So the only sensible way of growing fish is the community-based management approach. So that's what we tried to do. We tried to do community-based fish culture in flooded rice fields.

Reynolds *So how was that received?*

Dey Well OK let me give you an introduction to how we worked. We involved all the people so that there is not resistance. We involved all the participants concerned in the process. So, for example, the landowner who provided the land and at the same time participated in the operation will get return for the land as well as getting return for the operation. The non-participating farmer, they will give only land but they will not participate in the operation. So they will get return for land only. They will not get return for the operations. On the other hand, the landless labourer, they do not have any land so what these landless fishers will get is return for their labour for their operation. So everybody got something.

Reynolds *It sounds grand in theory but, in practice, didn't it require quite a lot of organization?*

Dey Yes! We worked for three years and it was a really tedious process. We did a participatory approach and we came through the consulting process saying, OK, x% will go to landowners, y% will go to landless labour and, if it didn't work that year, the following year, based on our experience, we will change. In fact, in one or two cases, the sharing arrangement was not right. So the following year the farmers said, 'No. The sharing you have is not really fair to me'. So we had to redevise the sharing arrangement.

Reynolds *So once you had got that established and groups of people who were agreed to participate and so on, had you, by that time, already established the technical feasibility of everything? You must have done.*

Dey Yes. Our three years' results show that it's technically feasible. I must tell you there are two ways we approach these things. One, we had dry season rice followed by only fish, particularly for deeper areas because it's not possible to have rice during the rainy season in these areas because it's too deep flooding. The other option is we had dry season rice, which is irrigated rice, followed by rice plus fish. Our results show that our yield of this cultured fish ranges from 400 kg per hectare in South Vietnam, where the duration of fish culture is low, to up to 1.5 tonnes per hectare in Bangladesh. So we got very good results from the technical point of view.

Reynolds *What about the effect of the fish on the rice when you were growing the rice and the fish together?*

Dey In both cases we didn't see any negative impact on rice yield. In some cases we saw some positive effect but we're not sure whether this is because of fish culture. But we are sure it didn't have any negative impact on rice yield. On the other hand, we saw positive impact on the cost of production of rice. Our research shows that because of the fish cultivation, the cost of production of rice decreased by about 10%.

Reynolds *Why?*

Dey Well for a variety of factors. One because fish culture in the rainy season meant land preparation in the subsequent season was easier so the cost of land preparation decreased. Weed infestation was less so the weeding cost was less. And disease and insect infestation were low. So the cost of pesticide use was also low.

Reynolds *So you had to be quite careful about which species of fish were selected?*

Dey We had to be. As mentioned before, we used participatory approaches. We didn't introduce any species which aren't available in the local water bodies.

Reynolds *But is there long enough in the season for raising fish for the fish to get to marketable size?*

Dey Yes we got 600-500g of say, common carp. 300-400g silver barb. 1kg size of grass carp.

Reynolds *So what now?*

OK, x% will go to landowners, y% will go to landless labou

Dey Now the government institutes and NGOs have shown very keen interest to disseminate it among farmers. As you know, ICLARM is a research organization and it is the national agency who should be involved in the dissemination. And both in Bangladesh and Vietnam, government agencies plus NGOs are very keen to disseminate this sort of community based fish culture in flooded rice fields.

Reynolds *Well, as fish stocks generally decline, there's going to be increasing demand, always, for more fish.*

Dey Yes. And, as I mentioned earlier, our experiment shows that community based fish culture in flooded rice fields is technically feasible. It is economically viable. It is not environmentally destructive and it is socially acceptable.

Community-Based Rice-Fish Culture on the Floodplains of South and Southeast Asia

Sampling of fish in a communally managed concurrent deepwater rice-fish plot in the Red River Delta, northern Vietnam

ICLARM

THE WORLD FISH CENTER

In the rainy season in Asia, floods inundate vast areas in an annual cycle. The inhabitants of these floodplains are among the poorest people in Asia. Their lives and livelihoods depend on the yearly floods to water the rice fields and yield harvests of fish. The green revolution brought immense gains in productivity to irrigated farming systems where production quadrupled. Other farming systems have not achieved their full potential. In the flood-prone system, there were "hungry" periods when the land was submerged beneath the floodwaters.

In traditional rice cultivation in floodplains, two varieties of rice are sown at the beginning of the dry season. The first, dry season rice, is harvested before the next flood arrives. The second, deepwater rice, may be harvested but also continues to grow or regrow as the floodwaters rise, thus providing a second, smaller crop at the end of the wet season. Indigenous fish that migrate into the rice fields with the floods also are harvested.

In the 1980s, the introduction of irrigation, flood control schemes, and high-yielding irrigated rice varieties led to sixfold increases in rice yields. But farmers abandoned deepwater rice and let the land lie fallow after the irrigated rice had been harvested because there was not time before the rains began to establish the deepwater rice. The fish catch declined because of pesticides and flood control structures obstructed fish migration.

Scientists at the World Fish Center saw opportunities to increase food production in these flooded conditions. The goal was to improve productivity while maintaining ecosystem balance and protecting biodiversity. More productive methods of fish farming in deep-water rice systems had proven to be too expensive for individual farmers. A community-based management approach was now adopted. Very poor farmers and fishers in these flooded ecosystems are largely landless and survive on less than US$0.50 a day. Fishing is an occupation of last resort, a means whereby even the poorest have customary rights to catch fish in the common waters of each monsoon flood.

The community-managed rice-fish systems divide the benefits proportionally among those who own land, those who both own land and contribute to the operating costs of raising fish, and those who contribute their labor. The landless population falls in the last category. In many communities there is agreement that landless people may continue to catch the small native fish species but will leave cultured fish to grow for the benefit of landowners. These native species are critical to their day-to-day survival.

Productivity in these flood-prone ecosystems has increased dramatically. Each hectare yields between 250 and 1,500 kilograms of fish. Rice yields have been maintained, and because fewer pesticides and less weeding and plowing are required, the costs of rice production have dropped by 10 percent. The rice-fish culture systems are environmentally nondestructive and there is no reduction in the catch of wild fish species.

In field trial sites in Bangladesh, annual per capita income increased by about 16 percent in three years, and fish consumption rose by about 2 percent. Many fish also were sold. Communities neighboring the trial and demonstration sites have copied the technology.

In Vietnam, the provincial government in the Red River delta is supporting the widespread application of the concurrent deepwater rice-fish technology as a consequence of the trials conducted by the World Fish Center and its partners at the Research Institute for Aquaculture No. 1 in Hanoi. The Bangladesh Department of Agricultural Extension is bringing the technology to farmers in project areas in two districts. The NGO Proshika is planning to disseminate the technology to 30 subdistricts. Forty thousand hectares in Bangladesh are suitable for the technology with the potential to produce an estimated 400,000 tons of fish per year worth some US$300 million.

The World Fish Center (ICLARM)
Headquarters: Penang, Malaysia
www.iclarm.org