

CPWF Project Report

Community-based Fish Culture in Seasonal Floodplains
and Irrigation Systems

Project Number 35

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Program Preface

The Challenge Program on Water and Food (CPWF) contributes to efforts of the international community to ensure global diversions of water to agriculture are maintained at the level of the year 2000. It is a multi-institutional research initiative that aims to increase the resilience of social and ecological systems through better water management for food production. Through its broad partnerships, it conducts research that leads to impact on the poor and to policy change.

The CPWF conducts action-oriented research in nine river basins in Africa, Asia and Latin America, focusing on crop water productivity, fisheries and aquatic ecosystems, community arrangements for sharing water, integrated river basin management, and institutions and policies for successful implementation of developments in the water-food-environment nexus.

Project Preface

“Community-based Fish Culture in Irrigation Systems and Seasonal Floodplains”

The overall objective of the project was to enhance fish production from seasonally flooding areas and irrigation systems using a collective approach to fish culture. The project sought to examine the institutions necessary to support community-approaches to fish culture in a range of social, cultural and economic conditions, in Bangladesh, Cambodia, China, Vietnam and Mali. Technical designs for fish culture were also tested, building on successes achieved in earlier trials in Bangladesh, with an emphasis on adapting the model to develop locally appropriate culture systems. The project showed that the model is able to generate important benefits for communities in Bangladesh, China and Mali, and may have the potential to do so in other countries. However, it was found that introducing fish culture into complex and dynamic institutional contexts, whereby open access waters lie over private property required a range of social, environmental and economic conditions to be in place for the adoption and continuance of the fish culture model.

CPWF Project Report series

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ABBREVIATIONS

CBO	Community-based Organisation
DoF	Department of Fisheries
FiA	Fisheries Administration, Cambodia
FFRC	Freshwater Fisheries Research Center, Wuxi, China
FMC	Floodplain Management Committee
FRP	Fish Refuge Ponds
FWUG	Farmer Water User Group
IER	Institut Economie Rural
PIC	Project Implementation Committee
WAPDA	Bangladesh Water Development Board

RESEARCH HIGHLIGHTS

Fish have been harvested in the reservoirs and canals of irrigation systems for at least two millennia, yielding substantial fish harvests. These 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.

Simultaneously, the world's water resources are under increasing pressure from agriculture, industry and domestic consumption. Efforts to increase the productivity of water 'per drop' have focused primarily on agriculture production, despite the potential for fisheries and aquaculture production to generate an important source of food with minimal consumptive water use. Floodplains are also under threat from conversion to agriculture, and the diversion of water to supply alternative industries. Floodplain aquaculture represents an alternative use of floodplain resources that has the potential to enhance water productivity, increase employment opportunities for rural households, and secure access for rural households to critical floodplain resources that support a diverse range of livelihood activities.

The main objective of this five year action research project was to test technical and institutional options for floodplain aquaculture, implemented on a collective basis at selected locations in five countries, namely Bangladesh, Cambodia, China, Mali and Vietnam. The community-based fish culture model was originally developed in Bangladesh, building on three decades of research in community-based fisheries management and floodplain aquaculture. The project aimed to disseminate the model to other countries with extensive floodplain resources that could potentially generate important benefits for floodplain communities. The countries selected represented a broad range of social, cultural, and economic contexts, presenting significant challenges to the implementation of the project, and an important opportunity to understand the conditions supporting and constraining community-based approaches to fish culture, resource management and economic activity on a collective basis.

The complexity of the project, and the introduction of fish culture into a diverse range of contexts, demanded a flexible and iterative approach to project development and research management. In response to the realities emerging on the ground midway through the project, an additional layer of analysis was introduced in order to systematically evaluate the role of context on the success of the project, and to understand the conditions under which community-based fish culture has the potential to generate benefits for rural households. As a result, the project has evolved to encompass three key areas: 1) technical design and implementation of fish culture on a community basis, 2) understanding the conditions that support or constrain collective approaches to fish culture, 3) development of alternative approaches to monitoring and evaluation and the application of participatory video techniques to understand impact at the community level.

The primary research area of the project, the design and implementation of fish culture, demonstrated that community-based fish culture has provided a significant source of income and employment in communities in Bangladesh, leading to income smoothing, in addition to improving cooperation within communities and amongst diverse stakeholders. In China and Mali, initial trials were promising. Significant problems of infrastructure, marketing, availability of inputs and preferences for individual aquaculture over collective action constrained production in Cambodia and Vietnam.

The analysis of factors supporting or constraining community-based fish culture generated important lessons for community-based aquaculture and community-based development, more generally. It was shown that a more detailed evaluation of the social, economic, technical, environmental and institutional characteristics of a community than

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project design often permits prior to project intervention can usefully support the selection of communities for which community-based aquaculture represents a viable and equitable livelihood opportunity. Indeed, the project permitted a frank evaluation of the way in which projects are designed and implemented. Particularly significant was the encouragement received from the CPWF to report on aspects of the project that didn't work, as well as those that did. A similar level of openness to the realities of research on the part of other organizations supporting research for development would significantly improve the value of research outputs and encourage research innovation.

EXECUTIVE SUMMARY

Background

The past decade has seen the growing recognition of the crisis facing the world's water resources and thus the need for concerted efforts to use them more efficiently. It is well understood that the efficiency of water use, or water productivity, can be increased by either producing more output per unit of water used or by reducing water losses – or by the combination of both.

However, strategies (developed and applied so far) for increasing output have been limited to agricultural crop cultivation and have not fully taken advantage of increased water productivity 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.

Objectives of the Project

The main objective of this five year action research project was to test technical and institutional options for floodplain aquaculture, implemented on a collective basis at selected locations in five countries, namely Bangladesh, Cambodia, China, Mali and Vietnam. The community-based fish culture model was originally developed in Bangladesh, building on three decades of research in community-based fisheries management and floodplain aquaculture. The project aimed to disseminate the model to other countries with extensive floodplain resources that could potentially generate important benefits for floodplain communities, addressing the following objectives:

1. To develop appropriate technical and institutional options for increasing water productivity at basin level through integration of community-based fish production into existing floodplain and irrigation systems.
2. To identify the most appropriate models of collective action for aquaculture under different socio-ecological contexts.
3. To assess the contribution of collective approaches to aquaculture for sustainable development of floodplain resources and irrigation systems.

In addition to these objectives, the project sought to apply a range of alternative approaches to monitoring and evaluation, including participatory video techniques.

Research Findings

The implementation of the project has led to a range of outcomes, some anticipated and some unexpected. Collective approaches to aquaculture have met with variable success in each of the project countries, with the project delivering different levels of benefits both within and between countries. Negotiating access, management institutions and benefit sharing arrangements within a system where rights are dynamic, overlapping, and heterogeneous has created particular challenges for the development of the project. As a result, only sites in Bangladesh and China generated data over a number of fish culture cycles. Substantial improvements in resource governance were, however, seen in Mali, where the intervention showed strong potential for uptake and dissemination.

In Bangladesh, successes have been substantial at some project sites. Building on previous community-based fisheries management experience in the country, community-based fish culture has been introduced in floodplains subject to a complex array of administrative arrangements. The project was implemented in government *khas* lands leased to fishers, and in areas of private ownership. In each system, enclosures were created within floodplain depressions. Fish culture was managed by a Floodplain

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Management Committee made up of representatives from all communities surrounding the floodplain, with participation of fishers, landless non fishers and landowners. As described by Haque et al. (2008), however, the complexities of access and ownership to land, water, and fishing rights have created serious challenges to the project. Despite these challenges, the community fishers' society at Beel Mail, Rajshahi District, with the support of local authorities, are in the process of securing an extension to their current leasing arrangement allowing them to continue fish culture until 2013. Fish culture is now financed by savings from successful fish culture during previous years.

Fish culture activities in southern Vietnam have been introduced on a collective basis in flooded rice fields of the Mekong Delta. In contrast to Bangladesh, the flooded land is entirely under private ownership, with members of the fish culture group drawn from households whose land is situated within the flooded area. Where annual flood height is low enough to permit the creation of enclosures around individual household plots, there has been a general preference toward fish culture on an individual basis, or a third rice crop, and insufficient incentive for farmers to work together collaboratively to raise fish. Consequently, there have been high levels of discontinuance of community-based fish culture in these areas, although approaches to collective fish culture are now evolving amongst groups of households who favor fish culture in a small number of enclosed rice fields. In the provinces of the Mekong Delta that border Cambodia, flood waters are deep, permitting only two rice crops each year. In these areas, the cost of creating individual enclosures, using fences of sufficient height to contain stocked fish, is prohibitive, making collective fish culture a more viable option. Benefit-sharing arrangements, management, and leadership of fish culture in community groups and fish marketing present significant challenges to the success of the approach.

In Cambodia, establishing community groups to successfully manage fish culture within flooded areas has proved problematic. Fish culture activities were introduced in open access reservoirs and flooded rice fields. Initially, households were keen to participate in the project. Farmers have since demonstrated a preference for fish culture on an individual basis, introducing the technology instead on their own homesteads and private plots. As in Vietnam, in some areas there was a move toward collective fish culture amongst smaller fish culture groups of 10-12 households who practice fish culture in 3-4 enclosed rice fields. Members of these fish culture groups took action to improve the rice field environment for fish culture by creating ditches along the rice field perimeter to act as refuges when waters are shallow. However, the approach did not prove successful in either Takeo or Prey Veng provinces. The reasons for this can be attributed to a number of factors, including unpredictable flooding events, a lack of quality seed inputs and poorly developed markets for aquaculture products. Economic migration during the flood season also limits the availability of labour in the community, and weak social capital and aversion to collective action resulting from the trauma of the Khmer Rouge era also undermine community institutions for fish culture. Floodplain refuge ponds were introduced as a possible alternative to community-based fish culture.

Farmers in China adopted a different approach to collective fish culture than their counterparts in other project countries. The project was implemented in two provinces, Yunnan and Jiangsu. In Jiangsu province, fish culture was introduced into irrigation canals. In Yunnan, fish were stocked in flooded rice nurseries that are also used for the production of lotus. In both cases, management of fish culture was entrusted to an individual who acts as a caretaker, feeding and guarding the stocked fish. In return, they receive a larger proportion of the benefit from production, with the remainder shared amongst project participants and local community funds.

Fish culture is a new activity in Mali, creating a new set of challenges in addition to those faced in the Asian countries. Fish were stocked in triangular enclosures in '*mares*', or floodplain depressions, which are generally managed by one community. Caution was

needed to ensure that the introduction of fish culture does not undermine traditional access to the water, subject to multiple uses by a variety of resource users, or that the change in value of both the water resource and fish production transforms the management and allocation of rights to water and fishing. A detailed analysis of access rights and institutions was undertaken prior to fish stocking.

Outcomes and Impacts

The outcomes and impacts of the project are, as described above, highly variable, yet we were able to see impact and change occurring at a number of levels, from the individual to the institutional. At the community level, fish culture on a collective basis had a significant impact in communities in Bangladesh, China and Mali. In Vietnam and Cambodia, research furthered our understanding of the conditions for collective action, and specifically for community-based fish culture, that will contribute directly to the development of locally appropriate and technically feasible fish culture systems in both countries. In Cambodia, the project responded to government commitments to establish Community-based Fish Refuge Ponds (FRPs) in every village in the country, by providing best-practice guidelines for FRPs.

In Bangladesh, stocked fish production reached 400 kg/ha at Beel Mail, representing an increase of 133% compared to the baseline. This increase in fish production brought significant changes to the community, who relate the story of their village in the community-produced film 'The Island of Dreams and Success'¹. During focus group discussions and Most Significant Change interviews, beneficiaries also reported that cooperation in the community has increased. Prior to the intervention, households fished individually from open waters and competed with one another for the fish catch. Since the introduction of fish culture on a community basis, households have to work together to manage fish culture activities and to protect the fish stock. The increased cooperation and communication in the community is beneficial for other aspects of community life. Beneficiaries in Melandi reported that their lives are transformed in particular for the duration of the fish harvest, which can last up to 110 days. At Kalmina Beel, the fish harvest, and associated benefits, continued for 95 days in 2009. Although the fish catch is lower on some days than it was in the past, the overall effect is one of income smoothing and the generation of income that permits households to afford education for their children, or to purchase assets such as mobile phones and televisions, technologies that are important in providing rural households with access to information.

Although relatively modest levels of fish production were achieved in Yunnan province, contributing little to total household incomes, fish production still provided significant benefits to the participating communities. In Taiping village, in particular, beneficiary households preferred to receive their share of production in the form of fish rather than in cash. Taiping is a relatively poor village, and fish is considered a luxury source of protein. As a result, households eat fish less than 10 times per year. Fish production from community-based fish culture led to a significant increase in fish consumption in the community. The additional fish that the project provided for home consumption was a sufficient incentive for the community to continue fish culture.

In Mali, outcomes and changes in community behaviour to protect fish culture enclosures and the mare environment far exceeded expectations, particularly as substantial delays in the implementation of the fish culture intervention meant that the first culture cycle took place only in the final year of the project. The impacts of constructing the aquaculture enclosures in "Mama Pondu" mare go well beyond that of the fish production

¹ <http://youtube.com/watch?v=fqitqImT420&feature=related>

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within the enclosures. Most significantly, all focus groups described a number of ways in which this projects' focus on development and management of the mare resources has increased the community awareness of their reliance on this common resource, and their commitment to improve mare resource governance overall. Consequently, livestock herders have taken greater care in tending their flocks, fishers have limited their poaching during the closed season, and farmers have reduced the amount of vegetation that they extract as fodder for small livestock. Together, these self-imposed measures are expected to have significant impacts on the amount of fish landed during the collective fishing event to be held in June, as well as the productivity of agricultural fields in the area. Community focus groups were also uniformly supportive of continuing these improved governance norms during the years to come.

At the institutional level, NARES partners also reported important changes in their working practice and research knowledge and skills. In China, partners reported that they have a greater interest in the socio-economic conditions of the communities in which they work, and are keen to learn more about the institutional and policy environment of their research. Participatory research methods were new to research partners at FFRC when the project began. The application of PRA methods has expanded the scope of their research beyond a simple analysis of fish productivity, and consultation with farmers at the local level to understand their needs and preferences has also increased.

The opportunity to build international partnerships was also cited as an important outcome of the project, particularly amongst NARES partner participants in China. The increased visibility of local departments, through the connections established through the project, have led to further funding for national level projects in areas that previously received little attention from national level agencies.

Capacity building in the form of new skills training was of importance to research partners from the Department of Aquaculture of the Fisheries Administration, Cambodia. Compared to other projects supported by international donors and network organisations, the principal investigator from the FiA appreciated the degree of autonomy and independence he was given to develop his own ideas, to brainstorm and to discuss ideas and make decisions in collaboration with other members of the team. The value of new skills in field observation, discussions with community members and the use of maps to discuss ideas with project participants at the community level were emphasized.

International Public Goods

The dissemination of the community-based fish culture model, developed in Bangladesh, to other countries in Asia and Africa represents an important contribution to a suite of aquaculture technologies currently available to rural households across the world. Testing the CBFC model in a range of environmental, social and economic contexts has provided important insights into the conditions that support community-based fish culture and where such an intervention is both appropriate and likely to generate benefits for rural communities. Joffre and Sheriff (2010) provide a detailed analysis of the conditions which either supported or constrained CBFC in each of the project countries, going on to define the type of locations in which CBFC may provide an appropriate livelihood option and, in contrast, the type of environments where CBFC is likely to fail. This analysis can feasibly support the identification of promising locations for CBFC in Asia, and possibly Africa.

The project has generated a series of reports and papers outlining important lessons learned with respect to the technical and institutional design of fish culture in seasonally flooding areas. In addition, the research has made significant contributions to our understanding of collective action and property rights in floodplains, where institutions

governing resource use, access and ownership are both complex and dynamic. Unlike the many studies that focus attention on one location, the project provided a unique opportunity to contribute to the body of literature on technology adoption, collective action and property rights based on a comparative analysis in five countries.

Alternative approaches to Monitoring and Evaluation, and to assessing impact, are becoming increasingly popular in development research. In an attempt to understand impact and change beyond a traditional analysis of fish production and household income, the project applied Most Significant Change and Outcome Mapping methodologies to determine the extent of project impact, and unanticipated changes in particular. The findings have been presented in Sheriff and Schuetz (in press) and the lessons learned disseminated through a series of information sheets outlining the advantages and constraints of applying each of the methodologies in a research for development context².

The impact of introducing participatory video techniques in Bangladesh has been two-fold. Firstly, by putting the camera in the hands of the community, PV is enormously empowering for the project beneficiaries, particularly for the women involved in the video production³. The video produced by the people of Melandi, 'Island of Dreams and Success', reflects the message that the community wanted to convey. As an M&E tool, PV can also flag the issues of most importance to the community, as the team discusses their preferred themes for the video. Secondly, the video is publicly available online, and reached over 31,000 viewers within 24 hours following posting on the independent, online Malaysian news portal Malaysiakini. The video conveys information about the project approach as well as the response of villagers whose lives have been affected as a result of the intervention. The value of the participatory video approach over traditional documentary film, written and filmed by outsiders has been communicated throughout the WorldFish Center and the CPWF. Furthermore, the communities involved in the PV process have continued to produce video films as a result of the relationships established between the community video team and Bangladeshi film maker Mustafa Sayeed, of Proshika⁴, who aims to establish a network of community film makers throughout rural Bangladesh.

Recommendations

- Community-based fish culture provides a great opportunity to maximize productivity from seasonally flooding environments, for the benefit of rural communities, with potential for positive impacts on productivity, income, food security, livelihoods and resource governance demonstrated across a wide range of countries and conditions.
- Aquaculture has the potential to bring considerable benefits to rural Cambodia but further development of the sector will be needed before sufficient infrastructure, inputs, market linkages and extension services are available to support the community-based fish culture model. The current initiative of the Cambodian government to develop community fish refuge ponds represents an important step towards building capacity and infrastructure for fisheries and aquaculture development. Further research and testing is needed to improve the productivity and sustainability of these systems, building on the knowledge generated by the CBFC project.

² See Appendix for information sheets. Pilot testing of Outcome Mapping in Vietnam was supported by ICT-KM of the CGIAR as part of the Knowledge Sharing in Research project (2008-2009).

³ See 'Putting the Camera in Archana's Hands' (<http://www.malaysiakini.tv/video/18376/-putting-the-camera-in-archanas-hands.html>).

⁴ Proshika is one of the largest NGOs in Bangladesh.

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- Experiences in Mali indicate that CBFC has the potential to improve *mare* productivity through aquaculture and improved *mare* governance. However, further research is needed to establish whether the same outcomes can be replicated at other locations, and to evaluate opportunities for out-scaling the approach in other areas of the Inner Niger Delta. Research demonstrated the importance of providing a platform for dialogue amongst all *mare* resource users, whereby aquaculture became a catalyst for improved management of all *mare* resources, both aquatic and terrestrial. The approach adopted within the CBFC project provides a potentially useful model for *mare* management throughout the region.
- The CBFC model in private and public floodplains has been successfully proven in Bangladesh. However, further research should focus on the environmental impact of CBFC, particularly the relationship between fish culture and rice cultivation, and downstream impacts resulting from changes in the water management regime. The potential of the approach in coastal areas should also be explored. A suite of technologies has now been developed in Bangladesh, based on decades of experience in community-based fisheries, permitting the selection of the most appropriate technology to suit the location and local needs. Future interventions should draw on this vast body of knowledge to ensure the most appropriate technology is selected to suit local conditions and preferences.
- Community Based Fish Culture has a high potential in the floodplains of Vietnam, but further modifications to the model tested in this study are required for CBFC to generate greater benefits. Smaller groups facilitate participation in the collective fish culture. Smaller production units will also help to develop alternate marketing strategies (including delayed marketing, with fish fattening in ponds) to improve economic return of the technology. Integration of fish culture in a rice-based agro-system is facilitated if the collective approach includes both types of production (e.g. fish and rice) in order to limit conflicts for water management and the rice culture calendar.
- Exclusion is a common feature of resource management interventions based on resources held in common by a defined user group. However, the potential for negative consequences to arise and impact resource users must be given full consideration before introducing a new technology. The approach undertaken in Mali is recommended, whereby a detailed investigation was undertaken prior to the introduction of fish culture to understand patterns of resources use and access, to assess the potential for negative consequences and conflict, and to ensure that all user groups were included in the development and implementation of fish culture (See Russell et al, in prep).
- The costs and risks associated with fish culture can be reduced using various strategies, besides the pooling of land and water resources, such as marketing strategies and the purchase of inputs. The emergence of alternative options to help communities maximize the benefits from seasonally flooding areas is best supported through a flexible research approach and the acknowledgement of the critical role of national research partners in leading the development and testing of new technologies. The CBFC project benefited from such an approach, particularly in Mali, Cambodia and China, which promoted the emergence of more innovative options, relevant to local preferences and conditions, as well as opportunities for capacity building amongst local staff.
- A range of conditions that support and constrain community-based fish culture was identified during the course of the research. Careful selection of locations where these conditions prevail, and consideration of the social, political and historical context could lead to a considerable improvement in uptake and adoption of community-based fish culture, and other related technologies, with associated benefits to poor rural communities.

INTRODUCTION

The past decade has seen the growing recognition of the crisis facing the world's water resources and thus the need for concerted effort to use them more efficiently. It is well understood that the efficiency of water use, or water productivity, can be increased by either producing more output per unit of water used or by reducing water losses – or by the combination of both.

However, strategies (developed and applied so far) for increasing output have been limited to agricultural crop cultivation and have not fully taken advantage of increased water productivity 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.

Fish and water productivity

Fish have been harvested in the reservoirs and canals of irrigation systems for at least two millennia, yielding substantial fish harvests. These 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 the capture activities by seasonal or part-time fisher-farmers of wild fish species that enter, grow and reproduce in the flooded fields. But in Cambodian floodplains, the value of fish caught through trap ponds within rice fields can reach as much as 37– 42% of the value of rice production.

A number of studies were conducted in the 1980s to test the technical feasibility of culturing fish in seasonally flooded rice fields (B. Roy et al. 1990; Das et al. 1990; Mukhopadhyay et al. 1991, Ali et al. 1993; Rothuis et al. 1998a; Rothuis et al. 1998b; and Ali et al. 1998). These studies also show that fish production can be increased by more than 1 mt/ha/yr by stocking flooded rice fields with fish (i.e., individual farmers fencing their plots and stocking fish during the flood season). In addition, the culture of fish within rice fields can increase rice yields, especially on poorer soils and in unfertilized crops where the fertilizing effect of fish is greatest. Savings on pesticides and earnings from fish sales can lead to increased yields and result in net incomes that are 65% higher than for rice monoculture alone. In spite of these potential benefits, the adoption of this technology by farmers has been very low, mainly due to the high cost of fencing individual plots.

Community-based Fish Culture

Recently, the WorldFish Center established a new approach in Bangladesh and Vietnam, where fish is cultured communally during the flood season, but the same land is cultivated individually to rice during the dry season.

The results of initial trials show 10% lower cost of rice production and net returns from fish production of US\$220-400 per ha. Significantly, these benefits were obtained with no reduction in the wild fish catch. The returns from fish culture were distributed among the group members according to pre-negotiated sharing arrangement at the beginning of the season. The share of the landless members can be significant due to limited income generating opportunity.

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 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)

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also require detailed analyses if the full social value of these resources is to be harnessed.

The project was based on the underlying assumption that seasonal waterbodies (over flooded crop fields) and canals/reservoirs in irrigation schemes can be communally managed by stakeholders under equitable and sustainable sharing arrangements, as recent on-farm demonstrations in Vietnam and Bangladesh have confirmed. If successful, it was envisioned that the approach would help mitigate the declining volume of inland capture fisheries production and subsequent increases in fish prices, which renders them less affordable and less accessible to the poor.

In Bangladesh alone, for example, there are 3 million ha of medium and deep flooded areas, of which about 1.5 million ha are suitable for community-based fish culture. Even if this approach is adopted only in half of that area, annual fish production would increase by 450,000 t (in addition to the current 60,000 t of wild fish catch) with estimated value of US\$340 million and would benefit an estimated 6.7 million people (2.7 million of which are either landless or functionally landless). Similar opportunities were seen for floodplain and deltaic systems in other countries in Asia and Africa.

PROJECT OBJECTIVES

The project began with four specific objectives;

1. To develop a methodology for measuring water productivity at the landscape level and to assess the contribution of aquatic resources to water productivity in irrigation systems and floodplains.
2. To develop appropriate technical and institutional options for increasing water productivity at basin level through integration of community-based fish production into existing floodplain and irrigation systems.
3. To develop a participatory diagnostic and stakeholder-involving diffusion approach for community-based fish culture in shared water bodies.
4. To enhance human resource capacity of NARES for supporting community based fish culture in shared water bodies

However, as the project developed, it was clear that the complex reality on the ground challenged a number of assumptions on which the project was based. In response, a flexible, iterative approach to research management was adopted to guide the continued development of the project. The impact of this approach will be reflected in the presentation of the results, discussions and conclusions.

The testing of technical and institutional options using an adaptive management approach was built on an assumption that community-groups would continue fish culture activities over a number of consecutive culture cycles, improving the approach year on year. However, in practice, the complexity of the social and biophysical systems precluded the continuation of fish culture at many project sites. In the face of high levels of discontinuance, primarily in Vietnam and Cambodia, a mid-project review was held to evaluate project activities and to propose a new direction that specifically addressed the impact of prevailing local conditions on the success of the intervention. The opportunity to address the issues that emerged as a result of this focused analysis was fortuitous, lending a new dimension to the project that became an important learning opportunity.

Following the mid-project review, activities to address objectives 1 and 3 were downscaled, and two new research questions were framed to guide research efforts during the final phase of the project.

Research question 1: *What are the most appropriate models of collective action for aquaculture under different socio-ecological contexts?*

Research question 2: *What is the contribution of collective approaches to aquaculture for sustainable development of floodplain resources and irrigation systems?*

The structure of the report reflects the changes that took place in the direction of the research. Section One begins with an overview of the fish culture intervention and approaches to community-based fish culture management. Section Two addresses research question 1. The report concludes with Section 3, responding to research question 2, synthesizing the outcomes of the project to further our understanding of the overall contribution of collective approaches to aquaculture in the context of floodplain development and the increasing demands on floodplain resources.

RESEARCH APPROACH AND METHODOLOGY

Implementation of fish culture intervention

The scale and complexity of introducing fish culture into multiple-use waterbodies limited the number of project sites that could be effectively managed and monitored within the project time frame. Four project sites per country were selected in Cambodia, Vietnam and China. In Bangladesh, three sites were selected, and two in Mali.

Local partners and WorldFish selected sites together according to information collected from local authorities and extension services. Selection criteria included

- the presence of community-based floodplain aquaculture or community willingness to develop it,
- the absence of conflict over the use of the water body,
- good water-management infrastructure in Vietnam and Bangladesh, and
- sufficient flood depth and flood period.

Secondary source information was reviewed and field visits were carried out in 2006, and one site was selected in Bangladesh and one Vietnam. In 2007, two more sites were selected in Bangladesh, as were three more sites in Vietnam, and project activity started in four villages in Cambodia. To compensate for discontinuance at three sites in Vietnam, local partners selected one more site in 2008. One site that discontinued in 2007 restarted in 2009 in a different setting.

The fish culture model was modified according to local preferences in each country, using small enclosures in Cambodia and Mali, and large water bodies in Vietnam and Bangladesh (Table 2). The size of enclosures for fish culture in Cambodia was limited due to lack of embankments or natural boundaries. As enclosures depend on fencing, they cannot be large, which also limits the number of potential beneficiaries.

In Bangladesh, individual project sites include more than one village and more than 100 beneficiaries, in contrast with those in Vietnam or Cambodia. This difference arises as several villages located around the water body house traditional users of the project area and those owning rice lands within it. These two criteria were used to select the project beneficiaries. Bangladeshi beneficiaries are classified in three main groups — landowners, fishers and the landless — which determines their share of benefits and duties under the project (Tables 3 and 4).

No such distinctions are made in Cambodia or Vietnam. In Cambodia, landowners and other villagers are included in the project, and there is no specific restriction on joining. Where the project site is located on public land, any villager is invited to join. At three sites in Vietnam, only those who own land within the project area can join. At two other sites, those without land could join, but their numbers were not significant (three households in Truong Xuan hamlet and six in Hung Binh hamlet at the beginning of the project, but none after 1 month of fish culture).

Concerning previous access rights, only at Beel Mail in Bangladesh was access restricted before project implementation, limited to members of the local fishers' society. In Cambodia, part of the site at Chroy Poan was a private pond used for watering livestock and irrigating rice. Other sites in Vietnam, Cambodia and Bangladesh were open access before the project.

In Bangladesh, WorldFish and the district and subdistrict (*upazilla*) DoF were the main stakeholders for project technical support and monitoring production. Their role included creating at each site a floodplain management committee (FMC) composed of project beneficiaries and responsible for project management. The FMC was supervised by a project implementation committee (PIC) which included representatives of local authorities, WorldFish Center representatives and local partners from the district DoF.

FMC members are selected by beneficiaries. They operate under written regulations and are funded through a joint bank account between the president of the FMC and upazilla DoF officer.

In Cambodia and Vietnam, there were no PICs, only committees with a structure similar to that of an FMC, including an elected president, vice-president, secretary and accountant. At four project sites in Vietnam, regulations are written and accessible to all beneficiaries, but this is not the case in Cambodia. In each country, the technical setting and organization of the collective group was decided together with beneficiaries and local partners.

In Vietnam, local authorities supported improving embankments if necessary. The commune and district DoF monitor the project together with local partners in the form of RIA2. DoF and RIA2 provide technical and management support. In Cambodia, the role of local authorities is less important, with monitoring and technical support done by the local and central FiA.

Monitoring and Evaluation

The project employed a range of traditional and innovative tools to evaluate project progress and to monitor activities against the assumptions made at the outset of the project. Initially, a detailed baseline survey was designed and implemented in each country. It was envisioned that the survey would be repeated at the end of the project to evaluate change against a range of indicators from fish production to health and well-being. The baseline survey was supplemented with a monitoring survey to understand longitudinal and seasonal changes that may not be captured in the baseline.

During the course of the project, it became apparent that the extensive collection of quantitative survey data was both costly and time-consuming. In order to reduce the burden on both financial resources and the time required of the national teams to gather the data, the survey form was revised to include only critical information. Additional techniques for understanding change in the participating communities were also introduced, including Outcome Mapping, Most Significant Change and Participatory Video. The use of approaches which adopt a more participatory approach to monitoring and evaluation were required to ensure we were building a complete and accurate picture of project impacts, which allow participants to more openly share their experience of the project out with the confines of a structured survey approach. Importantly, these approaches place emphasis on the impacts and changes that are important to beneficiaries. They also serve to validate the information obtained using survey approaches.

Table 1 Summary of technical and institutional design for community-based fish culture in five countries

	Technical design	Management Institutions
Bangladesh	<p>Culture site delimited by flood control dikes. No enclosure.</p> <p>Installation of bamboo fencing at water inlets and outlets to permit entry of larval wild fish and prevent escape of stocked fish</p> <p>Introduction of concrete ring culverts in Kalmina beel, and regulation of water using existing sluice gates in Beel Mail to increase water retention following flood recession</p>	<p>Floodplain Management Committee (FMC) established to represent stakeholder groups and responsible for decision making related to fish culture activities.</p> <p>Project Implementation Committee (PIC) comprises representatives from DoF, research team and other related government departments. Task to advise FMC and coordinate project activities</p> <p>Lease held by fishers committee in Beel Mail</p>
Vietnam	<p>Culture site delimited by dikes. Fencing to define culture area introduced at some sites.</p> <p>Fencing was installed on the top of dikes to prevent fish escape during high flooding.</p>	<p>At three sites, land ownership within the culture site was a pre-requisite for participation. At two sites, non-landowners were permitted to join, but few did.</p> <p>During a general meeting with the group members, leader, vice leader, secretary and accountant were elected and formed the Management Committee.</p>
Cambodia	<p>Culture sites located in rectangular enclosed areas made of nylon nets supported by wooden poles within open access reservoirs, or on private rice fields delimited by net fencing.</p> <p>Fish pathways and ditches were introduced into rice fields in some sites in the second year of culture to facilitate fish migration between rice fields and the culture area.</p>	<p>Participation was open to all community members. Those interested in participating in fish culture registered during a village level meeting.</p>
China	<p>In Jiangsu province, fish stocked in irrigation canals. Culture site delimited by net fencing.</p> <p>In Yunnan, fish stocked in flooded rice nurseries. No enclosure. No modification of infrastructure.</p>	<p>Fish culture managed by a single family</p>
Mali	<p>Six net pens create from one large enclosure located within the floodplain depression (<i>mare</i>).</p>	<p>Fish culture managed by a committee comprising the village chief and representatives of main ethnic groups and resource users.</p>

SECTION ONE: FISH PRODUCTION IN SEASONAL FLOODPLAINS AND IRRIGATION SYSTEMS

Bangladesh

The economy of Bangladesh is primarily dependent on agriculture. The fisheries are a key subsector, making a significant contribution to the national economy and livelihoods of millions of people in Bangladesh. Currently the agriculture sector contributes around 20 percent of gross domestic product (GDP) within which the fisheries sub-sector contributes 3.74 percent. Fisheries contribute 4.04 percent of the total export earnings and 21 percent of the agriculture sector (DoF, 2009, in Rahman et al. WP). The total national fish production of Bangladesh, including both marine and fresh water resources, is estimated at 2.56 million tones. of this, about 80% of the fish production (2.06 million tones) comes from inland fresh water resources and approximately 19% from marine resources (0.5 million tons). In 2007-08 floodplains contributed 77% of fisheries production from inland opens waters in Bangladesh (DoF, 2009). As Rahman et al (WP) note, about 6.7 million people receive direct benefits for their food security and livelihoods from the floodplains in Bangladesh of which 2.7 are poor and extremely poor categories (WorldFish Center, 2005; Dey and Prein, 2005; Dey and Prein, 2006).

Community-based fisheries and fish culture in Bangladesh have emerged during the last two decades in an attempt to develop a more equitable and sustainable approach to fisheries management, providing greater access and security for poor fishers for whom floodplain fisheries provide a critical source of food and income. As Sultana and Thompson (2007) describe, the floodplains of Bangladesh are divided into more than 12,000 *jalmohals*, or water estates, for which fishing rights were leased out for a period of 3 years by the Ministry of Land. Although preference was given to fisher cooperatives, control often fell to lessees, as fishers were less able to enforce property rights (Toufique 1999). The New Fisheries Management Policy (NFMP) was introduced in 1986 in order to deal with these problems. Under the NFMP, responsibility for nearly 300 waterbodies was transferred to the Department of Fisheries (DoF) (Sultana and Thompson 2007). The aim of the NFMP was to protect fishers from exploitation by influential middlemen, but in practice fishers continued to depend on past lessees to pay the lease fees (ibid). Since the NFMP ended in 1995, several projects based on community-based models have been introduced in an attempt to address the problems of fisheries management that fishers throughout Bangladesh continue to face.

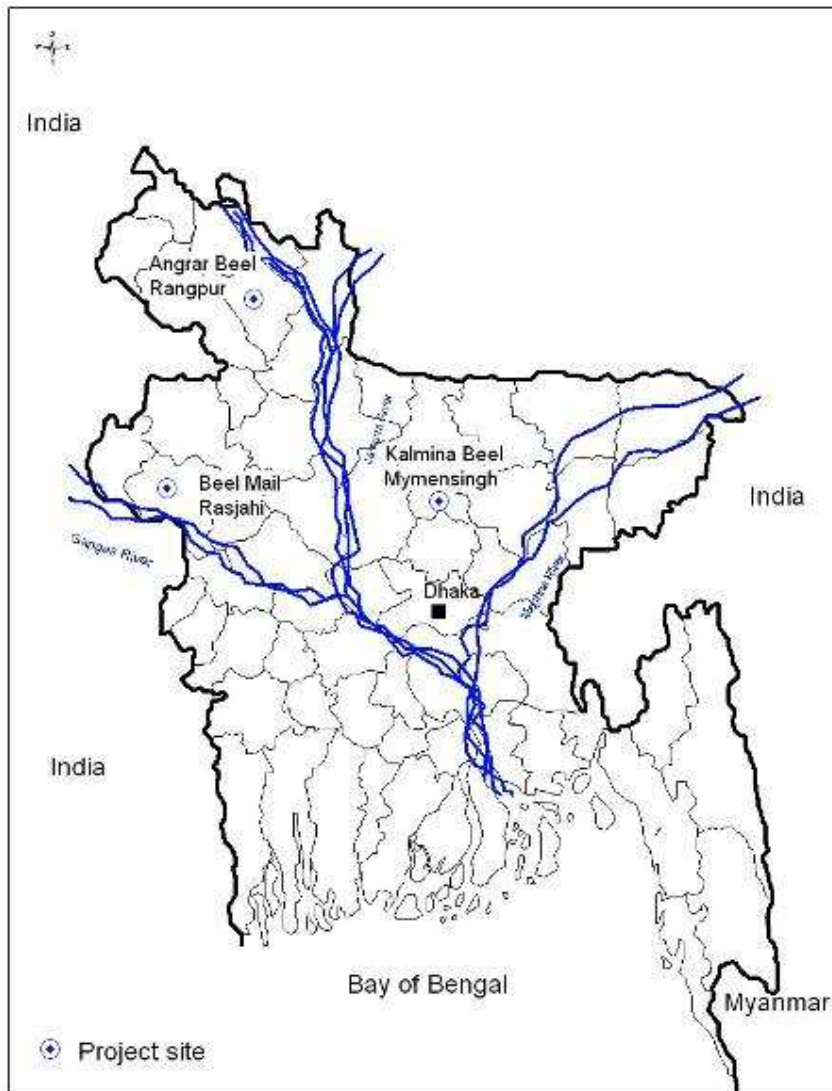
Open water fisheries have traditionally provided a major source of food for the population of Bangladesh. However, since the mid 1990's the share of production from aquaculture has risen, and now exceeds production from capture fisheries (Toufique and Gregory 2008). Pond aquaculture accounts for the bulk of aquaculture production, but floodplain aquaculture (FPA) projects have also been expanding, particularly in Daudkandi Upazila in the District of Comilla. Under the Daudkandi model, parts of the floodplain are enclosed through the creation of embankments and sluice gates, by the holders of land within the floodplain area (ibid). The area is then stocked with fish and the benefits distributed through dividends on shares and as land rents. However, reports indicate that this model excludes large numbers of poor people, who are further marginalised when benefits are captured by local elites (ibid).

Building on decades of experience in Bangladesh to improve fisheries management and the livelihoods of the rural poor, the community-based fish culture project aimed to develop a fish culture model that secured access to fisheries resources for poor fishers, whilst enhancing floodplain productivity and ensuring equitable distribution of benefits amongst a range of stakeholders.

Methods

Fish culture trials on a community-basis have been implemented at three locations in Bangladesh (Figure 1).

Figure 1 Location of project sites in Bangladesh



Beel Mail represents an area of 40 ha, with 15.2 ha considered as public land and the remaining 24.8 ha are privately owned. The fishing rights for the beel are leased to a fishers group from the village of Melandi, situated 3km from the beel. The minimum water level is 0.15 m (2008) or 0.33 m (2007) in January and a maximum of 3.5 m (2007) to 5 m (2008) was recorded during extreme flood. During these two years the average water level between June to January was 2.42 (2007) and 2.48 m (2008). The beel is delimited by flood management dykes, and with a sluice for water management. Community-based fish culture was introduced in 2007. Kalmina Beel, in Mymensingh province, comprises an area of 33ha of mostly private land.

Table 2 Characteristics of project sites in Bangladesh

Name of floodplains	Area (ha)	Ownership	River Basin
Beel Mail, Mohanpur, Rajshahi	40 (public 15.2 ha, Private 24.8 ha)	Public & private	Padma
Kalmina beel, Fulbaria, Mymensingh	33	Private	Brahmaputra
Angrar beel, Pirganj, Rangpur	31	Private	Teesta

Institutions for Community Based Fish Culture

A Floodplain Management Committee (FMC) was created at each site, representing all stakeholder groups including landless fishers, fishers from the local fishers group, and landholders, and elected by project beneficiaries. The FMC was responsible for management of the fish culture activities at the beel level, including species selection, stocking and harvesting decisions and financial accounting. The FMC was advised and supervised by a project implementation committee (PIC) that included representatives of local authorities, WorldFish Center representatives and district level DoF. The FMC operated under written regulations and through a co-management arrangement designed to increase transparency and reduce the likelihood of corruption, whereby funds were controlled through a joint bank account accessible only through simultaneous agreement between the president of the FMC and upazilla DoF officer.

Technical Intervention

Bamboo fences were installed at water inlets and outlets, permitting the entry of larvae and hatchlings of small indigenous species and preventing stocked fish from escaping (Rahman et al. 2010). In some cases, the peripheral dikes of the water bodies were also raised for holding water as well as preventing the escape of stocked fish.

Figure 2 Bana fencing installed at Kalmina Beel, Mymensingh



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Several ring culverts comprising ring concrete culvert (RCC) pipes with round holes of 60cm in diameter were installed at 0.3 meter above the bottom level of the floodplain and the upper side of the culverts was covered with soil for about 0.6 meter to maintain the water level and prolong the water retention time for Kalmina Beel floodplain. In Beel Mail floodplain, the existing sluice gates constructed by the Bangladesh Water Development Board (WAPDA) were regulated to retain water throughout the culture period and facilitate drainage of water for final harvesting of fish and the planting of winter rice.

The species combinations, ratios and stocking densities of fish fingerlings were determined based on factors such as local availability of fingerlings, the growth rates of the fish species and the experience of project participants. The Floodplain Management Committee (FMC) was responsible for selection, procurement and stocking of fish species in the floodplains through formation of different sub committees with the guidance of PIC. The fingerlings were procured either from the nursery farms of the beneficiaries or from the nearby commercial nursery farms. Indian major carps and Chinese carps were selected and stocked in the respective seasonal floodplains at varying ratios and stocking densities, as shown in Table 4- Table 11. The fingerlings procured from nurseries were transported effectively using locally developed technologies/devices (e.g. open system in local motorized rickshaw van in case of Beel Mail floodplains). Such technologies allow transportation of bulk amounts of large size fingerlings at a time with minimum stress and minimum cost involvement. Prior to stocking, the selected fingerlings were acclimatized in hapas (nylon net enclosure) placed in the respective floodplains. Fish fingerlings of different species ranging in weight from 30 to 46g were stocked in the floodplain at the rate of 31-48 kg/ha in different floodplains.

Figure 3 Villagers from Melandi sampling fish to check growth at Beel Mail, Rajshahi



Ownership of floodplains and beneficiaries

Floodplains completely under private ownership (Angrar Beel and Kalmina Beel) were similar in size, with similar number of beneficiaries and proportions of different types of beneficiaries (landless, fishers and land owners) with similar numbers of communities surrounding the floodplains. For the floodplain with public ownership and surrounded by private lands (Beel mail), the public land was leased out. For this floodplain the fishers'

group constituted the majority (55%) among the beneficiaries. The area of the floodplain was larger than that Angrar Beel and Kalmina Beel but the total number of beneficiaries was lower (Table 3). The higher proportion of fishers among the beneficiaries in Beel Mail was related to the fact that they were the lease holders of the floodplain. In floodplains under public lease normally the lessees took control over the floodplains (including the private lands) during monsoon. Land owners involved as beneficiaries, in this case were politically influential people. They earned income from the floodplain through returns on their financial investment in the scheme (they paid the lease value, management cost and security), rather than as land owners (DoF pers. Comm.). In privately owned floodplains brought under community-based fish culture, landowners were the major stakeholders. However, the inclusion of landless and fishers, who get benefits from the system, was also given importance (Haque et al. 2008)

Table 3 Beneficiary groups and numbers of beneficiaries at each project site

Floodplain	Area (ha)	Number of communities	Number of Beneficiaries (%)			
			Landless	Fishers	Land owner	Total
Angrar Beel	31	5	38 (22)	23 (13)	110 (65)	171
Kalmina Beel	33	5	52 (29)	25 (14)	97 (57)	174
Beel Mai	40	5	22 (18)	68 (55)	34 (27)	124
Total	104	11	112 (24)	116(25)	241 (51)	469

Results and Discussion

Fish production

Production of stocked and wild fish as a result of the fish culture intervention at each of the project sites are shown in Table 4-Table 11. Highest levels of production were achieved at Beel Mail, where production per hectare reached 400 kg in 2008. At Kalmina Beel, stocked fish production reached 310.89kg/ha.; an increase of 107% on the previous year's production. An increase in the production of wild stocked fish on 2007 production suggests that the regulation of harvesting, the addition of structures to allow the entrance of small, wild fish fry into the enclosure (bana fencing) and the practice of multiple harvesting contributed to the increased productivity of both stocked and non-stocked fish.

Comparatively larger fingerlings were stocked in the floodplains to ensure better survival and rapid growth. Fingerlings selected for Beel Mail floodplain were 30±4 to 45±6 g in size, 30±6 to 46±6 g for Kalmina beel floodplain and 30±4 to 40±7 g for Angrar beel floodplain. Survival rate of the stocked fishes was found to be moderate in the experimental floodplains, with the exception of Angrar beel. Slight variations in the survivability of stocked fishes were noted between beels. Survival rate varied from 38 to 65 % in case of Beel mail floodplain, 40 to 63 % in Kalmina beel floodplain and 27 to 44 % in Angrar beel floodplain. Low survival rates as observed in Angrar beel were mainly due to poor survival of silver carp (27 %) and common carp (34 %) (Rahman et al. 2010).

In floodplain aquaculture, the exotic species of fish showed the highest contribution in total fish production. In Beel Mail floodplain, the contribution of the exotic species bighead carp (63.72%) was the highest, followed by common carp (20.84%). Among the native fish species, catla showed a modest contribution (10.66%) while, rohu (2.55%) and mrigal (2.23%) contributed very little to the total fish production. Rahman et al. (2010) conclude that exotic carps such as, silver carp, bighead carp and common carp

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could be the preferable species for inclusion in the seasonal floodplain aquaculture because of their fast growth rate, high adaptability and consumers' acceptance.

The results suggest that fish culture did not have a negative impact on wild fish production (Table 12).

Table 4 Stocking regime and fish production at Beel Mail (40ha), 2007

Species	Fingerlin g stocked (numbe r)	Total wt of fingerlin g (kg)	Avg. wt at stockin g (g)	Avg. wt at harves t (g)	Net yield (kg)	% increase in biomass	Production (kg/ha)
Silver carp							
Catla	2360	82	35±4	836±1 37	1109	1352	29.78
Bighead	28,560	1200	42±5	700±1 29	8331	694	238.28
Rohu	1680	50	30±5	375±7 1	354	708	10.1
Mrigal	1680	50	30±6	460±1 12	241	482	7.28
Common carp	5560	251	45±6	750±1 78	1506	600	43.93
Total stocked fish	39,840	1633			11541	707	329.37
Total un- stocked fish					11815		295.38
Total					23356		624.72

Table 5 Stocking regime and fish production at Beel Mail (40ha), 2008

Species	Fingerling stocked (number)	Total wt of fingerling (kg)	Avg. wt at stocking (g)	Avg. wt at harvest (g)	Net yield (kg)	% increase in biomass	Production (kg/ha)
Silver carp	0	0	0	0	0	0	0
Catla	5040	202	40±3	675±133	1763	873	49.13
Bighead	22880	1007	44±5	740±120	7799	774	220.15
Rohu	3440	120	35±5	225±38	204	170	8.10
Mrigal	4000	120	30±4	200±32	240	200	9.00
Common carp	13280	505	38±4	775±138	4026	797	113.28
Total Stocked fish	48640	1954			14032		399.66
Total Un- stocked fish					11665		291.62
Total					25697		691.27

Table 6 Stocking regime and fish production at Beel Mail (40ha), 2009

Species	Fingerlin g stocked (number)	Total wt of fingerlin g (kg)	Avg. wt at stockin g (g)	Avg. wt at harves t (g)	Net yield (kg)	% increase in biomass	Producti on (kg/ha)
Catla	5225	221	40	800	2539	1149	69.00
Bihgead	11057	387	35	950	6351	1641	168.45
Silver	2200	77	35	850	973	1264	26.25
Shorputi	3600	81	20	150	279	344	9.00
Common carp	14425	577	40	875	5079	880	141
Total Stocked fish	36807	1343			15221	1133	414
Total Un- stocked fish					12600		315
Total					27821		729.1

Table 7 Stocking regime and fish production at Kalmina Beel (33ha), 2007

Species	Fingerlin g stocked (number)	Total wt of fingerlin g (kg)	Avg. wt at stockin g (g)	Avg. wt at harves t (g)	Net yield (kg)	% increase in biomass	Producti on (kg/ha)
Silver carp	4719	211.86	45±6	572	1489	703	51.5
Catla	5808	267	46±6	600	1405	526	50.7
Bighead	0	0	0	0	0	0	0
Rohu	660	20.13	30±6	303	96	477	3.5
Mrigal	759	30	40±7	272	65	217	2.9
Common carp	8547	497	42±5	397	862	173	41.2
Total Stocked fish	20493	1025.99			3917		149.8
Total Non- stocked fish					1526		46.24
Total					5443		196.03

Table 8 Stocking regime and fish production at Kalmina Beel (33ha), 2008

Species	Fingerlin g stocked (number)	Total wt of fingerlin g (kg)	Avg. wt at stockin g (g)	Avg. wt at harvest (g)	Net yield (kg)	% increase in biomass	Producti on (kg/ha)
Silver carp	16,335	653	40±5	550±97	4016	615	141.5
Catla	5,214	235	45±6	610±66	1485	632	52.1
Bighead	0	0	0	0	0	0	0
Rohu	5,313	170	32±3	250±33	467	275	19.3
Mrigal	0	0	0	0	0	0	0
Common carp	12,177	512	42±6	520±83	2721	531	98.0
Total Stocked Fish	39039	1570			8689		310.9
Total Un- stocked fish					2295		69.54
Total					10984		380.42

Table 9 Stocking regime and fish production at Kalmina Beel (33ha), 2009

Species	Fingerling stocked (number)	Total wt of fingerling (kg)	Avg. wt at stocking (g)	Avg. wt at harvest (g)	Net yield (kg)	% increase in biomass	Production (kg/ha)
Catla	2300	178	40	800	1484	834	69
Rohu	2200	146	32	350	478	327	23.30
Silver	7445	495	35	850	4370	883	162.4
Common carp	7286	549	45	490	2472	450	108.2
Total Stocked Fish	19231	1368	34	725	8804	643.56	349.69
Total Un-stocked Fish					3576		108.36
Total					12380		458.06

Table 10 Stocking regime and fish production at Angrar Beel (31ha), 2007

Species	Fingerling stocked (number)	Total wt of fingerling (kg)	Avg. wt at stocking (g)	Avg. wt at harvest (g)	Net yield (kg)	% increase in biomass	Production (kg/ha)
Silver carp	11,315	430	38±6	525±122	1174	273	51.7
Catla	3317	133	40±7	650±180	667	501	25.8
Bighead	5890	235	40±6	730±334	1013	431	40.2
Rohu	6262	188	30±4	200±35	363	193	17.8
Mrigal	0	0	0	0	0	0	0
Common carp	7905	314	40±5	425±150	828	263	36.8
Total Stocked Fish	34689	1300			4045		172.4
Total Un-stocked fish					1318		42.51
Total					5363		214.93

Table 11 Stocking regime and fish production at Angrar Beel (31ha), 2009

Species	Fingerling stocked (number)	Total wt of fingerling (kg)	Avg. wt at stocking (g)	Avg. wt at harvest (g)	Net yield (kg)	% increase in biomass	Production (kg/ha)
Silver carp	7828	274	35	400	1230	449	48.5
Catla	1750	70	40	450	290	414	11.6
Bighead	14171	496	35	375	1249	252	56.3
Common carp	5400	189	35	300	411	217	19.3
Total Stocked fish	29149	1020			3189	313	135.8
Un-stocked fish					2184		70.4
Total					5373		206.22

Table 12 Biomass of major groups of fishes harvested from Beel Mail Floodplain before and after fish culture under CB fish culture

Major groups of fish	Beel Mail			Kalimina Beel			Angrar Beel		
	Before	After	Change	Before	After	Change	Before	After	Change
Exotic carps	75	308	+233	1	166	+165	2	92	+90
Major Carps	32	57	+25	1	64	+63	3	80	+77
Minnnows and clupeid	43	79	+36	5	7	+2	6	6	+0
Catfish	36	48	+12	1	2	+1	7	7	+0
Glassfish	20	45	+25	3	6	+3	2	3	+1
Barb	28	41	+13	13	18	+5	9	8	-1
Gobies	15	18	+3	0.48	2	+1.52	0.7	2	+1.3
Murrels	15	19	+4	1	1	+0	1	2	+1
Small prawn	11	25	+14	18	19	+1	11	12	+1
Perches	1	3	+2	0.30	1	+0.7	0.3	0.9	+0.6
Eels	2	6	+4	2	2	+0	1	2	+1
Miscellaneous fishes	4	9	+5	0.12	0.37	+0.25	0.11	0.52	+0.41
Total	282	658	+376	46.00	288.4	+242.5	43.11	215.4	+172.3

Benefit Sharing

Benefit-sharing arrangements vary among sites according to the land tenure arrangements associated with the water body. At Beel Mail, where public land is leased by the fishers' society, fishers received a larger share of the net benefit than is the case at project sites that are entirely privately owned (Kalmina and Angrar beels). The benefit also depends on this parameter with a share proportional to the investment made in the lease. The fishers' share at Beel Mail has increased since the beginning of the project, with fishers investing in the lease amount. At all sites, the share includes a revolving fund, with Beel Mail achieving financial autonomy since 2007 (the group was able to reinvest in fingerlings and fencing after 1 year of fish culture). At Kalmina and Angrar beel, financial autonomy has not yet been reached, and the benefit-sharing arrangement still includes revolving funds. At two sites, management costs are included, and at one site it further included a donation to religious authorities to renovate the mosque. One interesting point is that harvesting payment for fishers corresponds to a share of the harvested fish value, including both self-recruited and cultured fish (Joffre et al., forthcoming).

At Kalmina and Angrar beels the share for owners of ditches or trap ponds varied. At Kalmina Beel, owners of ditches and trap ponds at Kalmina Beel receive a share of the benefits on the sale of the fish harvest, while at Angrar Beel ditch owners receive 25% of the total benefit from the fish harvest, to share amongst them. At these two sites, fishers receive 10% to 15% of the benefit and are paid for harvesting by the community-based fish culture group, while landless participants receive 5% of the total benefit. At Beel Mail, landless participants do not receive any share of the benefit but are allowed to catch self-recruited species, as at other project sites (ibid.).

Benefit-sharing arrangements seem more complex in Bangladesh because of the diversity of stakeholders and the presence of trap ponds. However, revolving funds established to increase the sustainability of the project reflect the sharing agreement only at Beel Mail, while at other sites savings from fish culture were insufficient to

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sustain project activity into the next year (ibid.). Fishers were able to continue access to the project site using local gears and received a 10% share of the benefit from fish culture.

Vietnam⁵

The Mekong Delta is the main inland fishing ground in Vietnam, representing 75% of the total national capture fishery. In 2006 capture fisheries reached 145,855 tons. The main provinces involved in fishing are within the seasonally flooding area of the delta, with An Giang, Dong Thap and Long An accounting for more than 89 % of the fishing effort, and An Giang and Dong Thap provinces accounting for more than 50% of the catch in 2006.

Between 80,000 to 90,000 fishing vessels were registered in the Mekong Delta, concentrated in Dong Thap, An Giang and Long An provinces. Small-scale fisheries, without engine boat are the main type of fishery (83%) found in the Mekong Delta.

For inland areas, the fishing period is concentrated during the end of the flood period from August to November, when water level recedes and fish migrate from floodplains to rivers and canals.

In 2007, aquaculture in the Mekong Delta represented 72% of the national production and 74% of the national aquaculture area (7,238 km² within the 10,180 km² of the entire country, with an increase of 62% of the cultivated area between 2000 and 2007 (General Statistics Office of Vietnam 2010)

Since the late 1990's, floodplain aquaculture in the Mekong Delta has not shown any significant development, as the Vietnamese government has prioritized intensification of rice culture. Following the boom of pangasius culture, the provinces of An Giang, Dong Thap and Can Tho located in the floodplains, became the main production areas for fresh water aquaculture. However, flooded rice fields did not support aquaculture, with most of the production occurring in cage or ponds. Flooded rice fields remain the main fishing grounds from August to November for professional and local fishers. The WorldFish Center and the Research Institute for Aquaculture No. 2, Ho Chi Minh city, developed a series of on farm trials in Tien Giang and Dong Thap provinces to test the economic and technical feasibility of community based floodplain aquaculture. The trials, with a limited number of farmers, showed that the technology was technically adapted to the environment, economically interesting and socially acceptable (WorldFish Center/IFAD 2002). Although floodplain aquaculture was found interesting, dissemination of the model was limited and only recently has the local government begun to experiment with different types of aquaculture in flooded rice fields, with extensive carp polyculture, tilapia or freshwater prawns.

The Community-based Fish Culture project builds on these early experiences, designed to increase our understanding of the institutional and socioeconomic conditions required to support floodplain aquaculture on a collective basis. In this second phase of trials, the number of potential beneficiaries has been increased as selected project sites are larger than previous trials, with a broader range of stakeholders targeted, including landholders and landless fishers.

Methods

Community-based fish culture has been implemented at a total of 8 project sites in the Mekong Delta, in the provinces of Can Tho, An Giang, Dong Thap and Vinh Long. As the approach is experimental and relatively new to this area, early trials did not lead to continued uptake of the fish culture model and the majority of sites established in 2006

⁵ Information presented in this section is drawn from Joffre et al 2010, which provides a detailed account of the fish culture trials in Vietnam.

did not continue for a second year. Project sites where fish culture trials were introduced for one year in 2006 are shown in Table 13. Trials at D1 hamlet, Can Tho province, were established in 2006 and continued until 2009, with a pause in 2008. Three new sites were opened in 2007, in C2 hamlet, Hung Binh and Truong Phu B hamlet. Finally, in 2008, fish culture was introduced at Kinh Hoi 6th hamlet, Dong Thap province (Table 14).

Institutions for Community Based Fish Culture

In contrast to the fish culture model developed in Bangladesh, the community-based fish culture model developed in Vietnam limited membership to households who owned land within the perimeter of the project site, although this configuration of beneficiaries was not intended at project inception. Previously an open access resource during the flood season, participants chose to exclude fishers from fish culture activities and benefits were shared amongst members of the fish culture group who held land within the boundaries of the culture site. In Hung Binh, Truong Xuan and D1 (in 2009 only) hamlets in Vietnam, the benefits were shared equally amongst members, whereas in Truong Phu B and C2, benefits were shared according to size of land holding within the project site.

Following site selection, announcements were made in the commune that a meeting would be held to discuss fish culture, led by the RIA 2 research team and local commune officials. Anyone interested in participating was able to attend the meeting, during which the prospective participants were told about the project and the proposed fish culture activities. All households owning land within the project area were encouraged to participate. Once participants had expressed their interest to join the fish culture group, a management committee comprising a group leader, deputy leader, secretary and accountant were elected from amongst the group, and regulations governing participation and the management of fish culture activities were defined.

Table 13 Summary of project sites in the Vietnamese Mekong Delta, 2006

Hamlet	Thoi Trung, Group 1	Thoi Trung, Group 2	Vinh Toi	Tan Cuong Group 1	Tan Cuong Group 1
Province	Can Tho	Can Tho	An Giang	Dong Thap	Dong Thap
District	Thoi Dong	Thoi Dong	Chau Thanh	Tam Nong	Tam Nong
Size of site (ha)	10	11.4	12	2.9	0.83
No. of HH	4	5		3	2
Total wt stocked (kg)	176.8	196	140	330	100
Species stocked	CC, SC, BH, RT, GC, SB, Snk	CC, SC, BH, RT, GC, SB, Snk	CC, SC, BH, RT, GC, Nc, Snk	CC, SC, BH, RT, Snk	CC, SC, BH, RT, Snk
Gross yield (kg)	2359	2760	1403.2	985.7	1607.8
Yield (kg/ha)	235.9	242	117	340	1937

Technical Design

Fish culture was implemented in flood areas that permitted two or three rice crops per year. In the latter case, the water level and flood period are shorter, with 2 sites with a flood depth of less than 100 cm and rice fields flooded later in the year - in September rather than August. Rice culture is the main production system in the flood plains, with a first rice crop from December to March (yield ranging from 6.2 to 7.9 t ha⁻¹), followed by a second rice crop in the rainy season from May-June to August (yield ranging from 4.1 to 5.1 t ha⁻¹). A third rice crop can take place if rice fields are protected from the flood in

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August and September, as in Truong Phu B and Hung Binh (hamlets (yield ranging from 4 to 4.1 t ha⁻¹). The landscape is characterised by rice fields delimited by flood protection infrastructures (dikes, embankment and canals). The population is mostly settled along the canals, with the rice field behind the homestead in most of the project sites (Joffre et al. 2010).

Figure 4 Flooded rice fields and lotus production at Truong Xuan project site, Dong Thap, Vietnam



The fish culture model is based on extensive fish culture of species suited for floodplain aquaculture, such as common carp (*Cyprinus carpio*), bighead carps (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*). In a few cases grass carp (*Ctenopharyngodon idella*) was also stocked. Only in one site, in Can Tho province, high value species such as snakehead (*Channa striata*) and red tilapia (*Oreochromis sp*) were nursed and stocked. Production was based on the availability of natural food in the water body (Joffre et al. 2010).

Table 14 Characteristics of project sites in the Vietnamese Mekong Delta (2006-2009)

	D1	C2	Trung Phu B (TPB)	Hung Binh (HB)	Truong Xuan (TX)
Province	Can Tho c	Can Tho	Can Tho city	Vinh Long	Dong Thap
District	Vinh Thanh	Vinh Thanh	Co Do	Binh minh	Thap Muoi
Rice cropping	Double	Double	Triple	Triple	Double
Flood management infrastructure	Early flood protection dike for double rice cropping since 1998-01	Early flood protection dike for double rice cropping since 1998-01	Early flood protection since 1994-95	Improvement of early flood protection dike in 2004-05	Early flood protection dike for double rice cropping since 1995
Flood period	Aug. to Nov.	Aug. to Nov.	Sep to Nov.	Sept. to Nov.	Aug. to Nov.
Max Water level in 2007 or 2008	102 cm, 1 st week of November	106 cm, 1 st week of November	60 cm, 1 st week of November	63 cm, 1 st week of November	> 100 cm in November (2008)
Project site area (ha)	65 (2005-2007) 19 (2009)	48	39	26	90 (2008) 120 (2009)
Enclosure type	Dike	Dike	Dike	Dike	Dike + fence
Land ownership	Private	Private	Private	Private	Private
Households involved in the project	34(2005,2006) 30 (2007) 11 (2009)	28	28	5	13 (2008) 7 (2009)

Table 15 Fish stocking and harvesting regime at D1 hamlet, Thanh Thanh commune, Vinh Tanh District, Can Tho 2006 (65ha, 34HH) (stocked 26 June 2006, harvest 26 Nov-7 Dec 2006.)

	No. stocked	Total wt stocked (kg)	Avg. wt at stocking (g)	No. harvested	Avg. wt at harvest (g)	Gross Yield (kg)
Common carp	81224	534	6.4	24073	371.5	8943
Silver carp	21096	192	8.9	3696	156.76	579.4
Bighead carp	11267	80.9	7.1	3294	410.5	1352
Red tilapia	8181	81	89.9	38	105.4	4
Grass carp	24411	219	7	583	174.4	101.7
Snakehead*	17000			859	340	292.1
TOTAL						11272.2

* stocked 30 August.

Table 16 Fish stocking and harvesting regime at D1 hamlet, Thanh Thanh commune, Vinh Tanh District, Can Tho 2007 (65 ha, 34HH, stocking density 6 fish/m²)

	No. stocked	Total wt stocked (kg)	Avg. wt at stocking (g)	No. harvested	Avg. wt at harvest (g)	Gross Yield (kg)
Common carp	75828	454	6	11783	374	4407
Silver carp	11060	70	6.3	4358	148	645
Bighead carp	21600	144	6.5	10381	289	3000
TOTAL						8052

Table 17 Fish stocking and harvesting regime at D1 hamlet, Thanh Thanh commune, Vinh Tanh District, Can Tho 2009 (19ha, 11HH)

	No. stocked	Total wt stocked (kg)	Avg. wt at stocking (g)	No. harvested	Avg. wt at harvest (g)	Net yield (kg)
Common carp	26640	222	8.3	8877	176.7	1346.5
Bighead carp	12065	95	7.9	7791	235.5	1739.9
TOTAL						3086.4

Table 18 Fish stocking and harvesting regime at Kinh Hoi 6th hamlet, Truong Xuan commune, Thap Muoi district, Dong Thap province 2008 (90 ha, 15 HH) Stocked 16-25 Aug 2008.

	No. stocked	Total wt stocked (kg)	Avg. wt at stocking (g)	No. harvested	Avg. wt at harvest (g)	Gross Yield (kg)
Common carp	172,800	266	1.54	11428	200.8	1949.7
Silver carp	7956	34	4.27	3271	160.5	525
Bighead	23200	80		11731	295.8	3470
TOTAL						5944.7

Table 19 Fish stocking and harvesting regime at Kinh Hoi 6th hamlet, Truong Xuan commune, Thap Muoi district, Dong Thap province 2009 (120ha, 7 HH) Stocking 15-26 August 2009

	No. stocked	Total wt stocked (kg)	Avg. wt at stocking (g)	No. harvested	Avg. wt at harvest (g)	Gross Yield (kg)
Common carp	172,215	445	4.3	8370	259.5	2172
Bighead carp	86978	446	4.6	28,670	273.8	7850
Grass carp	15200	40	2.7	2808	284.8	800
TOTAL						10822

Results and Discussion

In the first year of fish culture, yields of 235.9kg/ha and 242kg/ha were achieved at Thoi Trung hamlet, in groups 1 and 2 respectively. Yields of 1937/ha were recorded at Tan Cuong, However, the sites were relatively small with few households involved. During these early trials, red tilapia, grass carp, silver barb and snakehead all showed poor survival and were not stocked in subsequent years.

Survival rates of all species rarely exceeded 50%, with bighead carp occasionally showing the best performance, particularly in the early trials. Poor survival was frequently attributed to the small size of fingerlings at stocking.

D1 hamlet saw the most favourable yields compared with other project sites between 2006-2009, ranging from 124kg/ha to 179kg/ha. However, poaching, low survival rate of red tilapia, grass carp, and snakehead, low water levels and short grow-out period were cited as the main constraints to higher production. Small fingerling size and conflicts with other resource users undermined production at Truong Xuan (Joffre et al. 2010 – tech paper).

Capture of wild fish continued to make a significant contribution to the productivity of the flooded area during the fish culture intervention, with the catch dominated by snakehead, climbing perch, catfish and silver barb. In the Vietnamese Mekong Delta, previous studies showed wild fish productivity in rice fields of 118 kg/ha/season (Dey et al, 2005) and between 53 and 76 kg/ha (Rothuis et al, 1998a). Only at the Truong Xuan site, the wild fish catch was estimated to have increased by four to five times compared to the previous years, with farmers explaining that wild fish cannot migrate to canals when the flood is receding. The effect of enclosure on fish migration and rice field fish productivity needs further investigation (Joffre et al., in prep). When the water level became low enough to make the boundaries of individual rice fields visible, wild fish caught within the boundaries belonged to the rice field owner, and were not recorded as part of the community-based fish culture harvest.

Table 20 Production (kg), yield (kg/ha) and economic results of the community based fish culture. (1USD = 17,429 vnd in 2008 and 2009; 1 USD = 16,000 vnd in 2005, 2006 and 2007) (Adapted from Joffre et al., forthcoming)

	Year of culture	Site (ha)	Cultured Fish production (kg)	Cultured fish yield (kg/ha)	Wild fish production (kg)	Wild fish yield (kg/ha)	Operational cost (USD/ha)	Gross Return (USD/ha)	Net return (USD/ha)
D1	2006	65	11,271	173		m.d	74	70	-4
D1	2007	65	8,052	124	2455	38	39	80	41
D1	2009	19	3,403	179	589	31	90	63	-27
C2	2007	48	5,511	114	480	10	65	78	13
Trung Phu B	2007	39	4,935	126	39	10	21	37	16
Hung Binh	2007	26	2,191	84	208	8	50	27	-23
Truong Xuan	2008	96	5,900	61	3552	6 + 31 ^a	31	25	-6
Truong Xuan	2009	120	10,822	90	2520	9+12 ^b	32	23	-8
Trung Phu B small group	2008	3	660	220		m.d	19	72	53
Trung Phu B Individual (n=3)	2008		129 – 500	184-333		m.d	18-65	31-162	13-97

a): 6 kg/ha harvested by the group and 31 kg/ha estimated harvest by landowners when the water level was lower than rice field's dike.

m.d: missing data

b) 9 kg/ha harvested by the group and 12 kg/ha estimated harvest by landowners when the water level was lower than rice field's dike.

Cambodia

Cambodia's fresh water capture fisheries rank as the fourth most productive worldwide behind China, India and Bangladesh. The annual production is between 300,000 to 400,000 tones, 235 000 tones of which come from the Tonle Sap lake. According to Baran (2005), Cambodia has the most intense inland fishery in the world with 20 kilograms of fish caught per capita per year. Fisheries play an important role in the Cambodian economy. The fishery GDP in 2003 was US\$442 million or 12% of the total GDP. The estimated value at landing is between US\$150 million and US\$200 million.

Six million people, or 50% of the population, are employed full or part time in fisheries. Seventy five per cent of animal protein in Cambodia is supplied by fisheries (Ahmed et al, 1998). More recent figures estimate the percentage to be as high as 85% (FiA pers. com.). According to the Fishery Law (2006)^[1], fishing practices are classified into three type of fishing gears: small-scale fishing gears, middle scale and large scale (industrial) fishing gears.

Small scale fishing with hook, spears, or traps takes place in rice fields, reservoir lakes, rivers or inside Fishing Lots. The commercial fishing lot system in Cambodia has been in place since the French Protectorate. Based on auction to acquire the right to exploit the fishing lot geographically defined (river location, stretch of river, river beach or temporarily flooded land, for a duration of 2 years. Middle scale fishing is operated in open access areas using gill nets, round or seine net. Industrial fishing requires a license

(auctioned out by the government to private business for 2 years) to fish in designated areas called "Fishing Lot" using set nets and weirs.

Industrial and middle scale fishing are conducted for commercial purposes while small scale fishing is recognized as a subsistence activity. However, small scale fishing contribution is estimated to be around 60% of the total inland fishery. Rice fields and seasonal wetlands, with production estimates of 5-150 kg/ha (Gregory et al., 1996; Gregory and Guttman, 1999) can potentially support a fish production over 100,000 t year.

Community-based approaches to fisheries management have been increasing since 2001, when more than 50% of the Fishing Lots⁶ were released for public access, instead of auctioning to private entrepreneurs. Up to 2005, 56.46% of fishing lots have been released for small-scale fishers. The Royal Decree on Establishment of Community Fisheries was signed on 29 May 2005, and a Sub-Decree on Community Fisheries Management was promulgated on 10 June 2005 and 440 community fisheries management mechanisms are currently in place according to official statistics. However, as Ratner (2006) notes, community-based organisations lack capacity to manage the resource, as they cope with problems related to the implementation process, legal framework and governance mechanisms.

The Cambodian landscape can be loosely divided into the central floodplains in the center and southern part of the country, and the hills and highland areas. The floodplain occupies around 60% of the territory, with the Tonle Sap lake (or Great Lake) covering between 2,700 to 12,000 km² according to the season. The introduction of community-based fish culture into this environment represents an attempt to enhance productivity from floodplain resources, with the objective of providing an additional source of employment, income and nutrition to rural households with access to floodplain resources.

Methods

Institutions for Community Based Fish Culture

Selection of participants was done on a voluntary basis, including landowners in Chroy Proan. At all sites, benefit sharing was done according to membership and including a share of 10% for the poor household of the village in Chroy Poan and Pom Eith.

The process of community-group formation began with a stakeholder meeting, facilitated by NGO workers, attended by village representatives as well as local authorities and local FiA. The meeting was intended to introduce the project to members of villages that had been identified as potentially suitable locations for CBFC. This was followed shortly after by a meeting to present and discuss the project with the different stakeholders at the village level. Villagers interested to join the group were able to register for participation in the project. Participants then met to discuss group activities, and the terms under which fish culture would be operated, facilitated by FiA staff. This meeting also provided an opportunity to determine the contribution of each stakeholder group to the fish culture activities, and to negotiate benefit sharing agreements. The technical aspects of fish culture were explained to the group members and contributions of the members for materials and labor was agreed. The contribution varied according to site, with 2.5, 3 and 5 USD in Pom Eith, Thnal Kaeng (or the equivalent in bamboo for fence construction) and Chroy Poan respectively.

⁶ The commercial fishing lot system in Cambodia has been in place since the French Protectorate. Based on auction to acquire the right to exploit a geographically defined fishing lot (river location, stretch of river, river beach or temporarily flooded land, for a duration of 2 years).

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The Fisheries Administration at the central and cantonment level was in charge of project implementation, including site selection, facilitating and supporting the Community Based Organization and providing technical support to fish culture groups.

Both in Prey Veng and Takeo provinces, site selection and the first stakeholder meetings were facilitated by NGO's working in the area for several years. In Prey Veng, CARE International and Chamroeun Cheat Khmer (CCK) in Takeo Province, help the project by providing information on the local context and livelihood. However, after the starting phase, NGO's ceased to play a role in fish culture implementation.

Technical Design

Community-based fish culture trials were initiated at four sites in the southwestern region of Cambodia, close to the border with Vietnam. Seasonally flooding areas of Takeo and Prey Veng provinces were chosen for the intervention, where flood height and duration was considered sufficient to support fish culture activities.

In Takeo province the flood amplitude is higher than Prey Veng with flood waters reaching depths of 1.5 to 2 meters, while in Prey Veng study sites the water level ranges from 0.8 to 1.5 m. Production systems in the villages are based on rain fed rice culture (yield ranging from 0.7 to 1.7 t ha⁻¹) with some HYV irrigated rice (1.5 to 3.6 t ha⁻¹). Water management infrastructure is limited to reservoirs used to irrigate downstream rice fields in three of the sites (PE, TK and PT villages). Irrigation systems with canals are not well developed and in both provinces only 30 and 32% of the rice cultivation area are irrigated in Prey Veng and Takeo provinces respectively. At the project sites, irrigated rice is not common and areas cultivated are small, with less than 0.5 ha/HH in general (Joffre et al. 2010, in prep).

The culture sites ranged in size from 0.7 to 2.5 ha and were delimited by net fencing, limiting the size of the cultivated area due to the vulnerability of the fence during heavy flood. The stocking density was between 1.4 and 2 individuals with feed provided (rice bran, insects or duck weed), collected at the village level. Species stocked included silver barb (*Barbonymus gonionotus*), silver carp, tilapia (*Oreochromis niloticus*) and Indian carp (*Catla catla*). Only in one case (CP) the enclosure for fish culture partially used an existing dike, in which both rice fields and a seasonal water body were included in the cultured area. In one other site (TK), the enclosure was made of a net within a permanent water body while at the third site (PE) an enclosure was within a rice field area, within the flood plain (Joffre et al. 2010)

Figure 5 Flooded rice fields at the Chroy Poan project site, Takeo, Cambodia

(Photo: O.Joffre)

Floodplain Refuges

An additional research component was introduced in Cambodia in response to difficulties encountered in the implementation of community-based fish culture. Recognising the need for significant inputs of labour and resources, in addition to community-leadership and motivation to support aquaculture on a collective basis, floodplain fish refuges were piloted. Floodplain fish refuges incorporate elements of fisheries management and aquaculture, involving the stocking of fish in a managed environment, but with greater support from government agencies and less responsibility devolved to the community. The establishment of floodplain refuges across Cambodia is a government priority which the project has sought to support, providing guidance in the form of lessons learned and guidelines for best practice based on experiences from the current projects and previous initiatives to establish fish refuge ponds.

Refuge ponds are based on the principle of flood pulse. During the flood, inundated rice fields become a spawning ground for fish. When the water level recedes in the flood plain, fish migrate to deeper water areas. Providing refuges for fish during the dry season contributes to stabilizing fish resources in rice fields, considered as a common pool resource providing benefit to rural households highly reliant on rice field fisheries.

The refuge ponds are collectively managed by the community, which can include one or more villages, according to the size of the water body. The management body is composed of an Executive (3 to 5 members) elected by General Assembly. A by-law including roles and responsibilities of the members and other management rules is created. An agreement between the CFR Executive and FiA for the allocation of the fishing area is also established in the presence of local authorities (Commune and district). The main duties of the group are night watch, management of fish pathways, pond and dike, release of fish and meetings. Fish species released are captured brood fishes, snakehead (*Channa striata*), catfish (*Clarias batrachus*).

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In 2009, the Community-based fish culture project supported the formation of 3 CFRs, in Takeo (Kol Korm village), Svay Rieng (Prey Kiev village) and Prey Veng (An Soang village) provinces based on a site selection done in collaboration with local partners. The selection criteria included willingness of villagers to participate, presence of perennial water body, distance from the river and connection to flooded rice fields. During the implementation process community based organizations were formed in each site to manage the refuge pond and a 6 months planning was drafted. The Community Based Organization (CBO) was formed with an executive community elected during a general meeting with villagers (30-40 households present) where the different responsibilities of each member were defined, primarily patrolling activities. In each site, once the CBO was formed, 50 kg of broodstock was stocked and additional 12,000 fingerlings were stocked in one site (Kol Korm, Takeo Province).

Results and Discussion

Floodplain aquaculture in Cambodia did not achieve levels of production sufficient to generate a benefit for project participants. Environmental factors including flooding and late arrival of flood waters, reducing the grow-out period, undermined fish production. Vandalism of fish culture enclosures also led to high losses, and subsequently negative returns on investment were recorded at each site.

Wild fish productivity in enclosures was low (less than 40 kg/ha) compared to other studies, where rice field productivity was estimated by Gregory et al. (1996) to reach 125 kg/ha in southeastern Cambodia (Joffre et al. 2010 – tech paper). However, the presence of predatory wildfish limited aquaculture production and was reported by farmers as one of the constraints to production, contributing to low survival rates of stocked fish.

Table 21 Production (kg), yield (kg/ha) and economic results of the community based fish culture. (4,074 riels in 2007 and 2008) (Adapted from Joffre et al. in prep)

	Year of culture	Cultured Fish production (kg)	Cultured fish yield (kg/ha)	Wild fish yield (kg/ha)	Operational cost (USD/ha)	Gross Return (USD/ha)	Net return (USD/ha)
Cambodia							
Chroy Poan	2007	55	55	md	878	88	- 790
Chroy Poan	2008	34	20	m.d	935	-	- 935
Pom Eith	2007	30	12	m.d	515	-	-515
Thnal Kaeng	2007	-	-	m.d	1,116	-	-1,116

From an economic point of view, the operational cost per hectare of fish production in Cambodia was high due to technical factors (high stocking density) and to the high price of fingerlings (US\$3.55 to US\$4.71/kg). Higher costs combined with low production resulted in negative net returns. In order to reach economic sustainability the productivity of the model of community based fish culture in Cambodia needs to yield more than 200 kg per hectare in this specific socioeconomic context (with an average selling price of 2.5 USD/kg for Common carp).

With a low production, the market was limited to the village. Meanwhile, marketing constraints can be expected in Cambodia if fish production exceeds demand at the village level, with very poor market linkages at most of the project sites. In general, market linkages are absent in Cambodia. In addition, access to knowledge, inputs and

especially fingerlings is difficult, with the few existing aquaculture ponds stocked with wild fingerlings (Morales et al. 2007).

Low fish production in Chroy Poan and Thnael Kaeng project sites was also related to conflict for resource use, resulting in vandalism of the enclosure, allowing fish to escape. Conflicts were generated by the exclusion of traditional users from the open water body (in Thnael Kang) or were due to older conflict concerning the use of water (Chroy Poan). The technical setting of the enclosure made of poles and nets could be easily damaged. In addition, this model is also highly dependant on the flood pattern, with delayed flooding impeding fish stocking in Pom Eith and Thnael Kaeng (2009) or on the contrary, too high water level, resulting in water run off and fish escape in Pom Eith (2008).

These different factors, technical, environmental, governance and economic explained the low productivity of the fish culture site in Cambodia and the low economic return of the model.

Concerning Floodplain Refuges, the different sites implemented activities following broodstock and fingerling stocking in 2009. Communities followed the action plan developed during project implementation but adequate monitoring mechanisms were not put in place to assess productivity and impact.

Meanwhile, collective approaches for floodplain refuges were interesting and highlighted the importance of local authority's involvement and the assessment of previous users of the area for the success of the collective action. Other similar experiences need to be reviewed in order to understand the conditions for collective action in this specific context of fish refuges since the development of sanctuaries and floodplain refuges became a priority of the Royal Government of Cambodia.

China

Methods

Community-based fish culture was implemented in Heqing county, Yunnan Province and Huaian county in Jiangsu. Yunnan is a province located at the southwest of China, bordering Myanmar, Laos and Vietnam with a population of 44,830,000 located mostly in the eastern part of the province. Heqing is a county located in the Dali Bai Autonomous Prefecture, northern Yunnan. The county sits in a valley surrounded by a series of mountains and 108 of freshwater lakes, rich in mineral and water resources. Fish culture is a supplementary activity to farming. Two sites were selected for the intervention, in Mutun and Taiping. Mutun is relatively better off than Taiping in terms of natural resources, employment and clean water supply and an average net income per household is between RMB1475 (USD 216⁷). Around 25% out of 514 households have household based fish culture pond in Mutun. Silver art, quarry stone, metal workshops and a knife factory provide plenty of labor opportunities to the people around the village, especially during non-peak agriculture season. People work as temporary workers to earn a living, farming just sufficient amounts to provide for the household. In addition, 5-10% of young men from both villages work permanently in other towns including Zhong Dian (Shangrila) and Lijiang (heritage town) in construction and tourism.

Jiangsu is one of the fastest growing provinces in China; it houses many famous cities such as Shanghai, Wuxi, Nanking and Suzhou. The two villages selected for community-based fish culture trials, Liangzhuang and Baihu, are considered as agriculture villages. However, most of the households have more than one income generating activity. Given that the two villages are close to the town, most people are engaged in wage labor, driving, small business and some have gone to work in big cities in the country. Farming

⁷ At a rate of USD 1= CNY 6.84

is usually done by the women or old people in the home. About 70% of aquaculture in this area concentrates on crab culture. Compared to Yunnan, income per farmer in Jiangsu sites is almost 70% higher. The mission of the village is towards advanced technology and economic development.

Both provinces were first recommended by the provincial fisheries bureau because of the prevailing hydrological conditions, existing aquaculture infrastructure, willingness of local communities to participate in the project and high levels of support from the local authorities. Both project sites (4 villages) are directly connected to sufficient water supply from the river. Mutun and Taiping are connected to Haiweihe; Liangzhuang and Baihu to Baimahu lake and Yinhe River, which is also connected to the China South-North Canal. Water can be supplied to the farms anytime by just opening the sluice gate. In Yunnan province, Mutun and Taiping village in Heqing County were selected mainly due to the good hydrological criteria and established aquaculture experience. In Jiangsu, Baihu and Liangzhuang village were selected to make use of the established irrigation canal and plentiful source of water supply.

Table 22 Characteristics of project sites in China

Village	Mutun	Taiping	Liangzhuang	Baihu
County	Heqing	Heqing	Chuzhou	Chuzhou
Prefecture/ District	Dali	Dali	Huaian	Huaian
Province	Yunnan	Yunnan	Jiangsu	Jiangsu
Type of fish culture	Lotus Nursery Pond	Lotus Nursery Pond	Canal	Canal
Size of culture pond/canal (ha)	20	10	5.3	2.6
No. of HH involved	514	384	36	36

Institutions for Community Based Fish Culture

In China, the community-based fish culture model was adapted to create a system based on pooling of resources (land and/or labour) by community participants with the overall management of fish culture overseen by one or two households, who received a greater share of the benefits in return. In Yunnan, the project shared 1/3 of the fingerlings cost with the contractor whereas the contractor managed the whole process of fish culture inclusive of pond cleaning, water pumping, feeding, security and fish quality. The contractor was selected based on his experience of fish culture, willingness to join the project and the suitability of his pond to support fish culture. The contractor began fish culture three years prior to the start of the fish culture project. He is a migrant from a fishing family in Dali Municipality. The village head acted as the middleman between the contractor and villagers in negotiating disputes and communication. Unlike the community-based fish culture system in Bangladesh, villagers in Yunnan did not work together in fish culture, instead they handed over responsibility to the contractor, who had the skill and experience to manage the pond and fish culture. All households in each of the communities received a share of the benefit from fish culture either in cash, kind, services and facilities improvement.

In Jiangsu, instead of a contractor, the village committee hired a caretaker within the project committee to manage the fish culture process. The beneficiaries worked together in stocking and harvesting of fish, and the caretaker was responsible for feeding, security, disease control, cleaning and water quality checking. He is an experienced fish culturist compared to other villagers. He has owned fish culture ponds for many years ago and the Village Committee had trust in him. Besides a fish culturist, he is also responsible for water management in the village. When the farms need to be irrigated, farmers will coordinate with him for water releasing.

In Mutun village, where fish were stocked in a flooded rice nursery/lotus pond, the system was designed in such a way since the nursery pond is private property, to which all villagers have had the right of access for 30 years. The Village Committee (VC) consists of a village head, a secretary and members who hold the authority over the nursery pond and approves the leasing contract to auctioneers. Instead of sharing the land lease income with villagers, the VC uses it for rural development and at the same time reduced the annual fee villagers are required to pay to the VC.

Table 23 Benefit sharing arrangement in Yunnan province

Stakeholder in Yunnan Province	Share
Village Committee (Project management team) and farmers	50% of net profit
Care taker (contractor)	50% of net profit

Villagers and the contractor came to an agreement regarding the sharing of benefits during the first project implementation meeting. After deducting the cost of water pumping, dike repairs, contract fee and subsidy to the contractor, the net production value was divided into two portions. The contractor received 50% and another 50% was shared between farmers and the Village Committee. The beneficiaries received the benefit either in cash or in kind, as fish. Each household was required to contribute two workers for two days in each peak agriculture season, usually from May to June, for dyke maintenance, well digging and pond cleaning in Taiping village. Villagers also contributed funds for rural facilities development and maintenance of infrastructure. Additionally, they are required to pay RMB20 (USD 3) for water pumping services. Alternatively, households without young people at home to contribute labour could instead pay RMB25 (USD3.6) for a worker per day. In Mutun, approximately RMB100 (USD 14.6) was collected by the VC for such services. Through the fish culture project, farmers were allowed to replace it with their share of the fish from the project, to cover their contribution to village labour costs. In Baihu and Liangzhuang, participants were selected in a different way. A total of 36 farming households who use the canal for farm irrigation were selected to participate in the project in each village. Before the implementation of the project, the canal was only used for irrigation; none of the users had considered stocking fish in the canal due to lack of experience and confidence. A project management committee was established and a pond keeper was selected among the canal users to manage the fish culture process. The project management team consisted of 5 to 6 people from the Village Committee, fisheries bureau and village representatives. Farmers worked together in fish stocking and harvesting, while the pond keeper was responsible for feeding, cleaning, water pumping, security and fish quality.

The Deputy Director of the Chuzhou Agriculture, Forestry, Fisheries and Animal Husbandry Bureau in Jiangsu determined the benefit sharing system in Jiangsu. All participants, inclusive of the village committee and villagers, were invited to join the scheme. Unlike in Yunnan province, benefits shared in Jiangsu were based on the distribution of fish to individual households, rather than on the provision of community services.

Stakeholder	Share
Project management team	50kg of grass carp/year/person
pond keeper	RMB100/mu/year ⁸ , convert the value into quantity of fish
Participating farmers	<p>Farmers get remaining fish after distribution of benefits to the management committee and the care taker. The share per household is based on the area of land the household owns in the project site. Example:</p> <p>Household A owns 12 mu of land in the project site, which is 0.5% of the total land area.</p> <p>Remaining fish: 6000kg to be distributed to farmers. Portion of the share for household A would be 6000kg*5%, which is 300kg.</p>

In this project, the local fisheries bureau was the main party to oversee the project in the village. The village head from the Village Committee acted as a point of contact between the provincial partner and the villagers. An ad-hoc project committee consisting of village committee and representatives from the village was set up to ensure the smooth running of this project. The fisheries bureau, village committee and the project management group worked together to manage the project, engage in conflict resolution, strengthen project management capability and skills for the contractor, village committee and the people in the management group, provide technical guidance in aquaculture and implement an equitable benefit sharing system. Fisheries experts from the local fisheries extension station visited the sites each week to check the progress of the fish culture, water quality, feeding and assisted the contractor in the prevention, identification and treatment of fish disease.

Technical Design

In Jiangsu province, fish were stocked in an irrigation canal. The size of the canal for Liangzhuang is 79.5mu (5.3 ha) while for Baihu is 39.5mu (2.63 ha). Prior to the introduction of the fish culture project, the only function of the canal was irrigation. The entire canal system starts from Baimahu lake, 3.5km from the south and supplies water to the whole Nanzha township. All land owners of the surrounding paddy fields participated in the management and production of the fish culture, with one of the households assigned as a care taker of fish production in the canal.

In Yunnan, locally preferred species such as common carp, crucian carp, grass carp and silver carp were stocked and harvested for the three consecutive years. Common carp and grass carp were stocked in rice nursery ponds in Mutun village in July. The size of the nursery pond is 25mu (1.67 ha), surrounded with 300mu (20ha) of paddy field and lotus pond. The ponds are dry in winter and flooded from June to October. Farmers start sowing paddy in May when the rain season begins. Fish were grown in the nursery pond until August, and released to the flooded rice field for faster grow out. In November when the water receded, the fish were guided back to the pond and harvested in January. Unlike Mutun, common carp, grass carp and crucian carp were stocked in the pond for the entire culture period in Taiping.

⁸ 1 mu = 0.067 ha

Figure 6 Fish stocked in flooded nursery ponds, Mutun village, Yunnan, China

Fingerlings were supplied by a private hatchery in Heqing town. The project subsidized one third of the fingerlings and the rest were supplied by the contractor. The survival rate for the first year of stocking was 65%. Survival of crucian carp was particularly low due to the low water temperature and short culture period. Low temperatures from March to May precluded farmers from stocking larger fingerlings at a lower cost earlier in the year, so they were forced to stock fish later than June, when water temperatures were more conducive to fish growth. Fish stocking was also constrained by a lack of available fingerling supplies in the spring. Villagers also preferred to provide grass as feed rather than artificial feed, for better quality of health for fish and to maintain the quality of the sediment in the paddy field.

Table 24 Stocking species and quantity in Yunnan province, 2007 – 2009

Village	Species	2007		2008		2009	
		Quantity (kg)	Size/ fish (g)	Quantity (kg)	Size/ fish (g)	Quantity (kg)	Size/ fish (g)
Mutun	Common carp	300	200	400	200	300	400
	Grass carp	160	300	250	300	0	0
Taiping	Common carp	700	300	900	300	900	400
	Grass carp	250	300	400	300	750	600
	Crucian carp	53	100	0	0	0	0

Compared to Yunnan, survival rate in Jiangsu province was 5-10% higher. In addition to grass, the fish were fed with artificial feed, which was about 7-8kg per mu.

Table 25 Stocking species and quantity in Jiangsu province, 2007 – 2009

Village	Species	2007		2008		2009	
		Quantity (kg)	Size/ fish (g)	Quantity (kg)	Size/ fish (g)	Quantity (kg)	Size/ fish (g)
Liangzhuang	Common carp	0	0	119	50	238	56
	Grass carp	517	100	588	125	477	125
	Bighead carp	40	63	49	63	48	71
	Silver carp	159	45	120	50	119	56
	Mandarin carp	0	0	795 fish	5-7cm	795 fish	5-7cm
	Crucian carp	194	71	0	0	0	0
	Common carp	0	0	54	50	106	56
Baihu	Grass carp	231	100	267	125	213	125
	Bighead carp	18	63	22	63	22	71
	Silver carp	71	45	54	50	52	56
	Mandarin carp	0	0	355	5-7cm	355	5-7cm
	Crucian carp	86	71	0	0	0	0

Results

Table 26 shows the net production of fish in Yunnan project sites, where the cost of production was excluded. The production cost included RMB5000 (USD 731) for water pumping, RMB2000 (USD 292) for flood prevention and dike repair, RMB5000 (USD 731) of contract fee and RMB6000 (USD 878) of subsidy to the contractor in each intervention year. Small scale and less intensive fish culture system did not bring high production of fish in Yunnan. No artificial feeds were used because villagers preferred an organic fish production process. Yield was low in the first year of intervention due to the decline in water temperature in the pond. Changes in the climate, including melting of snow bringing unpredictable and sudden flooding and very cold water, and a longer than usual winter caused the low survival rate of the fish. A large flood also occurred in 2008, resulting in fish escapes and high mortality. Poaching also reduced fish production, with an estimated loss of 100kg in year 2007 and 1000kg in year 2008-2009. Fish production was extremely low in year 2009 in Mutun due to the low quantity and less variety of species stocked.

Table 26 Net production in Yunnan, 2007-2009

Pond size	Mutun						Taiping					
	2007		2008		2009		2007		2008		2009	
Fish Production	RMB	KG	RMB	KG	RMB	KG	RMB	KG	RMB	KG	RMB	KG
Total	23000	2100	24400	2400	3800	700	53400	3800	57000	4500	43400	3600
Contractor	11500	1050	12200	1200	1900	350	26700	1900	28500	2250	21700	1800
Farmers share	5500	305	6200	387	0	0	14700	815	16500	1031	9700	692
Public fund	6000	700	6000	813	1900	350	12000	1085	12000	1219	12000	1108
Production/ha(kg)		105		120		34.5		380		450		360

*Note: Production data shows in this table only reflect 1/3 of value and quantity of total production from the aquaculture pond in Mutun. Another 2/3 of production was belongs to the contractor alone.

Production in Jiangsu was higher and farmers received more income compared to Yunnan, the main reason was due to the provision of artificial feed. On average 7.5kg of feed per mu.

Table 27 Quantity of stocking and feed used, 2007-2009

	2007		2008		2009	
	Liangzhuang	Baihu	Liangzhuang	Baihu	Liangzhuang	Baihu
Stocking (kg)	909.5	405.5	876	395.5	882	393
Stocking kg/mu		11.4		11.1		6
Feed (kg)	5760	2330	6210	2570	6400	3000
Feed kg/mu	6.6	7	7	7.8	7.4	9

The relatively short distance between the project sites and the nearby towns of Chuzhou and Nanzha, approximately 2km away, was an advantage to the farmers as well, as they had convenient access to fish culture information and guidance provided by the Chuzhou Agriculture, Forestry, Fisheries and Animal Husbandry Bureau. Production cost in Jiangsu was also much lower than Yunnan, as farmers worked together for stocking, harvesting and flood prevention. They did not pay a contract fee to the land owner.

Table 28 Production in Jiangsu, 2007 -2009

Pond size	Liangzhuang						Baihu					
	2007		2008		2009		2007		2008		2009	
Production	RMB	KG	RMB	KG	RMB	KG	RMB	KG	RMB	KG	RMB	KG
Total	NC	9960	NC	10481	NC	12130	NC	6430	NC	5285	NC	5617
Yield/ mu	NC	129.7	NC	131.8	NC	152.6	NC	135.1	NC	154.1	NC	161
Pond keeper	7950	828	7950	795	9540	867	3550	370	3550	355	4260	387
Farmers share	NC	8881	NC	9436	NC	11013	NC	3965	NC	4630	NC	4930
Management team	2400	250	2500	250	2750	250	2880	300	3000	300	3300	300
Production /ha (kg)		1879		1978		2289		2442		2007		2133

*Note: NC means data was not recorded

Impact on wild fish and other aquatic resources

Fish culture has improved the production of lotus in Yunnan sites, especially Taiping village. Both villages reported a 5% increase in the lotus production for the last three years. The yield per mu was approximately 70kg with the market price of RMB3 to RMB4 (USD 0.3-0.6) per kg. At the same time, fish in the pond helped eradicate insects harmful to the lotus root. Improved security provided by the caretaker had also helped reduce the theft of lotus flowers, at the same time reducing disturbance to the lotus root.

In terms of wild fish, farmers have free access to wild fish on their portion of land. The amount of fish was low and only sufficient for household consumption. In contrast to the outcome in Bangladesh, production of wild fish in Jiangsu province was not significant.

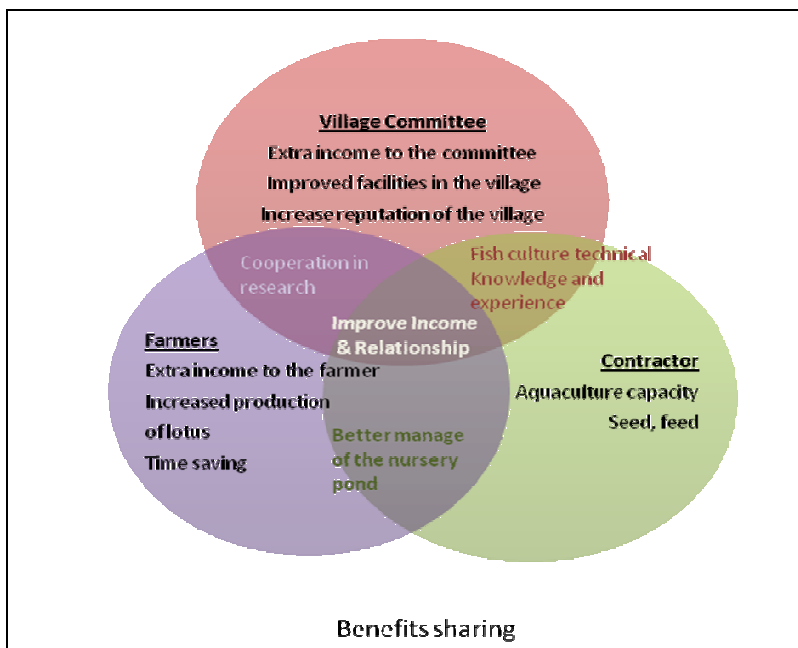
Benefit sharing

In general, community-based fish culture in China did not bring about a significant change in terms of income and livelihood for beneficiaries, as the monetary benefit was not sufficient to improve the income and lifestyle of the household. According to the management team, the income generated by each intervention was about 0.01% of the total household income. However, it did generate social benefits, such as creating additional funds for social welfare and rural development, at the same time decreasing the amount each household needs to contribute yearly. It has also improved the relationship between village committee and the villagers, and increased the reputation of the village and opportunity for the rural community to be exposed to international research approaches. Moreover, it has increased the production of lotus in Yunnan province and utilized the irrigation canal to generate more benefits in Jiangsu province.

In terms of output, many more households in Taiping chose to receive their share of production when compared to Mutun. As mentioned earlier, Taiping is relatively poor compared to Mutun and fish is a luxury protein for the villagers. They trusted the quality of the fish produced by the project. Without the project, a household usually purchases fish less than 10 times in a year. Most households purchase fish less than 5 times per year. The average weight of fish purchased was rarely more than 5 kg, 1-2kg for a small family, and it could be used for 2-3 meals. Fish is much more expensive compared to chicken and pork, which are all home produced. Households received only a small amount of fish from the fish culture intervention, approximately 5kg per households.

Most of the farmers shared the fish they got from the project with their family and friends, as it was not sufficient to be sold in markets for income in Jiangsu province.

Figure 7 Summary of benefits sharing among stakeholders in Yunnan Province



Generally, communities in Yunnan wished to continue fish culture, the main reason being easy access to eco-friendly protein at a lower price. Additionally, this is a good activity for unemployed household members.

Although the production of fish in Jiangsu was high, the value was not important to the farmers. Compared to their income from other sources, the value contributed by the project was less than 0.01% of the total household income. Community based fish

culture system was considered as an outmoded approach which is not suitable for the current situation in Jiangu. Commercial, large scale contract systems are the current priority for development.

Mali

The Inner Niger River Delta in Mali encompasses a 30,000 km² area bordering the Sahara Desert that undergoes an annual cycle of flooding and drought (Kone 1985, Dicko et al 2003). The flooding (during Sept-Oct) provides fish with an immense, nutrient-rich spawning ground, and this bounty is then captured by fishers during the season of declining water levels (Nov-Mar) (Welcomme 1986, Lae 1992). In some areas, natural flood plain reservoirs (known as mares) prolong local communities' access to these valuable resources well into the drought period (Apr-June), providing them with protein and income, as well as social/cultural networking opportunities during the season when most households face significant shortages (USAID 2008). The droughts of 1973 and 1978 had catastrophic impacts on local livelihoods, forcing many families to increasingly send family members on seasonal migrations to cities in order to reduce the burden on household food supplies.

The community-based fish culture intervention in Mali provides local communities, NGOs and NARES with a model for increasing the productivity of mares, which represent the primary source of income for most households during the dry season. The project intended to conduct the trials in two different communities (Severi and Komio), however a close analysis of local institutions uncovered a certain amount of institutional ambiguity concerning the access rights regimes to the mares at Severi, and the decision was made to limit the trials to Komio village alone. Based on a thorough analysis of local livelihoods, institutions and ecological conditions, this project introduced a low-cost aquaculture pen design in a small portion of Komio's largest mare ("Mama Pongu") in 2009. Extensive sensitization activities within the community, and engagement with community leaders helped to ensure that the benefits from the project would be shared by all. An analysis of impacts within the community highlighted a range of positive outcomes, even before the final fish harvest could be completed. The approach and results were disseminated to relevant NGOs and NARES.

Methods

The communities of Severi and Komio are both located roughly 40-45 km from the regional capital, Mopti, with Severi located on a small side arm of the Niger River, called the Mayo Dembe, while Komio village lies on the main Niger River channel. In both villages, access to agricultural land and mares is regulated by the main families descended from the original farming-fishing settlers. In addition, both communities play host to minority groups, particularly from traditional fisherfolk (Bozo and Somono) and livestock herders (Peuhl, Mabo, Diogorame). Over time, the livelihood strategies of the dominant Marka ethnic group and the Somono minority in Komio have diminished significantly with both diversifying into farming-fishing-livestock rearing. To a large degree, the Bozo and Peuhl minorities remain specialist river fisherfolk and livestock herders, respectively.

Technical Design

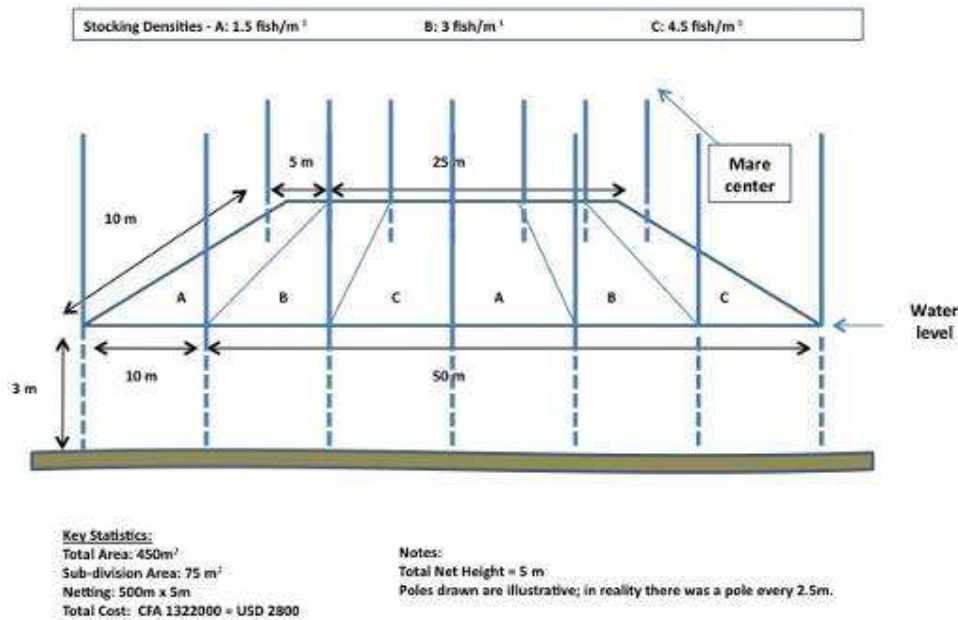
The aquaculture enclosure was located in the deepest portion of Mama Pongu mare in order to avoid damage from livestock passage and to ensure sufficient water availability into the dry season. The total enclosure area covered 450m², and was subdivided into six equal trial pens (75 m² each), each of which had a trapezoidal shape to allow fish maximum access to vegetation at the shallow ends of the pens during the dry season (see Figure 8). The construction was made of high quality 1-inch mesh multi-filament netting purchased in Mopti, and wooden poles purchased from a nearby village. The pens

were stocked with hatchery reared Tilapia (*Oreochromis niloticus*) fingerlings that weighed an average of 30g at the time of stocking. Three stocking densities were tested (twice): 1.5 fish/m³, 3 fish/m³, and 4.5 fish/m³, as calculated by the volume of water available during the more resource-limiting dry season depths estimated at roughly 1m. An extra 10% of fingerlings were added to each enclosure to compensate for potential mortality inherent in the process of transporting and transferring the fingerlings into the enclosures. No other inputs or feeds were supplied to the enclosures during these trials.

Institutions for Community Based Fish Culture

As part of this project, an analysis of local institutions was conducted (Russell and Coulibaly 2009) in order to ensure that the project’s intervention in this community did not exacerbate existing tensions or reinforce any pre-existing inequalities. This analysis indicated that the village leadership enjoys high levels of community support due to its transparency and effectiveness in management of the village irrigation scheme as well as a community development/revolving credit fund. The committee comprises the village chief and the representatives of the other main resident Marka, Somono and Bozo families, and given their success in managing these other collective community goods, the project decided that this group would be the most appropriate group to manage the aquaculture project. Upon harvesting the fish from the enclosures, the fish will be partly distributed among the families of the village, and partly sold for investment into the community fund. The main groups that are under-represented in this institution are the “non-resident” Bozo (though they may have lived in Komio for several years) and Fulani (who live on the periphery of the village between migrations. Through our discussions with the leadership, we have emphasized the need to better sensitize and engage with these groups regarding community development activities (including this project’s activities).

Figure 8 Diagram of fish enclosures constructed in Komio village's 'Mama Pondu' mare



Results and Discussion

Due to persistently high water levels in Mama Pondu mare this year, the enclosures could not be harvested before the end of the project. Our monitoring of fish growth in the enclosures revealed unexpected results (see Table 1) with larger average weights and total lengths measured in the fish extracted from the more densely stocked enclosures.

Table 29 Results from a monitoring fish sample in the enclosures (using seines and gillnets).

	1.5/m ³ (seine)	3/m ³ (seine)	4.5/m ³ (seine)	1.5/m ³ (gillnet)	3/m ³ (gillnet)	4.5/m ³ (gillnet)
Sample #	25	19	1	8	9	6
Avg. Weight (g) /St.Dev.	99.52/16.64	121.26/19.41	82/-	91.88/2.90	96.67/2.96	100.50/1.87
Avg. Total Length (cm) /St.Dev.	44.48/21.95	73.11/18.10	30/-	34.25/6.36	38.56/4.30	42.83/2.04

Although the fish have not yet been harvested from the enclosures, and an economic analysis regarding the economic viability of this aquaculture system cannot be fully assessed, the project conducted an analysis of community perceptions with regards to the project impacts so far. Based on extensive focus group discussions with all ethnic and gender groups, we can conclude, that neither the technologies introduced by the project, nor the processes used for sensitization and research activities had any negative impacts on any group within the community. The only short-coming cited was that the project was not able to fund infrastructural development within the community. The single most important development objective sought by almost all respondents in the community is the excavation of a channel connecting the mare to the river, which would benefit everyone as almost all farming, fishing, and livestock rearing depends to a significant degree on the water levels in the mare.

An analysis of project outcomes was made using the “Major Significant Changes” (MSC) approach described by Davies and Dart (2005). Having engaged people from both genders in each ethnic group in focus group discussions, a consistent series of outcomes cited revolved around improvements in mare resource governance and community cohesiveness. The two most frequently cited changes were described by two community members as follows:

“In previous years, many families would fish in the mare during the closed season using handnets in order to provide fish for the household meal. Others fished for commercial purposes using gillnets. This year the whole community showed great commitment to the closed season. This was in part motivated by fear that anyone caught fishing in the mare might be suspected of stealing from the pens. We have great hopes that this will result in greater fish catches during the collective fishing event to be held toward the end of the dry season. The economic benefits that we anticipate will benefit everyone and will more than compensate us for the fish foregone.”

“This year because of the enclosures we will have more rice. Usually, there are conflicts between farmers and livestock herders due to their grazing in the fields, however during the last season they have been much more vigilant of their cattle. They avoided grazing in agricultural fields surrounding the mare, making the harvest of crops easier and more bountiful. The herders also limited the cattle entry into the mare, significantly reducing the amount of trampled aquatic vegetation and stirring up of mud in the mare. This year the water in the mare is cleaner than usual, something that benefits people, livestock and fish, and the water levels have endured longer than usual. Therefore, in addition to the

decreased losses due to grazing in our fields, a larger area has been able to support agriculture this year due to the higher water levels.”

While impacts from this project on agricultural production are difficult to calculate, a hypothetical but plausible calculation based on catch data from 2008 can permit us to estimate the potential impacts on fish production in the mare overall (see Table 30). The calculation was made by assuming that 75% of the fish that would otherwise have been caught by poachers at a small size were left to grow and triple their weight by the time of the collective fishing event (2 months later). We find that the overall catch would increase over 100%, but more significantly, we find that the catch per individual participating in the collective fishing event would increase roughly 500%.

Table 30 Potential improvement in fish catch between 2008 and 2010 due to improved mare governance.

Fishing method	Beneficiaries	Tot. Est. catch (kg) 2008	Avg. Catch per person (kg)	Anticipated catch 2010 (kg)	Avg. Catch per person (kg) 2010
Collective fishing	4310	1988	0.48	11,154	2.59
Poaching	1125	3432	3.05	858	0.76
Overall	4310	5420		12012	

Discussion

The impacts of constructing the aquaculture enclosures in “Mama Pondu” mare go well beyond that of the fish production within the enclosures. Most significantly, all focus groups described a number of ways in which this projects’ focus on development and management of the mare resources has increased the community awareness of their reliance on this common resource, and their commitment to improve mare resource governance overall. Consequently, livestock herders have taken greater care in tending their flocks, fishers have limited their poaching during the closed season, and farmers have reduced the amount of vegetation that they extract as fodder for small livestock. Together, these self-imposed measures are expected to have significant impacts on the amount of fish landed during the collective fishing event to be held in June, as well as the productivity of agricultural fields in the area. Community focus groups were also uniformly supportive of continuing these improved governance norms during the years to come.

With respect to the pen aquaculture technologies themselves, pending the final harvest of the enclosures, it is not possible to draw conclusions regarding the optimal stocking density of fish in these ecosystems or the economic viability of these technologies with respect to the fish raised in them. Interest in the aquaculture technologies is high among villagers, and one of the community leaders indicated that he has followed suit and stocked another of the mares with fingerlings. Regional NGOs and other NARES similarly expressed significant interest in this technology, and the outcomes from it, though their adoption of it will depend to a certain degree on the economic viability in light of the final fish catches reported.

SECTION2: MODELS OF COLLECTIVE ACTION FOR AQUACULTURE UNDER DIFFERENT SOCIO-ECOLOGICAL CONDITIONS⁹

Introduction

The variable success of the community-based fish culture activities in the project countries led to a deeper consideration of context and its contribution to the success or failure of collective action under differing socio-ecological conditions. Socio-political history, in particular, is likely to have had a strong influence on project success. For example, the suggestion that private property, although no longer recognized as privately owned during the flood season, should revert to collective management for the purposes of fish culture has important implications in countries such as Cambodia and Vietnam, where recent history makes collectivization socially sensitive.

At the local level, an additional range of factors can be said to influence the sustainability of community-based institutions, including social context and motivation for collective action, group leadership, local markets, ecological context, and the role of the implementation process itself. Recognizing the broad influence of context on project success, and adopting the perspective put forward by McCay (2002), a framework was developed to guide the research during the final phase of the project. McCay (2002) describes how 'a more cultural and historical approach in human ecology sees "commons" questions as ones about competition and collaboration among social entities; the embeddedness of individual and social action; and the historical, political, sociocultural and ecological specificity of human-environment interactions and institutions.'

The framework provided a basis for the comprehensive analysis of the many factors that make up the complex socio-ecological context in which the project sites are embedded. The framework addresses issues of historical, political, socio-economic and cultural context, placing them firmly within an understanding of the socio-ecological linkages occurring at the landscape level. The study presented below draws on the research framework, and outlines the conditions that support and constrain collective approaches to fish culture in different socio-ecological contexts.

Methods

Site Selection and sample size

The study covers 12 sites in Vietnam¹⁰ Cambodia¹¹ (

Figure 9) and Bangladesh. Mali and China were excluded from the study both for reasons of time and resource limitations, and also due to the limited number of sites involved in each country, and the late implementation of fish culture in Mali.

In Vietnam and Cambodia, more than half of the beneficiaries were interviewed at each site, as were at least 10 other households living nearby¹². The household sample was chosen for maximum diversity, including association leaders, secretaries and representatives, as well as long-term, recent and discontinued beneficiaries. Non-beneficiaries included landowners adjacent to the fish culture area and those farming

⁹ This section presents data from Joffre et al. (forthcoming) Please consult the report for a more detailed account of the study.

¹⁰ In Vietnam, two projects sites in An Giang and Dong Thap provinces that were implemented in 2006 but discontinued in 2007 were not visited.

¹¹ At Potamon in Cambodia the project was never implemented beyond preliminary meetings, so the number of beneficiaries is null.

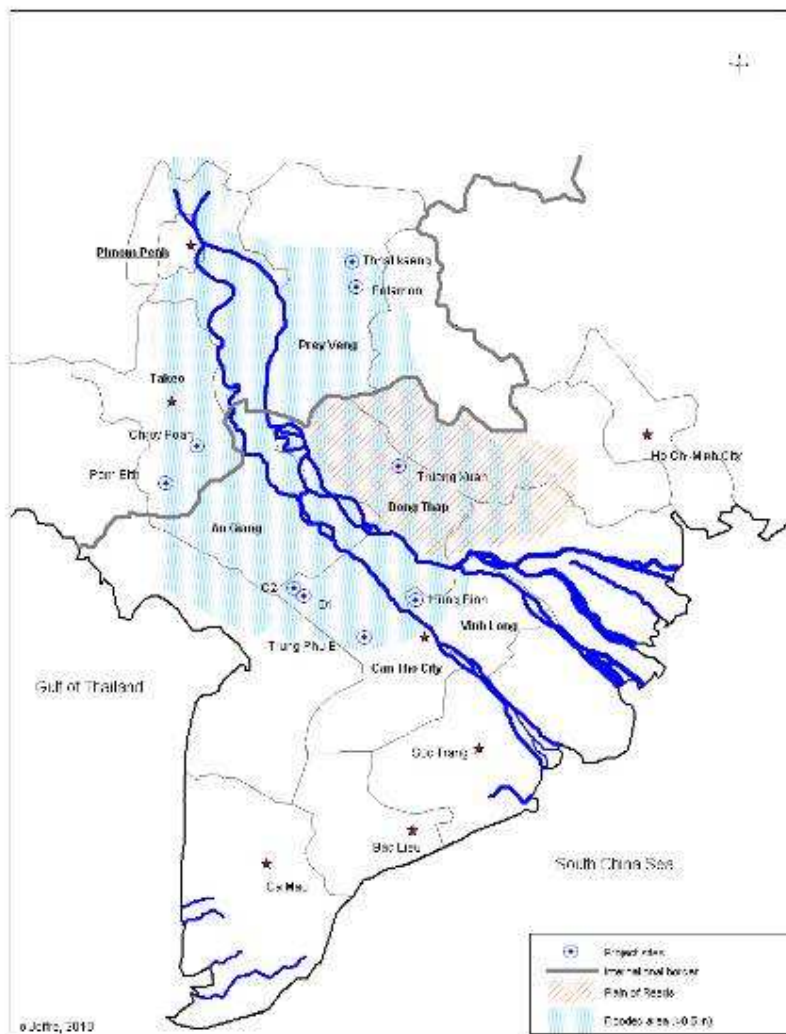
¹² At Truong Xuan hamlet in Vietnam, only five non-beneficiary households were available for interviews.

Objectives CPWF Project Report

within the fish culture area but not involved in the project. Landless farmers living in the project area were also included.

As Bangladesh had larger sites, some including five villages and beneficiary groups of more than 100 households, a different approach used key informant interviews and focus group discussions with distinct stakeholder groups at each survey site: landowners, fishers and the landless, as well as with the management group. Non-beneficiaries were not interviewed in Bangladesh because the high population density around the project sites would have required too large a sample of non-beneficiaries to ensure that it was representative.

Figure 9 Location of project sites in Vietnam and Cambodia included in the analysis of conditions for collective aquaculture



Data collection

Surveys were conducted in October 2008 and March 2009 in Vietnam, December 2008 and January 2009 in Cambodia, and June and July 2009 in Bangladesh.

Semi-structured household interviews in Vietnam and Cambodia, and focus group discussions in Bangladesh with beneficiaries and other community members, investigated the following topics:

- the beneficiaries' incentives to join the project and their expectations;
- constraints on developing community-based aquaculture and the enabling factors needed for them;
- the governance and institutional setting of the community and its evolution since the beginning of the project;
- the roles of local partners and government agencies; and
- the main impacts, both positive and negative, of the project.

Open-ended questions were addressed to project participants, individuals who had discontinued their participation in community-based fish culture, and non-participants, representing a total of 341 respondents. More structured questions were asked on quantitative aspects to understand the economic opportunities at project sites and estimate operational costs, yields, gross returns and net returns of different land uses, including rice cropping, individual fish culture or other land uses. Answers were collected from individual households. The role of fisheries in livelihoods was also investigated to allow estimating the importance of fisheries in term of income, catch and fishing ground locations. The economic importance of households' off-farm activities was also estimated.

Results¹³ - Conditions for collective fish culture

Historical and political context

Influence of recent historical events on collective action. Examining recent historical events at a potential site for community-based fish culture can provide insights into the likelihood of uptake by a community of fish culture on a collective basis. Understanding the historical context is of particular importance in countries such as Cambodia and Vietnam, where recent history indicates that the introduction of collective action may be problematic. In post-independence Vietnam in the 1950's, Communist ideology favoured land collectivization. Although relatively successful in the North, farmers in the South resisted collectivization and continued to farm individually (Do and Iyer 2005). In Cambodia, forced collectivization under the Khmer Rouge regime, and later under the Vietnamese-backed administration, was catastrophic and led to the deaths of hundreds of thousands of Cambodian people. Given the sensitivity of the issue, it is not, therefore, surprising, that the introduction of a community-based approach to fish culture, dependent on the collective use of land and water resources, should fail in Cambodia and southern Vietnam, although past experience of collective action at individual sites was not explicitly stated by respondents as a constraint to collective action.

Recent historical events, such as enforced collective action under the Khmer Rouge in Cambodia, or the failure of collectivized agriculture in the Mekong Delta suggest that the introduction of fish culture on a collective basis may be sensitive and likely to see little or no uptake and adoption, or that there is a preference for individual culture systems. Under these conditions, there should be evidence of other strong incentives, such as limited alternative livelihood options (see below), before community-based fish culture is introduced.

¹³ A summary of the key findings is presented here. Further details can be found in the full report by Joffre et al. (2010).

Socio-cultural context

Previous experience of collective action and community-based management.

The presence of existing community-based institutions and evidence of collective action has been put forward as a pre-condition for successful collective action. Site selection in Vietnam was partly based on the willingness of farmers to join the group and on the presence of an existing collective for rice farming or fish culture. At two sites, farmers were grouped by irrigation unit to share drainage and irrigation costs. In Vietnam, a number of official groups exist in every commune, with branches at the hamlet level level, including a Farmer Organisation, Womens Organisation, Youth and Veteran Unions and a Health Care Organisation (See Werthmann, in prep). Even if CBFC was not successful, project implementation was facilitated by the presence of these groups, as in Kalmina Beel in Bangladesh, with collective action for school construction or rotational microcredit and integrated rice pest management in Pom Eith village in Cambodia. In Cambodia, a Khmer NGO Chamroe Chiet Khmer Organisation (CCK) supported the formation of three self-help groups in Pom Eith village, including a group to prevent the outbreak of brown plant hopper, a savings group and a bicycle group. In Thnal Kaeng, the international NGO CARE has encouraged community activities in the village, including the establishment of rice and credit banks, as well as the Farmer Water User Group (FWUG) (Werthmann, in prep).

However, the extent to which the presence of these organizations influenced the outcome of community-based fish culture activities is unclear. The nature of the interaction amongst members of the fish culture group differs considerably from the requirements of participation in the official groups in Vietnam, or the NGO created groups in Cambodia. The benefits from collective action in the institutions described are qualitatively different from the potential benefits from fish culture, and also do not carry a financial risk if the activity fails. As Gillinson (2004) reports, solidarity benefits and social gratification are important incentives for collective action, as studies by Schlozman (1995) and Walter and King (1992) have showed, albeit in the United States. In the case of pest management, and the control of the brown hopper, cooperation is essential for effective control against outbreaks. As a contributing factor in the continuance of community-based fish culture, the primary advantage that can be gained from community participation in existing organizations, is the creation of greater social cohesion, mutual understanding and trust amongst members.

Livelihood context

Availability of labour. Labour is important to the success of fish culture, as protecting and harvesting the fish stock is labour intensive. In Cambodia, more than in Vietnam, participation in the project was constrained by seasonal migration. Men and, to a lesser extent, women migrate to Phnom Penh or Thailand to work in construction, in factories or on large farms when there are no rice-farming activities in the village. In Thnal kaeng and Pom Eith, more than three-quarters of households had at least one household member, often the household head, who migrated out of the community for employment during the flood season. Villagers preferred to migrate even briefly to ensure a monthly income for the household instead of joining a group for fish culture, thus limiting the number of participants in the project. Seasonal migration is less pronounced in Vietnam. This phenomenon was not observed in Bangladesh, as farmers were occupied in rice fields that were not inundated during the rainy season.

In Vietnam, as in Cambodia, the availability of labor for guarding cultured fish was a constraint at sites where sharing this responsibility was mandatory. Some fish culture groups chose to pay hired labour to guard the fish, increasing the cost of fish production. At Hung Binh hamlet, where only five households participated in fish culture, labour shortage was a problem. At Truong Xuan hamlet, 33% of the respondents found the

work too onerous, as 90 ha was managed by only 13 participants. The following year, 2009, saw seven participants managing 120 ha and hiring workers during the harvest. Among non-beneficiaries interviewed at Pom Eith in Cambodia, 45% said they preferred not to join the project because of the heavy duties involved in the night watch and food collection.

Labour problems were compounded by the constraints on some members of the group to participate in the night watch and harvesting activities, from which women and older participants were excluded.

Availability of alternative livelihood options. The employment opportunities provided by fish culture may provide a strong incentive for participation and cooperation, particularly where alternative occupations are limited or absent. Employment as guards or workers building the bamboo fence is an incentive for poor fishers and the landless to participate. At Beel Mail, the monthly salary for a guard is \$29.40 /month and for fencing labor \$2.20/day, which is the daily rate for labor in the region. At Kalmina Beel, the landless hired to work in rice fields benefit from higher rice yields, which creates more jobs. At D1 hamlet, employment as a guard or harvester was a clear incentive, paying \$1.17/night in 2007 and similar rate for harvesting. Beneficiaries working as both night guards and harvesters could earn more than \$117 during the fish culture period. Competition for work as night guard and harvester later created conflict in the group.

In Bangladesh, harvesting, night watch and other duties are undertaken by the landless and fishers, not by landowners as in Vietnam. The daily rate in Bangladesh for harvesting is \$5.88/day, which is more than 2.5 times the labor rate in agriculture of \$1.70-2.20/day. In Vietnam, daily rates in agriculture or construction are \$2.00-4.60, which is more attractive than harvesting fish for about \$1.10/day. At several sites in Vietnam, harvesting was mandatory and unpaid.

However, in locations where alternative occupations exist, and generate greater or more stable benefits than fish culture, community-based fish culture is less likely to be adopted due to the high costs of cooperation and demand for labour for guarding and harvesting the fish stock.

Economic benefit is key to individual decisions to continue the project. In Cambodia and Vietnam, the economic results were negative (Table 6), prompting 68% of beneficiaries at D1 hamlet, 78% at C2, 76% at Trung Phu B and 44% at Truong Xuan to quit the project. At Choy Proan village in Cambodia, 40% of participants quit for lack of income.

Even if seasonal migration in Cambodia or other employment during the entire flood period did not occur, villagers and specifically poor farmers preferred not to be bound to a project with daily or weekly duties, but rather be available for off-farm activities that can provide daily income. For example, four participants at Truong Xuan hamlet left the project for off-farm employment. Another declined to join in favor of being hired by a forest enterprise with a daily wage. In addition, the project was perceived as a new technique with no guarantee of benefits at the end of the flood season, and thus not really appealing to villagers. Off-farm activities and fishing are subsistence activities during the flood season, while income from fish culture is earned only after fish harvest in December or January, if at all. During a meeting of the fish culture group at Truong Xuan hamlet, the wives of some small landowner participants interrupted the meeting to complain about the lack of income due to their husbands' involvement in the project instead of fishing or being hired as wage labor.

In Bangladesh, involvement in other activities affected only the attendance of landowners at meetings at Angrar Beel. Participation in the project did not interfere with other activities, perhaps thanks to the involvement of professional fishers during the harvest and the employment of the landless for the night watch. Various stakeholders pointed out that other wage labor is not regularly available at this time of year.

Institutional context

Supportive local authorities. The support of local authorities was found to be a critical factor in the successful development of community-based fish culture. Local authorities were instrumental in preventing illegal fishing and poaching, supporting the maintenance of critical infrastructure, including water management infrastructure and promoting transparent management mechanisms in a co-management arrangement.

Local authorities play an important role in preventing illegal fishing and poaching at project sites. At two sites in Vietnam where poaching was high, D1 and C2 hamlets, as well as at one site in Cambodia where the project faces vandalism problems, Thnal Kaeng village, beneficiaries saw lack of support from local authorities as a constraint; 5% of respondents in D1 and 13% of respondents in C2 cited this lack of support, as did four project participants, or 80% of the beneficiaries, in Thnal Kaeng village. At Kalmina Beel in Bangladesh, local authorities' support in preventing vandalism of the fence was an important factor contributing to success, according to project beneficiaries.

In Cambodia, access to knowledge and support from extension services or the private sector is limited. In Chroy Poan village, for example, individual aquaculture spread only after frequent visits of FiA staff during the project.

In Bangladesh, district and upazilla officers are involved directly in the project, making several visits to the site and participating in the PIC. In addition, FMC meetings are held in the presence of the senior upazilla DoF officer. Upazilla and district officers received some payment from the project for their involvement. In the case of public land, support from the administration is needed to acquire the lease, and on private land the support of local authorities is needed as a guarantee against vandalism and poaching. The DoF also supports CBFC through fingerling release programs. Project beneficiaries report that technical, economic and management supervision by an external advisor such as the DoF or WorldFish is needed. In Beel Mail, members of the FMC acknowledge as an enabling factor the proper planning of tasks done in collaboration with project partners. Project beneficiaries contrast this approach with their less-successful first attempt at CBFC in 2005, when there was no scheduled planning or monitoring of activities.

In Truong Xuan hamlet in Vietnam and Chroy Poan village in Cambodia, project implementation prompted more frequent visits from local authorities and technicians in the DoF and FiA to these remote areas, bringing new access to knowledge and inputs and creating a favorable environment for aquaculture development.

However, land tenure is a sensitive issue and source of conflict in Bangladesh. The involvement of government agencies in a privately owned area can create suspicion among landlords of land tenure change. This suspicion limits the participation of landowners in the project, as happened in Kalmina Beel during the early stages of the project.

The influence of DoF officers and local authorities in project management is a greater constraint in the case of private land, as at Kalmina and Angrar beels, than of public land such as Beel Mail, where they have the legal authority to manage resources. Beneficiaries' perception of DoF staff was also important. At Kalmina Beel, DoF staff had a reputation for corruption, so transparent roles and behavior were required to gain beneficiaries' trust.

Technical support from WorldFish and/or local project partners was highlighted as important at the three sites in Bangladesh and at the villages of Chroy Poan and Pom Eith in Cambodia. For 30% of the beneficiaries at Pom Eith and 40% at Chroy Poan, the incentive to join the project was to gain access to aquaculture knowledge.

Issues of access and ownership. Of interest when comparing Vietnam and Bangladesh is the role of absentee landowners. In Hung Binh hamlet in Vietnam, five absentee landowners during the flood season limited the number of beneficiaries

involved in the group, as did three absentee landlords in Truong Xuan hamlet. In Bangladesh, landowners are not involved in harvesting or guarding but only in monitoring. Involving previous users of the area in technical implementation of the project at sites in Bangladesh made more labor available, allowing landowners spend their time pursuing other activities.

Size of land holding. A similar comparison can be made about land holding size. In D1 hamlet in 2006 and 2007, as well as in C2 and Trung Phu B hamlets, benefits are shared according to landholding, as in Bangladesh. However, two landowners with less than 1 ha in C2 hamlet preferred not to participate in the project because their potential benefit was too small, considering the time investment. In Bangladesh, small landowners joined the project, perhaps because of the absence of any constraining duties such as the night watch or harvesting.

Environmental context and landscape levels factors

Land availability and dependence on fishing and fish culture. In Bangladesh, farmers have access to land at different elevations, allowing them to cultivate rice during the rainy season. In the Mekong Delta in Vietnam, by contrast, farmers do not have access to lands unaffected by floods and cannot cultivate during this period. This allows farmers to dedicate some of their time to monitoring fish culture, having secured a part of their income from rice, upland crops like vegetables and potatoes, or individual fish culture. In Vietnam, fish culture is the only activity on farmers' land during the flood, so Vietnamese farmers are involved in more CBFC activities such as guarding and harvesting than are landowners in Bangladesh. This is why the risk for Vietnamese farmers is higher, as a result of their dependence on a limited number of income sources during the flood season.

Duration and amplitude of flooding. The length of the flood in Vietnam and at some sites in Cambodia is shorter than it is in Bangladesh. In Vietnam, early flood protection to protect the mature second rice crop and the draining of rice fields in December limits the period of fish culture to August-December and, in triple-cropped rice areas, September-December. As in Cambodia, inter-annual variation of the flood renders the start and amplitude of the flood unpredictable.¹⁴ At two sites in 2008, the flood was delayed until after August, and fingerling stocking was cancelled. A shortened flood period necessitates the use of larger fingerlings to reach market size and reduces the potential of advantageous sequential harvest as practiced in Bangladesh.

Delayed flooding and low amplitude impeded fish stocking at Thnal Kaeng and Pom Eith in Cambodia in 2008, as the flood was delayed until September and the water was too low to allow fish culture. In 2007, Bangladesh experienced abnormal flooding. At Beel Mail, a flood height of 5 meters was recorded in 2007 and 3.5 meters in 2008. At Angrar and Kalmina beels, the lack of flood control was highlighted as a main technical constraint on fish culture.

At Trung Phu B hamlet in Vietnam, 24% of beneficiaries considered the flood too low in 2007 for fish culture, as the maximum water depth of 60 centimeters in September meant high water temperatures and a lack of nutrients for fish culture. In the same month, the depth was 106 centimeters at C2 hamlet and 102 centimeters at D1. In 2009, late and low flooding at D1 slowed fish growth. With rice culture intensification and a shortened flood period, stocking is 1-2 months later in Vietnam than in Bangladesh and the harvest is earlier, finishing in early December, as compared with January in

¹⁴ In his study, Pillot (2007) shows that the Mekong flow is within $\pm 10\%$ its 40-year average in only 3 years out of 5. The maximum height of the river can vary by 2 meters, which greatly affects the extent of flooding.

Bangladesh. These differences in the growth period can partly explain differences in productivity.

Presence of flood-management infrastructure. The presence of flood management infrastructure may be essential to control unpredictable flooding events and the associated damage to the fish culture system. Flood management infrastructure and fencing are strongly linked technical requirements. In Vietnam, the regional early flood-protection system provides a favorable environment for fish culture, with large areas delimited by embankments. Sites were selected in Vietnam on the basis of the presence of dikes to protect against flooding. Community development of an irrigation scheme provides tools with which to manage water for flood protection and drainage, facilitating the harvest. However, some losses were incurred in C2 and Hung Binh hamlets as the dike was too low, and fish escaped after a heavy rain. Flashflooding was the main technical constraint on CBFC cited by 53% of respondents at C2 and all respondents at Hung Binh.

The water bodies into which fish culture was introduced in Bangladesh are local depressions surrounded by rice fields, with dikes that allow some water management, facilitated by sluice gates at Beel Mail and Angrar Beel. However, at Kalmina Beel, some improvement in water management was necessary to lengthen the fish culture period. The local population welcomed the construction of a sluice gate because it benefits not only fish culture but also rice cultivation by protecting against flashfloods and allowing irrigation during droughts.

In Cambodia, which lacks a flood control system, and there are no mechanisms for local management of broad flood conditions, fish culture groups suffered losses of stocked fish as a result of high and unpredictable flooding events. In Pom Eith village, the enclosure fence failed to hold fish after heavy rain caused a sudden rise in the water level at Pom Eith village. Flood problems in Cambodia can be exacerbated by the effects of downstream infrastructure. In Takeo Province in southern Cambodia, the sluice gates at the Cambodian-Vietnamese border built to protect Vietnamese rice cause higher flooding in the upstream part of the floodplain and constrain fish culture during this period, according to villagers, necessitating a higher dike or fencing to protect the cultured area.

Water chemistry. Water acidity limits fish culture to the flood period in the Plain of Reeds of Vietnam. The local DoF officer in Thap Moi District characterizes Truong Xuan hamlet as having only limited potential for year-round aquaculture, as half of it is severely affected by acidity, thus limiting fish culture to the flood season. This may favour community-based fish culture, as acidity could preclude the development of commercial, year-round pond aquaculture.

Site size and location. Beneficiaries identified site size and location as important factors contributing to fish culture success. In Vietnam, sites in rice fields are usually adjacent to homesteads, facilitating fish-culture activities. Only at Hung Binh hamlet homesteads were situated far from project site, which was considered a constraint as close proximity to the culture site facilitates guarding. At Pom Eith village in Cambodia, the site in 2007 was found to be too far from the village, at 1.5 kilometers, and was relocated closer to the village in 2008 to facilitate the night watch. Similarly at Thnal Kaeng, a project site was selected close to beneficiaries' houses.

The size of the enclosure was found to be problematic at several places in Vietnam. In Truong Xuan, 33% of respondents found 90 ha too large for 13 participants to harvest. In 2009, the area was enlarged to 120 ha with only 7 participants, requiring the group to hire labor for the harvest. At C2 hamlet, 22% of respondents considered 48 ha too large for 28 beneficiaries. At D1 hamlet, 40% of respondents stated that an area smaller than the existing 65 ha would be easier to protect from poaching.

Markets and Economic Viability

Access to markets. The presence of a market for distribution of culture products is crucial to the success of any fish culture enterprise. However, it was found that market factors were an important constraint in the development of viable, profitable, fish culture.

In Cambodia, smaller size fish were marketed in villages for a retail price of \$1.50-2.00/kg, which was higher than wholesale price, according to beneficiaries. Marketing was an important constraint in Vietnamese project sites, with low market prices for cultured fish during the fish harvest period and trading of a large quantity of fish, with big head carp sold at \$0.22/kg, silver carp at \$0.34/kg and common carp sold at \$0.20-0.40/kg. In Bangladesh, where the size of the fish trade is similar to that of Vietnam at more than 20 million tons, marketing was not found to be problematic. The involvement of professional fishers in the group ensured good technique in harvesting and processing fish for the wholesale market. Beneficiaries reported average selling prices of \$1.04/kg for common carp, \$0.69/kg for big head carp and \$0.63/kg for silver carp between 2006 and 2008 and benefiting from a more competitive market than in Vietnam, where marketing is done by contract with a few fish traders during a short period when fish prices are at their lowest.

Market prices that provide a return on investment. Alternative marketing with early sequential harvest using long fence trap nets before the bulk of harvest did not provide significant results, accounting for only 6% of the gross return at Truong Xuan hamlet. Marketing was ranked as a main constraint on CBFC by 26% of respondents at D1 hamlet, 33% at C2, 22% at Truong Xuan and 18% at Trung Phu B.

Higher rice prices on the national market induced individual farmers to intensify their rice culture, as was noted in Hung Binh hamlet, where most of the farmers decided to shift from two rice crops per year to three when the price for paddy increased from 4,000 dong/kg to 6,000 dong/kg.

At all sites in Vietnam, economic results were limited by marketing constraints and fish market price fluctuation. Marketing was ranked as a main constraint by 26% of respondents at D1 hamlet, 33% at C2, 18% at Trung Phu B and 33% at Truong Xuan. Low market price (see Regional level above) and the marketing of large amounts of fish through traders in a short period lowered the selling price.

Availability of cost effective, high quality inputs. The cost and availability of inputs for fish culture, particularly fingerlings, was also a limiting factor. During project implementation in Cambodia, access to high-quality seed was difficult and even delayed stocking. In Prey Veng and Takeo provinces, only one public hatchery and eight private or farmer-run hatcheries function in each province, producing 2.4 million fingerlings in Prey Veng in 2004 and 3.1 million in Takeo. The average price of fingerlings stocked during the project is higher in Cambodia, at \$3.55-4.71/kg, than in Vietnam, at \$2.01-2.88/kg. The lowest average fingerling price was found in Bangladesh, at \$1.14-1.41/kg. Thus, fingerlings cost three times more in Cambodia than in Bangladesh, and the average fingerling size smaller, at 11 grams each compared with more than 30 grams in Bangladesh. This reflects a considerable difference in fingerling market development between the two countries.

Incentives for uptake and adoption

The economic viability of fish culture is the strongest incentive to pursue community-based fish culture. In Vietnam, the incentive to join the project was mainly economic, as 95% of respondents at D1 hamlet and 73% at C2 claimed to join the project to increase their income during the flood season, expecting income of up to \$117/household, or more than the value of fishing for home consumption or renting land out for duck rearing. At other sites, the expectation of increased income was less important (52% of respondents at Trung Phu B and 38% at Hung Binh). However, economic benefits from fish culture have not matched expectations or been able to compete with other income-generating activities. In contrast, at Kalmina Beel and Beel Mail in Bangladesh the economic results for individuals improved with the project. In Bangladesh, it was important that landowners can also benefit from fish culture, as before the project flooded rice fields provided no benefits. At Kalmina Beel, landowners were able to gain \$72.60/ha in 2008, and moneylending landowners at Beel Mail increased their income by 25%. The landless reaped a net benefit of \$2.20/participant from the improved fish catch with restricted access for previous users. At Beel Mail, the landless can catch 250-2,000 grams of fish per day, many times the 50 grams/day caught before the project.

Fishers are the main beneficiaries at Beel Mail, increasing their income with their share of the net benefit and of the harvest. On average, fishers claim to earn \$103-294 each, compared with \$14-73 previously. Similarly at Kalmina Beel, fishers income rose from \$29-36/household/year to \$59-73/person/year. At Beel Mail and Kalmina Beel, participants cited increased income for all beneficiaries as the main impact. Compared with other opportunities like off-farm labor, earning \$2.20/day, CBFC is more lucrative. Moreover, the successful result at Beel Mail and Kalmina Beel created opportunities for beneficiaries to diversify their incomes. At Beel Mail, more than 20 households are now involved in potato or fingerling trading. At Kalmina Beel, 10-12 households started fingerling nurseries. Economic incentives are important for the continuance of collective action in Bangladesh, with all stakeholders benefiting from the project.

Increased fish production and access to cheaper fish during off-peak harvest season was an important incentive in Cambodia, as 80% of respondents at Chroy Poan village and 20% at Pom Eith expecting to increase their fish consumption. In Bangladesh, improved fish stocks and communities' access to cheaper fish were important incentives. Fishing was not totally restricted in Bangladesh, but this regulatory difference reflected local fishing practice. The Bangladeshi use of extensive fishing gear like push nets or trap nets to catch only self-recruited species is uncommon in Vietnam, where most use long fence trap nets or gill nets, which do not restrict the catch to self-recruited species.

Discussion

The study presented above investigated the impact of a broad range of conditions that support or constrain fish culture on a collective basis in seasonal floodplains. However, the findings contribute to the body of literature on collective action more broadly, with the cross-country comparison that the study offers providing a valuable perspective. Poteete and Ostrom (2004) recognized that there is a need to identify conditions that facilitate and hinder collective action, particularly as there are important differences among the types of collective action problems that individuals and communities confront. Studying collective action nested within a wider action research project on community-based fish culture has allowed us to explore the influence not only of property rights on collective action, but also the impact of dynamic institutions, in which access to resources and the conditions of their ownership changes on a seasonal basis.

We find that many of the factors supporting or constraining collective action are widely reported in the literature: well-defined boundaries (Wade 1988, Ostrom 1990), small groups (Wade 1988; Agrawal and Goyal 2001), access to markets (Gebremedhin et al 2002), previous experience of collective action (Wade 1988), heterogeneity (Baland and

Platteau 1999; Bardham and Dayton-Johnson 2002; Jones 2004). However, relatively fewer studies have combined an examination of technical, environmental, financial and institutional factors, together with a consideration of the likely impact of the historical and political context on the success of collective action.

Although a prescriptive list defining the conditions that need to be in place to support community-based fish culture is unrealistic, our study did show a number of common factors that are likely to support or constrain community-based fish culture in the countries studied, that are likely to be applicable in other country contexts also.

- **Technical and environmental parameters.** Flood length determines the culture period of the fish. Together with other biotic parameters such as natural productivity, water temperature and fingerlings size at stocking, it influences fish size at the end of the culture period. In Bangladesh, the combination of large fingerlings and a long culture period from June or July until January allows fish to reach market size. In addition, a longer culture period allows sequential harvesting after 5 months. Ensuring adequate flood height and duration is therefore a critical factor in successful fish production in seasonal floodplains. The required flood duration is dependent upon the availability and cost of fingerlings of sufficient size to reach market size within the grow-out period, natural productivity and water temperature.
- **Market factors.** The economic viability of fish culture was undermined in Cambodia and Vietnam by issues of market access and the timing of the fish harvest. In Vietnam, alternative strategies are needed to ensure that fish harvest takes place during a time when fish demand is high, to ensure a return on investment. Access to a market other than villages in the immediate vicinity of the culture site is a requirement for viable fish culture in Cambodia, as is the availability of inexpensive, but good quality seed.
- **Livelihood factors.** Community-based fish culture has greater potential in locations where fish culture activities do not coincide with other livelihood alternatives. For this reason, locations where agricultural activities are precluded in the flood season due to deep flooding are preferable to locations where flood waters can be controlled to permit the continuation of agriculture in the flood season. Rural communities that are distant from urban centres, but are able to link to urban markets following fish harvest, are likely to have greater incentives to sustain fish culture activities than those living in close proximity to towns with access to numerous alternative employment opportunities in the flood season.
- **Group size.** The fish culture group should comprise a sufficient number of members required to participate in the protection and harvesting of the fish stock. The size of the culture site should also be considered to ensure that the culture site is of a manageable size for the number of group members. In areas where out-migration of the most able-bodied members of the household is common, community-based fish culture is not recommended, unless fish culture activities provide an alternative occupation and reduce the need for out-migration during the flood season.
- **Economic viability.** The economic viability of the fish culture system and the benefits generated for participants is one of the most critically important factors affecting the uptake and continuation of community-based fish culture. Many of the conditions upon which a successful fish culture intervention may depend contribute to the economic viability of the production system. Financial benefits from fish culture provide the strongest incentives for communities to persist with fish culture in the face of risk and often complex social transactions. This,

economic viability becomes both a condition for success, and evidence of impact of the intervention. It is important to note, that economic viability is not a condition for successful fish culture in itself, but the result of the presence of other factors which contribute to the good growth and survival of the fish, the sale of the fish for a good price on the market and the cooperation of participants to manage fish culture activities and to agree upon an equitable sharing of the benefits. The perception of the level of benefits that constituted a sufficient incentive to continue varied between countries.

SECTION 3: CONTRIBUTION OF COLLECTIVE APPROACHES TO AQUACULTURE FOR SUSTAINABLE DEVELOPMENT OF FLOODPLAIN RESOURCES AND IRRIGATION SYSTEMS

Fish culture intervention – a viable technology?

Fish culture on a collective basis generated tangible benefits for some communities involved in the project. In Bangladesh, the approach generated income and food security benefits for a range of stakeholders. Members of the Melandi fishing community, a relatively poor Hindu community, reported that fish production led to significant income smoothing during two months of the year, during which time their lives were transformed by the increased income from fish harvests. In addition, they reported that cooperation between members of the community had increased, with knock on benefits in other aspects of community life.

In Vietnam, fish culture trials did not find a successful solution to overcome the problem of low fish value at harvest. The need for strong incentives to help project participants overcome the transaction costs of working on a collective basis and sharing benefits from fish culture was not met in Vietnam, and participants expressed a preference for individual culture systems or other livelihood options available in the flood season. In areas where three rice crops were feasible, rice production was preferred over fish culture, and water was pumped from land to support continued agricultural production. In these areas, the importance of rice in both the diets of individual households and to the national economy outweighed the potential nutritional or income benefits from fishing or fish culture. For most communities in the Mekong Delta, numerous alternative livelihood options are available, making the time investments required to support effective fish culture unappealing. High financial returns are possible by activities including duck raising and wage labour. As an economic activity, the community-based fish culture model tested in the Mekong Delta did not provide sufficient returns to make it a viable activity. High cost of fingerlings and the low value of fish at harvest frequently led to negative returns. In addition, weak community-based institutions could not ensure that infrastructure was maintained and that the stocked fish were protected from poaching. As a result, losses from the fish stock were frequent and significantly undermined the productivity of the system. However, it should be noted that although the low value of fish at sale during the season of peak fish supply led to low returns for the fish culture group, it does signify the availability of low cost fish to consumers in the Mekong Delta, which is most likely to benefit the most vulnerable groups (Joffre pers comm.).

The perceptions of participants regarding the ownership of the fish stock and their role in ensuring a harvest was also important in determining the success of the fish culture model. In cases where the project supported the purchase of fingerlings, the fish were deemed to be 'project fish' and therefore any loss of fish did not have a significant impact on project participants, as they had not made an investment and could not therefore lose out.

It could be argued that fish culture, the stocking of fish into a communal body, did not confer greater advantages in terms of productivity than a suite of fisheries management interventions may have brought. However, the move towards decentralization of management, and an effective co-management model, coupled with privatization conferred by the lease holding arrangements secured as a result of the strengthened co-management arrangements created as a result of the project, possibly delivered benefits into the hands of the relatively less well-off rather than exclusively to the wealthy landowners. The stocking of fish adds an extra dimension to the rights available to the fishing community. The project helped to secure their continued access to the resource, prevents the encroachment of private entrepreneurs into public or state owned land for conversion to other uses, and generates benefits that go primarily to the fishing community.

The project case studies highlighted a number of issues regarding the nature of development interventions involving community-based organizations and the enclosure of open access resources to generate private goods. The potential for negative impacts to emerge as a result of such an approach, including exclusion of potentially vulnerable resources users from a previously open access waterbody, must be given greater consideration when a new intervention is planned.

The viability of fish culture on a collective basis as a suitable livelihood option for poor rural communities should give consideration both to the future development context, as well as the current policy environment. As pressure on floodplains and water resources increases, and resources are privatized, rural households are displaced and traditional livelihood activities undermined. In some locations, fish culture on a collective basis may not appear to be the most equitable option, favoring households with medium to good well-being status rather than the poorest and most marginalized in society. However, these households, while not the poorest of the poor, are also emerging from poverty and are vulnerable to changing economic and environmental conditions. In Vietnam, government policy favors the commercialization of floodplain resources for aquaculture, with a simultaneous reduction of capacity in small-scale fisheries, with fishers finding alternative employment on commercial farms and associated industries. Under this scenario, if fish culture on a collective basis is deemed viable by local government authorities, ownership of land resources and access to floodplain resources by poor rural households may be secured through the informal institutions and property rights conferred when community-based organizations are established.

OUTCOMES AND IMPACTS

The outcomes and impacts of the project are, as described above, highly variable, yet we were able to see impact and change occurring at a number of levels, from the individual to the institutional. At the community level, fish culture on a collective basis had a significant impact in communities in Bangladesh, China and Mali. In Vietnam and Cambodia, research furthered our understanding of the conditions for collective action, and specifically for community-based fish culture, that will contribute directly to the development of locally appropriate and technically feasible fish culture systems in both countries. In Cambodia, the project responded to government commitments to establish Community-based Fish Refuge Ponds (FRPs) in every village in the country, by providing best-practice guidelines for FRPs.

In Bangladesh, fish production reached 399.65kg/ha at Beel Mail, representing an increase of 133% compared to the baseline. This increase in fish production brought significant changes to the community, who relate the story of their village in the community-produced film 'The Island of Dreams and Success'¹⁵. During focus group discussions and Most Significant Change interviews, beneficiaries also reported cooperation in the community has increased. Prior to the intervention, households fished individually and competed with one another for the fish catch. Since the introduction of fish culture on a community basis, households have to work together to manage fish culture activities and to protect the fish stock. The increased cooperation and communication in the community is beneficial for other aspects of community life. Beneficiaries in Melandi reported that their lives are transformed for the two months of the year during which fish harvesting takes place. Although the fish catch is lower on some days than it was in the past, the overall effect is one of income smoothing and the generation of income that permits households to afford education for their children, or to purchase assets such as mobile phones and televisions, technologies that are important in providing rural households with access to information.

Although relatively modest levels of fish production were achieved in Yunnan province, contributing little to total household incomes, fish production still provided significant benefits to the participating communities. In Taiping village, in particular, beneficiary households preferred to receive their share of production in the form of fish rather than in cash. Taiping is a relatively poor village, and fish is considered a luxury source of protein. As a result, households eat fish less than 10 times per year. Fish production from community-based fish culture led to a significant increase in fish consumption in the community. The additional fish that the project provided for home consumption was a sufficient incentive for the community to continue fish culture.

In Mali, outcomes and changes in community behaviour to protect fish culture enclosures and the mare environment far exceeded expectations, particularly as substantial delays in the implementation of the fish culture intervention meant that the first culture cycle took place only in the final year of the project. The impacts of constructing the aquaculture enclosures in "Mama Pondu" mare go well beyond that of the fish production within the enclosures. Most significantly, all focus groups described a number of ways in which this projects' focus on development and management of the mare resources has increased the community awareness of their reliance on this common resource, and their commitment to improve mare resource governance overall. Consequently, livestock herders have taken greater care in tending their flocks, fishers have limited their poaching during the closed season, and farmers have reduced the amount of vegetation that they extract as fodder for small livestock. Together, these self-imposed measures are expected to have significant impacts on the amount of fish landed during the collective fishing event to be held in June, as well as the productivity of agricultural fields

¹⁵ <http://youtube.com/watch?v=fqitqImT420&feature=related> (temporary link)

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in the area. Community focus groups were also uniformly supportive of continuing these improved governance norms during the years to come.

At the institutional level, NARES partners also reported important changes in their working practice and research knowledge and skills. In China, partners reported that they have a greater interest in the socio-economic conditions of the communities in which they work, and are keen to learn more about the institutional and policy environment of their research. Participatory research methods were new to research partners at FFRC when the project began. The application of PRA methods has expanded the scope of their research beyond a simple analysis of fish productivity, and consultation with farmers at the local level to understand their needs and preferences has also increased.

The opportunity to build international partnerships was also cited as an important outcome of the project, particularly amongst NARES partner participants in China. The increased visibility of local departments, through the connections established through the project, have led to further funding for national level projects in areas that previously received little attention from national level agencies.

Capacity building in the form of new skills training was of importance to research partners from the Department of Aquaculture of the Fisheries Administration, Cambodia. Compared to other projects supported by international donors, the principal investigator from the FiA appreciated the degree of autonomy and independence he was given to develop his own ideas, to brainstorm and to discuss ideas and make decisions in collaboration with other members of the team. The value of new skills in field observation, discussions with community members and the use of maps to discuss ideas with project participants at the community level were emphasized.

Summary Description of the Project's Main Impact Pathways

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
MALI				
Village leaders	Increased enforcement of mare closed season.	Increased profile of mare fishery governance; concerns with avoiding theft from aquaculture pens.	Extensive leadership discussions around mare resource governance, aquaculture pen construction.	
Village leaders	Stocking of another mare with local fingerlings, and intentions to construct fish pens elsewhere in the future.	Pen aquaculture principles.	Leadership discussions and participation in aquaculture pen construction and stocking.	
Somono and Bozo fishers	Increased observance of fishing closed season in mare.	Increased profile of mare fishery governance; concerns with avoiding conflicts or suspicion of theft from aquaculture pens.	Social impact assessment (SIA) through extensive stakeholder focus groups about conflict management norms and institutions around the mare.	
Marka and Somono farmers	Reduction of vegetation extraction in mare.	Community concerns with avoiding conflicts associated with aquaculture pens.	Social impact assessment (SIA) through extensive stakeholder focus groups about conflict management norms and institutions around the mare.	
Funali herders	Increased vigilance of livestock movements in and around the mare.	Stakeholder concerns with avoiding conflicts associated with aquaculture pens.	Social impact assessment (SIA) through extensive stakeholder focus groups about conflict management	

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			norms and institutions around the mare.	
BANGLADESH				
Fishers, Landless non-fishers and land owners in the floodplains	Improvement in water management in seasonal floodplains and increased yield of fish from better stocking and harvesting practices.	<p>Technical knowledge on setting of large meshed (~1cm) low-cost (compare to concrete structure) bamboo fence in inlets and outlets of floodplains-allowing excess water to pass quickly and facilitate un-stocked small fish to enter into the floodplains from outside sources.</p> <p>Change in KAS of stakeholders regarding community based arrangements: improved knowledge of species selection, advantage of stocking large size fingerlings of suitable species at right densities earlier in the season to get higher production.</p>	The intervention was carried out as a Participatory Action Research project over 3-4 years from 2006 to 2009, actively involving all stakeholders and beneficiaries in decision-making processes, particularly in the technical design of the fish culture intervention. An adaptive management approach permitted improvements to both technical and institutional arrangements each year to improve fish production, increase the generation of benefits, create more equitable benefit sharing arrangements, greater transparency in financial accounting, increased security of resource access and ownership for poorer fishers and improved cooperation between community-based organizations and local authorities through co-management arrangements.	<p>Fish yields increased more than three-fold compared to the baseline year</p> <p>Production of un-stocked fish also increased (production doubled at Beel Mail)</p> <p>Fishers and poor non-fishers were able to harvest fish over a longer period of time than prior to the intervention, obtaining a higher income from fish harvest.</p>
	Improved compliance regulations for use of gears (ban on use of large gears during certain months allowing stocked and non-stocked fish to grow faster in the system).	Awareness amongst beneficiaries (fish culture group and landless fishers) of benefits of protecting the fish stock Follow regulation in gear use for certain period and use techniques of partial harvest of small fish and larger carps allowing space for others to grow, resulting in higher fish	The process was facilitated by local DoF officers and	

		yields.	members of the WorldFish Center research team.	
	Improved fish marketing	Harvest fish based on their demand in the local markets especially the unstocked small fish. Large stocked fish harvested and sold to wholesaler for sale in distant urban markets. Improved market linkages.	However, the project emphasized the responsibility of the project participants in the development of a successful fish production system, and the responsible management of the financial benefits accrued.	
	Increased participation of all stakeholders in decision making for all the activities	Improved understanding and communication amongst resources users and stakeholders from different social and well-being backgrounds. Increased cooperation amongst stakeholders.		
	Improved equitability and greater responsibility for benefit sharing amongst stakeholders			
Local DoF (Upazila and District Level)	Greater confidence amongst DoF local Upazila and District officials to work with different stakeholders to bring seasonal floodplains under fish culture using a community-based approach	Experience has introduced a more practically oriented program in this area for dissemination of community-based fish culture.	The project involved local DoF as the implementing agencies considering them as one of the vital institutions for this purpose.	With DoF support, the local CBOs were able to continue their fish culture activities in floodplains with minimal support from outside. Further, new areas of intervention have been developed with support from DoF.
	Floodplain ownership diversified amongst a range of different stakeholders, including poorer fishing communities.			

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	<p>Acceptance of approach based on active involvement of, and investment by, beneficiaries in a government intervention program in floodplains.</p>	<p>In most cases in large open water bodies (floodplains, rivers, reservoirs) activities for promotion of fish production have taken place by the initiatives of the Bangladeshi Government through large projects (Third Fisheries, Fourth Fisheries, Govt. Special Projects supports) with all investments from the Government. Most people are largely involved only as beneficiaries and a few are involved in implementation as contractors to supply fingerlings, building up structure etc. The approach of CB fish culture in seasonal floodplains we introduced largely with the beneficiaries is unusual, and requires a shift in attitude by the people in order to gain acceptance.</p>	<p>The approach was accepted through the active demonstration of the project, and the resulting success and benefits to the participants.</p>	
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Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

MALI:

Assuming that the increased fish harvested during the collective fishing event (anticipated at over 100%), and increased agricultural production are realized, the greatest impact from the project is clearly due to the improved overall governance of the mare resources by farmers, herders and fishers. This is a conclusion that the community has arrived at as well, and there is widespread interest in ensuring that the same norms are maintained with regards to mare resource access in the future. Such an adoption of new attitudes toward this resource that most livelihoods rely upon can only have positive impacts on most (if not all) community households.

BANGLADESH:

The involvement of a broad range of resources users/stakeholders including fishers, landless non-fishers, land owners, together with local DoF as and necessary support from strategic national and international institutions allows a potentially larger number of floodplains in the country to be brought under community based fish culture, with associated benefits to rural communities from fish production, employment, and increased income.

The adaptations to fish culture infrastructure, in the form of low-cost bamboo fencing with larger mesh instead of concrete structure, provide an alternative option for floodplain water management with the potential to increase water retention times of floodwaters providing longer periods for fish harvest and increased availability of water for irrigation. The dissemination of this technology could be a valuable addition to the technical options for both fish culture and floodplain management.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends.

MALI:

Local partners will harvest the aquaculture pens in June, shortly before the collective fish harvest is to take place in the mare. This will allow us to determine the adviseability of different fish stocking densities in future mare pen aquaculture projects. Additionally, they will monitor the fishing harvest during this year's collective harvest to determine whether the improved closed season regulation did indeed result in increased fish catches. Through this project, the local partner has developed a close collaboration with local community leaders, and they will visit the community periodically in order to support the community in its governance of the mare, and any attempts in pen aquaculture.

BANGLADESH:

The leasing of public floodplains to CBOs is an issue that still requires further consideration, particularly the availability of long-term leases based on performance and importance of benefit generation. Under the current system, short term leases (3-5 years) do not provide sufficient tenure security for fishers and community groups, with the risk that access will be lost at the end of the lease period. Without the possibility of obtaining a longer-term lease, the very positive changes achieved during the fish culture intervention will be lost within a short period and the poor will be negatively affected. Fishers in Melandi village, Rajshahi, are hoping to obtain a longer-term lease, with the support of the local DoF officers. The relationships established between stakeholders and local authorities as a result of the project has provided benefits beyond fish production in the form of an increased voice and linkages to influential authorities, as well as the increased confidence and empowerment of community groups themselves.

it is expected fish culture will continue at both Beel Mail, Rajshahi and Kalmina Beel, Mymnesingh beyond the end of the project, with support from local DoF and a government fish stocking program.

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Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors. Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?) Why were they unexpected? How was the project able to take advantage of them?

MALI:

The first three impact pathways were hoped for, although the extent to which local leaders and the fisherfolk accepted the closed season were surprising. The additional impacts from the changed behaviors of Fulani herders and the Marka/Somono households far exceeded our expectations.

Our intention in conducting focus group discussions revolving around mare resource access and conflict resolution institutions were intended to spur some community introspection and discussion around how best to avoid conflicts associated with the pen aquaculture. However, we did not expect that each stakeholder group would adopt such extensive measures to avoid conflict or damage with the aquaculture project. This result has been fortuitous for the project, as it already demonstrates a clear project impact on all livelihoods in the community.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

GENERAL COMMENTS:

- Support the testing of a great range of opportunities for collective action in addition to the fish culture model, particularly where there is a preference for individual culture systems. Costs and risks of fish culture can be shared by other means besides the pooling of land and water resources, and could include marketing strategies and the purchase of inputs. Greater flexibility in the research approach could promote the emergence of more innovative options, relevant to local preferences and conditions.
- Less emphasis placed on the collection of quantitative data, which absorbed significant amount of project resources. A more focused survey placing lesser demands on the research teams for data entry and analysis would have permitted project staff to spend more time working with the community on learning and adaptive management.
- Careful selection of project sites and project countries. It would be preferable to concentrate on a smaller number of countries and focus on identifying the best combination of technical and institutional options within those countries.
- Promote greater interaction between national research partners, facilitating knowledge exchange.
- An incremental approach to the introduction of technology should be considered when introducing a new technology. Each country in the project was at a different stage on the development trajectory, with different experiences of fisheries, aquaculture and community-based approaches. Under these circumstances, it may be preferable to consider the model and scale of intervention appropriate for the context rather than introducing a generic model based on different levels of experience, and different market and institutional conditions than the country in which the technology emerged.

MALI:

We would invest more time and resources in conducting the livelihoods and institutions research at the start of the project, so as to be able to advance more quickly to the aquaculture interventions. As it was, we were only able to do one iteration. Ideally, we would have hoped to have been able to see at least two years of pen culture growth, both in order to gain a better understanding of the most appropriate technologies (stocking densities, siting, inputs, construction materials) to be recommended, and to be able to quantify the direct (stocking) and indirect (through improved mare governance) livelihood impacts of the pen aquaculture intervention.

INTERNATIONAL PUBLIC GOODS

The dissemination of the community-based fish culture model, developed in Bangladesh, to other countries in Asia and Africa represents an important contribution to a suite of aquaculture technologies currently available to rural households across the world. Testing the CBFC model in a range of environmental, social and economic contexts has provided important insights into the conditions that support community-based fish culture and where such an intervention is both appropriate and likely to generate benefits for rural communities. The Working Paper 'Conditions for Collective Fish Culture' provides a detailed analysis of the conditions which either supported or constrained CBFC in each of the project countries, going on to define the type of locations in which CBFC may provide an appropriate livelihood option and, in contrast, the type of environments where CBFC is likely to fail. This analysis can feasibly support the identification of promising locations for CBFC in Asia and possibly Africa.

The project has generated a series of reports and papers outlining important lessons learned with respect to the technical and institutional design of fish culture in seasonally flooding areas. In addition, the research has made significant contributions to our understanding of collective action and property rights in floodplains, where institutions governing resource use, access and ownership are both complex and dynamic. Unlike the majority of publications that focus attention on one location, the project provided a unique opportunity to contribute to the body of literature on technology adoption, collective action and property rights based on a comparative analysis in five countries.

Alternative approaches to Monitoring and Evaluation, and to assessing impact, are becoming increasingly popular in development research. In an attempt to understand impact and change beyond a traditional analysis of fish production and household income, the project applied Most Significant Change and Outcome Mapping methodologies to determine the extent of project impact, and unanticipated changes in particular. The findings have been presented in Sheriff and Schuetz (in press)¹⁶ and the lessons learned disseminated through a series of information sheets outlining the advantages and constraints of applying each of the methodologies in a research for development context¹⁷.

The impact of introducing participatory video techniques in Bangladesh has been two-fold. Firstly, by putting the camera in the hands of the community, PV is enormously empowering for the project beneficiaries, particularly for the women involved in the video production¹⁸. The video produced by the people of Melandi, 'Island of Dreams and Success', reflects the message that the community wanted to convey. As a M&E tool, PV can also flag the issues of most importance to the community, as the team discusses their preferred themes for the video. Secondly, the video is publicly available online, and reaching over 31,000 within 24 hours following posting on the independent, online Malaysian news portal Malaysiakini. The video conveys information about the project approach as well as the response of villagers whose lives have been affected as a result of the intervention. The value of the participatory video approach over traditional documentary film, written and filmed by outsiders has been communicated throughout the WorldFish Center and the CPWF. Furthermore, the communities involved in the PV process have continued to produce video films as a result of the relationships established between the community video team and Bangladeshi film maker Mustafa Sayeed, of

¹⁶ See also Community-based Fish Culture Working Paper Series No. 6

¹⁷ See Appendix. Pilot testing of Outcome Mapping in Vietnam was funded by ICT-KM of the CGIAR as part of the Knowledge Sharing in Research project (2008-2009).

¹⁸ See 'Putting the Camera in Archana's Hands' (<http://www.malaysiakini.tv/video/18376/-putting-the-camera-in-archanas-hands.html>).

Proshika, one of the largest NGOs in Bangladesh, who aims to establish a network of community film makers throughout rural Bangladesh.

PARTNERSHIP ACHIEVEMENTS

Working in partnership with national and international government and research institutions is essential to the successful implementation of a project of this scale, working across multiple countries that differ considerably in their social, cultural, environmental and institutional characteristics. The insights and perspectives provided by national partners in the development of locally appropriate technologies and institutions were critical to the fish culture intervention.

The partnerships established during project inception and developed during the course of the project were an important source of exchange and learning, particularly between the lead institution and national partners. In Cambodia, Mali and China in particular, national research partners at FiA, IER and FFRC adapted the community-based fish culture model to suit local conditions and preferences based on their knowledge and experience, adaptations that could not have been so effectively introduced developed by outside researchers. The research also benefited from open discussions with partners in Cambodia regarding the cultural and social sensitivities of collective action, increasing our understanding of the role of context in collective action and the degree to which it influenced project outcomes.

National partners reported that their knowledge and skills in the application of participatory research, the benefits of consulting with project beneficiaries on their needs and preferences, and a deeper understanding of socio-economic conditions of the communities in which they work had been amongst the most important outcomes of the project for their personal and professional development, and that of their institution. The project has also introduced a new technology that partners in Bangladesh, China, Mali and Vietnam are keen to disseminate more widely. In Cambodia, the project highlighted constraints to aquaculture development and the need for strengthened institutional linkages between central and decentralized government agencies.

The project has established good working relationships with research partners in five countries, providing a firm basis for future collaboration.

Working within the structure of CPWF confers additional partnership benefits, through knowledge exchange and interaction between other CGIAR scientists, NARES and ARIs, facilitated by opportunities to interact at conferences and workshops, and through regular communications from the CPWF Secretariat. The project has benefited greatly from feedback and interactions with Theme Leaders and others within the CPWF network, and a research environment that values innovation, responsive and responsible research and the importance of learning from both failure and success.

RECOMMENDATIONS

- Community-based fish culture provides a great opportunity to maximize productivity from seasonally flooding environments, for the benefit of rural communities, with potential for positive impacts on productivity, income, food security, livelihoods and resource governance demonstrated across a wide range of countries and conditions.
- Aquaculture has the potential to bring considerable benefits to rural Cambodia but further development of the sector will be needed to provide sufficient infrastructure, inputs, market linkages and extension services which can support the community-based fish culture model. The current initiative of the Cambodian government to develop community fish refuge ponds represents an important step towards building capacity and infrastructure for fisheries and aquaculture development. Further research and testing is needed to improve the productivity and sustainability of these systems, building on the knowledge generated by the CBFC project.
- Experiences in Mali indicate that CBFC has the potential to improve *mare* productivity through aquaculture and improved *mare* governance. However, further research is needed to establish whether the same outcomes can be replicated at other locations, and to evaluate opportunities for out-scaling the approach in other areas of the Inner Niger Delta. Research demonstrated the importance of providing a platform for dialogue amongst all *mare* resource users, whereby aquaculture became a catalyst for improved management of all *mare* resources, both aquatic and terrestrial. The approach adopted within the CBFC project provides a potentially useful model for *mare* management throughout the region.
- The CBFC model in private and public floodplains has been successfully proven in Bangladesh, and its potential for outscaling is promising. However, to do so further research is warranted to develop and implement institutional arrangements and a supportive policy environment for local co-management of - and equitable access to - floodplain fish resources. Particular attention could be given to constraints and opportunities in relation to the current auction system for the lease of public waterbodies to community based organisations and overlapping property rights in seasonal floodplain lands under private ownership
- Future research should also consider potential environmental impacts of CBFC, such as the relationship between fish culture and rice cultivation, and downstream impacts resulting from changes in the water management regime. The potential of the approach in coastal areas should also be explored. A suite of technologies has now been developed in Bangladesh, based on decades of experience in community-based fisheries, permitting the selection of the most appropriate technology to suit the location and local needs. Future interventions should draw on this vast body of knowledge to ensure the most appropriate technology is selected to suit local conditions and preferences.
- Community Based Fish Culture has a high potential in Vietnamese floodplains but requires some modifications compared to the initial trials. To improve participation in collective approaches, smaller groups are easier to develop and to manage fish production. Smaller production units will also help to develop alternate marketing strategies (including delayed marketing, with fish fattening in ponds) to improve economic return of the technology. Integrations of fish culture in a rice based agro-system is facilitated if the collective approach includes both production systems (e.g. fish and rice) in order to limit conflicts in relation to water management and rice cultural calendar.
- Exclusion is a common feature of resource management interventions based on resources held in common by a defined user group. Therefore, the potential for negative consequences to arise and impact resource users must be given full consideration before introducing a new technology. The approach undertaken in Mali is recommended, whereby a detailed investigation was undertaken prior to the

introduction of fish culture to understand patterns of resources use and access, to assess the potential for negative consequences and conflict, and to ensure that all user groups were included in the development and implementation of fish culture (See Russell et al, in prep).

- The costs and risks associated with fish culture can be reduced using various strategies, besides the pooling of land and water resources, such as marketing strategies and the collective purchase of inputs. The emergence of alternative options to help communities maximize the benefits from seasonally flooding areas is best supported through a flexible research approach and the acknowledgement of the critical role of national research partners in leading the development and testing of new technologies. The CBFC project benefited from such an approach, particularly in Mali, Cambodia and China, which promoted the emergence of more innovative options, relevant to local preferences and conditions, as well as opportunities for capacity building amongst local staff.
- A range of conditions that support and constrain community-based fish culture was identified during the course of the research. Careful selection of locations where these conditions prevail, and consideration of the social, political and historical context could lead to a considerable improvement in uptake and adoption of community-based fish culture, and other related technologies, with associated benefits to poor rural communities.

PUBLICATIONS

Working Papers

The working papers represent work-in-progress, forming a series of documents presenting research findings from the project. Readers are advised that the papers have not been subjected to academic quality control, nor edited for errors of fact or interpretation.

1. Impacts of technological interventions on fish production and biodiversity of seasonal floodplains in Bangladesh
2. Assessment of potential mare stocking impacts on resource access rights and livelihoods in Komio Village, Niger River Delta, Mali
3. Contextual analysis in two villages of the Niger River Inner Delta
4. Landscape level characterization of seasonal floodplains under community based aquaculture: illustrating a case of the Ganges and the Mekong Delta
5. Institutional histories, seasonal floodplains (mares), and livelihood impacts of fish stocking in the Inner Niger River Delta of Mali
6. Benefits and challenges of applying Outcome Mapping in an R4D project
7. Conditions for collective action: understanding factors supporting and constraining community-Based fish culture in Bangladesh, Cambodia and Vietnam
8. Country Report: China.

All working paper are available online on the **project website** at

<http://www.worldfishcenter.org/wfcms/CBFC2005/default.aspx>

Policy Briefs

Community-based Fish Culture: Getting it Right. WorldFish Center Lessons Learned Brief.

Videos

Available on Multimedia page of the project website at
<http://www.worldfishcenter.org/wfcms/CBFC2005/article.aspx?ID=779>

Peer-Reviewed Articles

Joffre, O., Chau, L.N., Ngai, H.H., Pich, S., Heng, K. and N. Sheriff. Community Based Fish Culture model in seasonally flooded rice fields: technical and financial perspectives from experiences in Vietnam and Cambodia (submitted to Aquaculture Economics and Management)

Joffre, O., Sheriff, N., Chau, L.N., Ngai, H.H. and N.V. Hao. Community-based fish culture – a viable coping strategy for farmers in the Mekong Delta? *Advances in Global Change Research (in press)*

Haque, A.B.M.M., Visser, L. and M.M. Dey. Designing and Testing of Institutional Options for Community Based Fish Culture in the Seasonal Floodplains in Bangladesh (*in prep*)

Haque, A.B.M.M., Visser, L. and M.M. Dey. Impact of Community Based Aquaculture in Seasonal Floodplains on Livelihoods in Bangladesh (*in prep*)

Nagabhatla, N., Nguyen-Khoa, S., Beveridge, M., Haque, A.B.M.M., Sheriff, N., Van Brakel, M., Rahman, F. and B. Barman. Multiple-use of water in Bangladesh floodplains: seasonal aquaculture and conjunctive use of surface and groundwater for improved rice-fish production systems (*submitted to Ecology and Society*)

Rahman, F, Md., Barman, B.K., van Brakel, M. and S. Dewan. Impacts of technological interventions on fish production and biodiversity of seasonal floodplains in Bangladesh. (*in prep*)

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Russell, A., Coulibaly, S., Sinaba, F., Kodio, A., Joffre, O. and N. Sheriff. Institutional histories, seasonal floodplains (mares), and livelihood impacts of fish stocking in the Inner Niger River Delta of Mali (*Submitted to Journal of Arid Environments*)

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Sheriff, N., Joffre, O., Meinzen-Dick, R., Werthmann, C. and B. Barman. Collective approaches to aquaculture - conditions for success, causes of failure (*in prep*)

Conference Papers and Presentations

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Haque, A.B.M.M., Barman, B.K. and M.M. Dey. 2008. Development of institutional options for community based fish culture in seasonal floodplains in Bangladesh. Abstract p 98.

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