AN EVALUATION OF SMALL-SCALE FRESHWATER RURAL AQUACULTURE DEVELOPMENT FOR POVERTY REDUCTION

OPERATIONS EVALUATION DEPARTMENT
Asian Development Bank
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ISBN 971-561-550-3

Publication Stock No. 091704

Published by the Asian Development Bank, 2005.

This publication is available on the Asian Development Bank’s publication website:
http://www.adb.org/Publications
Finding suitable aquaculture development approaches to open up livelihood opportunities for the rural poor remains a challenge. The poor face many constraints to adopting fish farming because of lack of access to capital and resources, vulnerability, and aversion to risks. Fish farmers need appropriate skills, land and water, financial capital, organizational arrangements, physical facilities, and infrastructure in order to adopt, operate, and sustain their aquaculture practices.

However, there are considerable opportunities for the entry of poor people into aquaculture through low-cost technologies and help to secure access to and control of resources. This is not merely a question of focused targeting toward the poor. It demands a comprehensive understanding of contextual circumstances, operating environments, and enabling conditions.

The Asian Development Bank (ADB) has supported development of small-scale freshwater aquaculture in a number of countries in the region and accumulated considerable experience in interventions that have as their objective poverty reduction as well as increasing fish production. This special evaluation study (SES) was designed to identify and assess the major channels of effects through which selected practices of small-scale freshwater rural aquaculture can generate livelihoods and reduce poverty, and to recommend steps to make ADB operations in aquaculture development more relevant for poverty reduction.

The SES was based on eight case studies—3 in Bangladesh, 3 in the Philippines, and 2 in Thailand—that form the second part of this book. The case studies probed various aspects of freshwater aquaculture in different and diverse settings. Together, they provide a representative selection of freshwater aquaculture practices in the context of farmers’ access to livelihood capital assets and processes that influence outcomes in terms of incomes, employment, nutrition, and natural resource sustainability.

This report was prepared by a team supervised by Graham Walter of the Operations Evaluation Department. Njoman Bestari, senior evaluation specialist (team leader) was responsible for the preparation of this report. Maria Rosa Ortega (evaluation officer), Maria Victoria de la Cruz, and Caren Joy Mongcopia supported the study in Manila. Several consultants collaborated in the study: Nesar Ahmed (research associate, Bangladesh), Peter Edwards (aquaculture development specialist), Brenda Katon (research associate, Philippines), Alvin Morales (rural economist, Philippines), and Roger Pullin (Aquatic Resources Management Specialist). Cherdaks Virapat and Supawat Komolmarl collaborated with the team on the preparation of two case studies in Thailand. The book was edited by Jay Maclean. Ram Cabrera did the design and layout.

The evaluation and the individual case studies provide many lessons for development practitioners that are useful not only for ADB project personnel, but for research and development workers in all institutions—public, private, non-government, and international—working toward poverty reduction in developing countries of Asia.

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EISUKE SUZUKI
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Abbreviations

ADB      Asian Development Bank
BFAR     Bureau of Fisheries and Aquatic Resources
DEGITA   Dissemination and Evaluation of Genetically Improved Tilapia
Species in Asia
DFID     Department for International Development of the United Kingdom
FAO      Food and Agriculture Organization of the United Nations
GIFT     genetically improved farmed tilapia
HACCP    hazard analysis critical control point
ICLARM   International Center for Living Aquatic Resources Management
NACA     Network of Aquaculture Centres in Asia-Pacific
NGO      nongovernment organization
SES      special evaluation study
TA       technical assistance
WHO      World Health Organization

Weights and Measures

ha  hectare
kg  kilogram
m   meter
t   metric ton

Note

In this report, “$” refers to US dollars.
EXECUTIVE SUMMARY

The Asian Development Bank (ADB) has accumulated substantial experience from its operations in the development of aquaculture, including small-scale freshwater aquaculture. The results of various projects have underscored the importance of (i) realistic assessment of operating risks and the extent to which project designs address these risks, (ii) recognition of actual operating requirements and the extent to which targeted participants can meet these requirements, and (iii) other enabling conditions for achieving success.

Part 1. THE EVALUATION

This special evaluation study (SES) was designed to identify and assess the major channels of effects through which selected practices of small-scale freshwater rural aquaculture can generate livelihoods and reduce poverty, and to recommend steps to make ADB operations in aquaculture development more relevant for poverty reduction. Using case studies, the SES examined the channels and enabling conditions that affect small-scale freshwater aquaculture farmers in their operations. The SES recognized the importance of access to capital assets in five dimensions (human, social, natural, physical, and financial capitals), and key transforming processes, including (i) markets; (ii) public and private institutions; (iii) facilities, infrastructure, and services; (iv) legal framework and development policies; (v) aquatic resources management and the environment; and (vi) various safeguards, including biosafety and aquatic health. The SES also recognized seasonality, shocks, and trends that influence outcomes.

Based on case studies in Bangladesh, Philippines, and Thailand, and lessons and experience drawn from evaluations of ADB-financed operations in freshwater aquaculture development, the following recommendations to improve ADB operations in this sector were made.

Analyze Conditions for Livelihood Generation and Poverty Reduction. Contextual understanding of the conditions under which selected practices of small-scale freshwater aquaculture can reduce rural poverty is critical. Those involved in project preparation and design for aquaculture development should consider adopting the conceptual framework utilized in this study.

Recognize Barriers, Requirements, and Risks. Assessing characteristics of farm households and analyzing their poverty features are parts of the process of finding ways to make aquaculture work for the poor. When aimed at poverty reduction, aquaculture development efforts should be designed carefully by clearly defining the beneficiaries and devising appropriate strategies to help them benefit from the interventions. Project design should address (a) specific features of poverty in the target area; (b) feasible options to overcome key barriers for entry into and to remain in aquaculture; and (c) risks that the poor have little capacity to cope with, and ways to mitigate these risks.

Assess Specific Demands on Users’ Capacity to Operate Aquaculture Systems. An assessment is needed of (a) technology options for selected farming practices and the capital assets required, (b) users’ access to capital assets, and (c) the extent to which intended users of selected aquaculture systems have the required capacity to operate and sustain the systems.

Analyze Available Options for Providing Access to Land and Water. Without land and water the poor are unlikely to engage directly in fish farming. Secure access and tenure rights are necessary.

Consider Options for Financing Aquaculture Investments and Operations. Access to affordable credit is an important feature of farmers’ household finance. Evidence indicates that small-scale farmers often do not borrow from banks because of various administrative hurdles and the need for collateral. Instead, they rely on credit from suppliers, traders, or buyers; contract farming; and partnership arrangements with financiers/investors. Microfinance can also make a difference to the poor.

Analyze Markets and Marketing of Aquaculture Products and Factors of Production. Small-scale farmers, including those in aquaculture, must generate satisfactory returns by providing goods and services for which there is effective
demand at prices and costs that can justify their supply. A thorough assessment is required of markets and marketing of farm outputs and factors of production.

**Analyze the Labor Market.** A labor market assessment should be conducted to analyze formal and informal employment opportunities, wage rates, and other labor market characteristics, such as labor migration and seasonal patterns that influence households’ decisions on employment. Farm households rarely have a single source of income. Livelihood choices and sources should be assessed to ensure that aquaculture as an option for livelihood is not analyzed in isolation.

**Understand the Roles of Services, Facilities, and Support Infrastructure.** Small-scale farm households have limited resources at their disposal, and innovative approaches are required to reach the poor among them. Government agencies may remain important sources of technical advice for small-scale farmers, but the extent to which private service providers are involved in extending advisory and information services should be examined. Aquaculture development cannot succeed if pioneered and left to sustain itself in locations where essential support services and markets are absent. Roads, transportation, and communications play important roles in the flow of goods, services, and information.

**Assess the Roles of Public and Private Institutions.** Public institutions can catalyze and facilitate aquaculture development, but governments’ role in the sector must not stifle, crowd out, or replace the role of the private sector.

**Assess the Policy Environment and Legal Framework and Their Conditions.** Appropriate policies, legal instruments, and enforcement can remove identified constraints to aquaculture development. Licenses, rules, and regulations, including processes for conflict prevention and resolution, for aquaculture operators, associated agents, and labor can influence the extent to which the poor can benefit.

**Protect Aquatic Resources, Environment, and Aquatic Health.** The development of aquaculture cannot be sustained without paying adequate attention to aquatic resources management, environment, and aquatic health. Steps must be taken to ensure sustainability of the environment by taking measures for biosafety, disease prevention, and environmental protection.

**Recognize Multiple Uses of Water and Minimize Conflicts.** Freshwater aquaculture coexists with other water uses. The multiple uses of water and their relationships are largely unplanned, with possibilities of serious conflicts ahead. Improvement in relationships between freshwater aquaculture and other sectors needs to be forged by recognizing the limited availability of freshwater and finding ways to benefit as many users of water as possible.

**Part 2. THE CASE STUDIES**

This compilation of case studies provides up-to-date portraits of the small-scale freshwater farming subsector in three countries—Bangladesh, Philippines, and Thailand. In each country, one or more features of particular interest from the point of view of poverty reduction have been selected and treated in detail. In Bangladesh, the benefits to the poor of a project that gave groups of the poor, mainly women, access to fish farming are outlined; a second study shows how a simple but effective fish farming technology was taken up by the poor and how the benefits spread to intermediaries and markets. In the Philippines, the focus was on tilapia, which dominate freshwater aquaculture there, and on socioeconomic aspects of the two main farming systems, ponds and cages. In Thailand, the study examined how an appropriate technology was developed and disseminated in a resource-poor area in the northeastern part of the country.

**Bangladesh**

**Case Study 1,** an overview of small-scale freshwater aquaculture in Bangladesh, was designed to investigate the countrywide significance of freshwater aquaculture, social dimensions of rural poverty among farmers, major aquaculture systems, fish markets, employment in aquaculture, and ADB’s support to aquaculture development. The freshwater aquaculture systems have improved greatly over the past two decades. Freshwater aquaculture, mostly small-scale farms, accounts for more than one third of total fisheries production in the country. However, there is still much potential for gain by rationalizing the choice of species used for farming and in comprehensive programs to conserve genetic diversity and produce quality broodstock. The importance of secure access to land and water and to microfinance in assisting the poor to access small-scale aquaculture is highlighted.

**Case Study 2,** farming carps in leased ponds by groups in Chandpur District, outlines a project—part of a larger project financed by ADB to improve livelihoods in the District—that brought freshwater aquaculture to the poor in an irrigation area. The aim was to capitalize on a
low-cost technology based on carp polyculture. The project organized the poor, primarily women, into 175 groups totaling nearly 2,600 persons; trained them in the technology; helped them to acquire fishponds; and provided them with microfinance services. The study found that the project helped unemployed, underemployed, marginal, and landless persons. It describes the socioeconomic conditions of the group members, their perceptions of the financial and health benefits of this form of aquaculture, empowerment of women members, and the constraints to continuing and increasing their operations. Also described are the characteristics of other parts of the subsector—the fish traders, seed traders, and harvesters—which are also benefiting from the growth of small-scale aquaculture in the area.

**Case Study 3**, illustrating livelihood profiles of fish farmers in Kishoreganj, was undertaken in the Greater Mymensingh area, representing a major region in Bangladesh for freshwater fish farms. This area was targeted from 1988 to 1997 under an ADB-financed project to promote fish farming through the establishment of demonstration fishponds and farmer-to-farmer contact. This case study investigated common livelihood conditions of inland freshwater fish farmers. Described are the pond operations and management, which are semi-intensive in nature, the village nurseries that supply most of the seed, the amounts of organic and inorganic fertilizer used, harvest frequency, yields, and markets. Nearly all the operators were primarily rice farmers or engaged in microenterprise. Fish farming is a secondary occupation and third in terms of income generation. Nevertheless, all the households surveyed confirmed that as a result of aquaculture development, their food and fish consumption had increased, they had benefited from employment and cash income, and anticipated that they would continue to benefit from aquaculture in the future.

**Philippines**

**Case Study 4**, an overview of freshwater aquaculture of tilapia in the Philippines, was prepared in order to investigate tilapia markets, prices, marketing channels, access to inputs (fish seed, feed, fertilizers, land, and water), support services, and relevant lessons. The farming of Nile tilapia has expanded rapidly since the introduction of this species in the early 1970s. Since the mid-1980s, growth of freshwater tilapia farming has averaged nearly 9% annually. Real prices have declined during this period, making the fish more affordable to the poor and cheaper than milkfish, traditionally the most popular and cheapest freshwater and brackishwater fish in the market. Numerous hatcheries and nursery operations have sprung up to meet the demand for seed, currently estimated at about 1 billion fingerlings annually. A special feature has been the use of monosex fish (sex reversed using hormones), which grow faster than mixed-sex fish. Tilapia aquaculture has also contributed to growth of the feed industry, although finding cheaper alternatives to complete feeds is needed to lower production costs. At least a quarter of a million people directly and indirectly benefit from employment in tilapia farming and ancillary activities in the country. Small-scale farmers have benefited from the wide availability of informal credit, often under agreements with traders and suppliers, and in contract farming or caretaker-financier arrangements. The legal framework also favors small-scale tilapia farmers, but to date, lack of funding and capacity hamper implementation of the laws.

**Case Study 5**, farming tilapia in small ponds in Central Luzon, was undertaken to illustrate biophysical and socioeconomic characteristics of Central Luzon as the main producer of tilapia in the country, followed by accounts of technology and management for farming tilapia, profiles of fish farmers, markets, institutions, support services, policy and legal instruments, natural resources management, and environmental issues. The survey found there were 142 hatcheries in the region, supplying continually improving tilapia strains. There were usually two fish crops per year and a range of stocking and feeding practices. Generally, tilapia farmers made a basal application of inorganic fertilizers and used commercial feeds. This region is the country’s main rice bowl and depends heavily on rainwater and irrigation. The great majority of tilapia farmers drew on the plentiful groundwater using deep wells, and this minimized conflict with rice farmers. The marketing system for tilapia was robust and efficient; the infrastructure well developed. The profitability of small-scale tilapia farming was found to be much greater than that of rice, but so were the problems—declining tilapia prices, rising feed costs, and increasing numbers of tilapia farmers—that prevented even more households entering the industry. However, there is considerable scope for growth of the industry in the region. Both small-scale tilapia farmers and rice farmers had at least one other occupation, mostly another crop or livestock. Both groups felt better off than in the recent past and were confident about the future, although concerned about deteriorating natural resources.

**Case Study 6**, tilapia cage farming in Lake Taal, Batangas, provided accounts of the technology and management used for tilapia cage farming and
nursery operations, profiles of fish farmers and other beneficiaries, and relevant processes pertinent to markets, labor, institutions, support services, policy, legal instruments, natural resources management, and environmental issues pertinent to the lake. Lake Taal has become a major site for farming tilapia, with nearly 7,000 cages in the lake producing two crops each year, supported by separate nursery operations in nearby converted ricefields, and an efficient marketing system. It has contributed to poverty reduction in the area through direct employment of farmers and their families and intermediaries along the marketing chain. However, the growout system is intensive and its success threatens its future because of overcrowded cages and pollution from feeds and wastes. These problems are beginning to be addressed through better policies and management. Nursery farmers were optimistic about the future of the industry at the lake. Cage farmers were facing declining cash incomes and were worried about the deteriorating resource base, but were nevertheless expecting that the industry would continue with improvements in technology.

Thailand

Case Study 7, an overview of small-scale freshwater aquaculture in Thailand, was tailored to investigate and illustrate the historical development and importance of aquaculture, fish seed supply and fish farming, markets, extension services, community-based initiatives, aquaculture development policy, pertinent aspects of safeguards, key lessons, and ways to reach the poor. Freshwater fisheries have declined dramatically in recent decades, providing a major stimulus for the relatively recent development of aquaculture. The majority of freshwater aquaculture is based on species of relevance to small-scale farming—herbivorous and omnivorous carps, gouramis, and tilapia. Most farming is in ponds. Seed supply is adequate and distributed through networks of local and distant traders. Nile tilapia is the dominant species, about 30% of total freshwater aquaculture production. Marketing involves a variety of channels and is almost all done by the private sector. The Government has been active in promotion of various technologies through extension (see case study 8) and transfer of new technologies to farmers. The Government’s fisheries policy assumes continuation of small-scale aquaculture, primarily for domestic consumption and local food security. Therefore, research is aimed at innovative, low-cost technologies. The main aquaculture tool used by the Government to address poverty reduction is the Village Fish Pond Development Project, which attempts to increase fish production through community management of natural or modified water bodies at the village level. Success has been variable, but the recent decentralization of government authority has given new impetus to decision making at the community level.

Case Study 8, development of technology and extension for small-scale fish farms in Northeastern Thailand, was undertaken to examine (i) the steps, processes, and challenges involved in developing technology options and extension for small-scale fish farmers; and (ii) the relevance of a distance extension approach for resource poor, mobile, and literate fish farmers. This case study draws heavily from the experience of the Aqua Outreach Program (AOP) of the Asian Institute of Technology and the Department of Fisheries (DOF) of Thailand. Northeastern Thailand, which occupies one third of the country, is an area of mainly rainfed agriculture. The yields are so low that most farmers work off-farm to augment their income; semi-permanent urban migration is increasing. Small-scale aquaculture in ponds and ricefields is common but yields are again low. Beginning in 1988, AOP investigated the nature and relevance of aquaculture in provinces of the region; found that there was scope for much improvement in pond management at little cost to farmers; and developed effective, simple technologies for fertilizing ponds and nursing seed until large enough to escape from predators. DOF had been encouraging hatchery development and seed supply (of carps and tilapia) had greatly improved. A distance extension approach was needed because of the few available government extension officers, and these were not trained in aquaculture. Extension materials were developed in consultation with farmers and DOF. The products (booklets) were in local languages and tailored to the farmers’ culture, experience, and lifestyles. Dissemination was encouraged by the DOF. Although farmers often modified the recommendations, the main concept of “green water” as being desirable for fish growth clearly spread successfully, both through the materials and word of mouth among farmers.
BANGLADESH

National Capital
City/Town
River
Municipal Boundary
Provincial Boundary
International Boundary
Boundaries are not necessarily authoritative.

Study Area
Matlab

Study Area
Bajtipur, Nikli, and Kollai

Chandpur
PART 1

The Evaluation
CHAPTER 1

INTRODUCTION

GLOBAL CONTEXT

Generally defined as farming of aquatic plants and animals, both in inland and coastal areas, aquaculture is an important food production system in developing countries. Rural aquaculture may be defined as the farming of aquatic species, using technologies adapted to locally available and limited resources of households.1

During 1984–1998, global aquaculture production grew at an average annual rate of more than 11.0%, compared with annual growth rates of 3.1% for terrestrial-farmed animal meat production and 0.8% for landings from capture fisheries.2 Asia produced 36 million metric tons (t) or 91% of total global aquaculture production in 1998, and accounted for all of the world’s top 10 producers: People’s Republic of China, India, Japan, Philippines, Indonesia, Republic of Korea, Bangladesh, Thailand, Viet Nam, and the Democratic People’s Republic of Korea, in that order. Major policy influences on Asian aquaculture development have led to the recent broadening of technical and economic objectives toward social objectives that include poverty reduction, livelihood development, and food security.

Aquaculture has been one of the fastest growing food production systems in the world, with the bulk of output currently produced in developing countries and with expectation for aquaculture to continue its contribution to food security and poverty reduction. The Food and Agriculture Organization (FAO) of the United Nations recognizes, in its Code of Conduct for Responsible Fisheries3 and accompanying guidelines,4 the current importance and future potential of aquaculture for rural communities and for food security. An increasing recognition of the importance of small-scale aquaculture is taking place.5 Rural aquaculture generates employment and cash income, and provides animal protein and essential nutrients to consumers. It contributes to rural livelihoods, improves food supply, and makes low-cost fish available in domestic markets. Integrating aquaculture into smallholder farming systems can reduce risks to farmers through crop diversification; it also allows nutrient recycling.6 The Network of Aquaculture Centres in Asia-Pacific (NACA) and FAO endorsed this recognition by publishing a declaration and strategy on the role of aquaculture in improving food security and alleviating poverty.7 In recent years, experts have continued to find ways to increase the relevance of aquaculture to poverty reduction.8

ASIAN DEVELOPMENT BANK’S ROLE IN AQUACULTURE DEVELOPMENT

The Policy on Fisheries of the Asian Development Bank (ADB) is anchored on (i) equity in balancing the interests of competing resource users, (ii) sustainability in conservation and use of fisheries and aquatic resources, and (iii) efficiency in the development and management of aquatic resources.9 For aquaculture, ADB’s Policy on Fisheries emphasizes increasing production from existing aquaculture farms and coastal areas, and

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integration of aquaculture with existing crop and livestock farms. ADB also supports aquaculture development through research and development, dissemination of environmentally-friendly technologies, and provision of unsubsidized inputs and financial services, including microfinance.

By 31 December 2003, ADB had financed 25 projects with major aquaculture development components, with approved loans totaling $665 million (Appendix 1, Table A1.1). Early aquaculture development initiatives date from the 1970s (6 projects), but the majority of project approvals (13 projects) took place in the 1980s, coinciding with a surge in global interest in aquaculture. This was partly because of its recognized potential to meet production and consumption needs, and to generate foreign exchange through exports. ADB approved 5 aquaculture projects in the 1990s, and 1 project in 2002. In general, these projects focused on intensifying and improving the efficiency of aquaculture production through development of hatcheries and support services, such as credit, extension, and related services. Of these 25 projects, 21 projects have been completed, 1 project was canceled when its approval lapsed, 3 projects are ongoing, and 12 projects have been independently evaluated. Successful projects demonstrated aquaculture technologies, provided livelihood opportunities, strengthened local institutions, and propelled private sector interest in hatchery and aquaculture pond operations.

ADB pronounced poverty reduction as one of its five strategic development objectives in 1992. By then, 10 ADB-financed aquaculture development projects had explicit objectives to address the needs of small-scale fish farmers. Despite this explicit bias, project completion reports and project performance audit reports indicated that the outcomes of these projects did not always favor poor small-scale fish farmers because of (i) ineligibility for credit because of limited assets for collateral; (ii) high operating risks, inability to absorb losses, and rising debts; (iii) inadequate water supply, substandard water quality, poor farm management, and inadequate site selection; (iv) limited skills and experience with the newly acquired technology and management practices; (v) inflexible and unresponsive institutions; and (vi) inappropriate policies. This experience affirmed that focused targeting of the poor is insufficient to improve their socioeconomic conditions. ADB progressively expanded its development approach to encompass a wide range of social and environmental concerns. In addition, ADB declared poverty reduction as its overarching goal in 1999.

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10 ADB also supports marine aquaculture of fish, seaweeds, bivalves, and other invertebrates to the extent that these activities do not negatively alter the ecological balance in coastal areas.

11 This comprises 9 wholly aquaculture projects and 16 fisheries projects with aquaculture components. All have been completed, except for the (i) Fisheries Resource Management Project in the Philippines (expected to be completed in 2004); (ii) Coastal Community Development and Fisheries Resource Management Project in Indonesia (expected to be completed in September 2005); and (iii) Aquatic Resources Development and Quality Improvement Project in Sri Lanka (expected to be completed in 2009).

12 According to the project performance audit reports, 5 projects were rated either generally successful or successful, 5 partly successful, and 2 unsuccessful.

13 These successful projects generally attained economic internal rates of return of 10–26%, with marked increases in yields and net incomes. However, due to the paucity of data in general, the impacts of these projects on benefit distribution, employment, nutrition, and food security could not be easily ascertained.

14 ADB adopted poverty reduction as one of its five strategic development objectives in its Medium-Term Strategic Framework (1992–1995); the other four objectives were promoting economic growth, supporting human development, improving the status of women, and managing natural resources and the environment soundly.

15 ADB. 1999. Fighting Poverty. Manila. The ADB’s Long-Term Strategic Framework (2001–2015) provides fundamental operating principles to ensure that all activities are integrated and directed to its overarching goal.
CHAPTER 2

RATIONALE, PURPOSE, AND METHOD OF EVALUATION

RATIONALE FOR THE SPECIAL EVALUATION STUDY

In the past, determination of benefit distribution was not prominent in most ADB-financed aquaculture development projects. Aquaculture was often narrowly viewed as intensive farming of shrimp and prawn species, adopted mainly by relatively wealthy farmers to provide high-value products for exports. Such views frequently dominate despite concerns that the expansion and growth in shrimp farming without safeguards has often led to environmental degradation. This narrow view of aquaculture development hides the potential of fish farming, particularly in the context of rural development.

Evaluation findings of completed projects underscore the importance of (i) realistic assessment of the risks facing farmers and operators and the extent to which project designs address these risks; (ii) requirements for innovative credit schemes, credit demand analysis, and realistic access conditions; (iii) environmental assessments, aquatic resources management, and appropriate safeguards; and (iv) aquatic biosafety and health care. The findings also emphasize the need for rigorous assessment of the capacity of executing and participating agencies, extension services, infrastructure enhancement, resource management, and enforcement of regulations to prevent aquatic diseases and environmental degradation.

Finding suitable aquaculture development approaches to open up livelihood opportunities for the rural poor remains a challenge. The poor face many constraints to adopting fish farming because of lack of access to capital and resources, vulnerability, and aversion to risks. Fish farmers need appropriate skills, land and water, financial capital, organizational arrangements, physical facilities, and infrastructure. However, there are considerable opportunities for the entry of poor people into aquaculture through low-cost technologies and help to secure access to and control of resources. This, however, is not merely a question of targeting the poor. It demands a comprehensive understanding of contextual circumstances, operating environments, and enabling conditions. Current knowledge gaps largely concern environmental and social aspects, and the livelihood aspects of small-scale and poor farmers, including barriers and access to adoption of technology and sustained farm operations.

PURPOSE AND METHOD OF EVALUATION

This special evaluation study (SES) was designed to identify and assess the major channels of effects for livelihoods and poverty reduction of small-scale freshwater rural aquaculture, and to recommend steps to make ADB operations in aquaculture development more relevant for poverty reduction. For the analysis, the SES examined the channels through which small-scale freshwater aquaculture farmers are affected in their farming operations, such as access to livelihood assets, markets and prices, the labor market, access to services and facilities, infrastructure, and key transforming processes, including institutions and policies.

The SES used a case-study approach with an array of methods: (i) review of relevant publications, including documented non-ADB experience in freshwater rural aquaculture; (ii) secondary data analysis; (iii) key informant interviews and focus-group discussions; and (iv) household surveys of small-scale fish farmers and others who had not adopted fish farming. The SES used both qualitative and quantitative methods of data collection and inquiry. The presurvey activities were reconnaissance and rapid rural appraisal, pretesting and revision of


survey instruments, preparation of sampling frames, sampling of respondents, training of field enumerators, and a survey dry run and its feedback. The Statistical Package for Social Sciences was used to generate descriptive statistics (frequency counts, percentages, and means) and inferential statistics for analyzing survey data. The survey was based on recall by respondents rather than on documented baseline information. Interviews with nonadopters of aquaculture provided insights to illustrate barriers and vulnerability of access to aquaculture.

The SES applied a conceptual framework based on a modified sustainable livelihood approach.\(^\text{19}\) The framework places selected freshwater aquaculture practices in the context of farmers’ or operators’ access and vulnerability to livelihood capital assets and processes that influence outcomes (incomes, employment, nutrition, and natural resource sustainability). This framework (Figure 1) recognizes the importance of access to capital assets in five dimensions (human, social, natural, physical, and financial capitals). The conceptual framework also recognizes key transforming processes: (i) markets and prices; (ii) labor market; (iii) public and private institutions; (iv) facilities, infrastructure, and services; (v) legal framework and development policies; (vi) aquatic resources management and the environment; and (vii) various safeguards, including biosafety and aquatic health.\(^\text{20}\) This framework also recognizes seasonality, shocks, and trends that influence outcomes. The importance of access to different kinds of capital assets can vary with specific and local circumstances. However, some conditions (such as access and tenure rights to land and water) are essential for all aquaculture.

As a means of determining perceived outcomes, survey respondents were asked to assess various situations over time: (i) 5 years ago, (ii) at present, and (iii) 5 years from now. A visual ladder-like scale with 10 steps was used, allowing respondents to make ordinal judgments.\(^\text{21}\) Step 1 on the ladder represented the worst possible situation while step 10 portrayed the best possible scenario.

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\(^{20}\) Transforming processes and structures are also known as the policies, institutions, and processes dimension of the sustainable livelihoods framework used by DFID. Available: http://www.livelihoods.org/pip/pip_home.html

CASE STUDIES

Eight case studies were selected and undertaken, covering Bangladesh (three case studies), Philippines (three), and Thailand (two). These case studies are compiled in Part 2 of this book.22

The selection of case studies took into account (i) inclusion of the poor among operators of or participants served by selected fish farming practices; (ii) presence of rural, small-scale freshwater aquaculture applications and practices; (iii) features indicating representative socioeconomic and agroecological conditions; and (iv) favorable security or peace and order conditions that allowed unhindered access to selected sites and conditions for generating outcomes. The SES was largely undertaken in 2003.23

The case studies probed and emphasized different aspects of freshwater aquaculture in diverse settings. Altogether, the eight case studies in three countries provide a composite illustration of the SES conceptual framework.

**Bangladesh.** ADB first supported aquaculture development in Bangladesh through a project in the late 1970s.24 A later project further supported aquaculture development to increase fish production for domestic consumption, expand employment, and increase incomes in rural areas.25 ADB has supported Bangladesh in promoting and disseminating fish farming technology, particularly carp polyculture. Three case studies were undertaken in Bangladesh.

(i) Case study 1, an overview of small-scale freshwater aquaculture in Bangladesh, was designed to investigate countrywide significance of freshwater aquaculture, social dimensions of rural poverty among farmers, major aquaculture systems, fish markets, employment in aquaculture, ADB’s support to aquaculture development, safeguards for aquaculture development, relevant lessons, and ways to benefit the poor.

(ii) Case study 2, farming carp in leased ponds by groups in Chandpur, was based on a component of the ADB-financed Command Area Development Project.26 To mitigate the decline in capture fisheries, a small-scale freshwater aquaculture project was designed using a low-cost technology based on carp polyculture that had been promoted by an earlier ADB-financed project in Chandpur.27 The project (i) organized the poor, primarily women, into groups; (ii) trained these groups on fish farming; (iii) helped the groups to acquire fishponds; and (iv) provided them with microfinance services. The project helped unemployed, underemployed, marginal, and landless people who had access to less than 0.2 hectare (ha) of cultivable land. The study included a survey of 100 randomly selected fish farming groups and 100 households from the farm groups, and interviews with fish traders, fish seed (juvenile fish including fry and fingerlings) traders, and fish harvesters.

(iii) Case study 3, livelihood profiles of fish farmers in Kishoreganj, was undertaken in the Greater Mymensingh area, a major region in Bangladesh for freshwater fish farming. Kishoreganj was among 22 districts targeted in 1988–1997 under the ADB-financed Second Aquaculture Development Project to promote fish farming based on semi-intensive carp polyculture pond technology through the establishment of demonstration fishponds and farmer-to-farmer contact (footnote 27). This case study investigated common livelihood conditions of inland freshwater fish farmers in Bangladesh and included a survey of 100 households with fishponds. Households were selected randomly in areas typical of the Greater Mymensingh area.

**Philippines.** From the late 1980s, ADB and other aid agencies contributed funds for research on genetic improvement of farmed tilapia and dissemination of improved breeds.28 Nile tilapia (*Oreochromis niloticus*) farming was also promoted through other

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22 The eight case studies (Part 2 of this book) were prepared as supporting documents for ADB’s evaluation (Part 3) of the sector.

23 Fieldwork was interrupted on a number of occasions because of unanticipated security conditions and travel restrictions, which caused scheduling difficulties for several SES team members who were engaged intermittently for the study. These conditions included the emergence of the severe acute respiratory syndrome (SARS); local security advisory and conditions to ensure safe and unhindered access to survey sites in the Philippines for interviewers and enumerators; and an aborted mission in April 2003 in Bangladesh, when team members were prevented from visiting sites outside Dhaka. Consequently, the fieldwork commenced in June 2003 in Bangladesh, and in July 2003 in the Philippines and Thailand. Information gathering, data analyses, data interpretation, and synthesis of information for the case studies continued until January 2004.


26 ADB, 1995. *Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the People’s Republic of Bangladesh for the Command Area Development Project.* Manila. (Loan 1399-BAN[SF]: Command Area Development Project, for $30 million, approved on 7 November 1995.) The project was designed for implementation over 5 years, but loan closing was extended for 2 years to 30 June 2003.


28 Through selective breeding, the development of genetically improved farmed tilapia (GIFT) was partly financed by ADB under TA 5279-REG (ADB, 1988. *Technical Assistance for the Genetic Improvement of Tilapia Species in Asia.* Manila), for $475,000, approved on 8 March 1988. ADB also supported dissemination of GIFT through TA 5558-REG (ADB, 1993. *Technical Assistance for the Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA).* Manila), for $600,000, approved on 14 December 1993. The DEGITA distributed GIFT to Bangladesh, People’s Republic of China, Philippines, Thailand, and Vietnam, with on-station and on-farm evaluation of their performance.
ADB-financed projects in the Philippines.20 Farmed tilapia production increased more than five-fold from 1981 to 2001, largely because of improved breeds, increased input supply and commercial feed, technical support and extension, and cooperation between government agencies and the private sector. Taking into account the dominance of tilapia in freshwater aquaculture in the Philippines, three case studies were undertaken for the SES.

(i) Case study 4, an overview of freshwater aquaculture of tilapia in the Philippines, was undertaken to investigate tilapia markets, prices, marketing channels, access to inputs (fish seed, feed, fertilizers, land, and water), and support services, and to derive relevant lessons.

(ii) Case study 5, farming tilapia in ponds in Central Luzon, was undertaken to illustrate biophysical and socioeconomic characteristics of this region as the main producing area of tilapia in the country, and to describe the technology and management for farming tilapia, profiles of fish farmers, markets, institutions, support services, policy and legal instruments, natural resources management, and environmental issues. This case study included a survey of 248 farm households comprising tilapia farmers and rice farmers who had not adopted fish farming.

(iii) Case study 6, tilapia cage farming in Lake Taal, Batangas, was undertaken to describe the technology and management used for tilapia cage farming and nursery operations, profiles of fish farmers and other beneficiaries, and relevant processes pertinent to markets, labor, institutions, support services, policy, legal instruments, natural resources management, and environmental issues. This case study included a survey of 100 tilapia cage farmers and 81 nursery pond farmers from three major tilapia-producing municipalities that accounted for 98% of the total number of cages in the lake and associated nurseries.

**Thailand.** In an attempt to learn from non-ADB experience, two case studies were undertaken in Thailand.

(i) Case study 7, an overview of small-scale freshwater aquaculture in Thailand, was designed to investigate and illustrate the historical development and importance of aquaculture, fish seed supply and growout (the farming of fish seed to market size), markets, extension services, community-based initiatives, aquaculture development policy, safeguards for aquaculture development, key lessons, and ways to benefit the poor.

(ii) Case study 8, development of technology and extension for small-scale fish farms in Northeastern Thailand, was undertaken to examine (a) steps, processes, and challenges involved in developing technology options and extension for small-scale fish farmers; and (b) relevance of a distance extension approach for resource-poor, mobile, and literate fish farmers. This case study draws heavily from the experience and cooperative efforts of the Aqua Outreach Program of the Asian Institute of Technology and the Department of Fisheries of Thailand.

**REPORT STRUCTURE**

Chapter III discusses relevant features of poverty and dimensions of vulnerability. Chapter IV analyzes features of capital assets and transforming processes that influence small-scale freshwater aquaculture, using examples from the case studies. Chapter V summarizes key findings from the case studies. Chapter VI draws pertinent lessons from ADB operations in freshwater aquaculture in general. Chapter VII provides recommendations for making small-scale freshwater rural aquaculture more relevant for poverty reduction.

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CHAPTER 3

UNDERSTANDING POVERTY AND VULNERABILITY

FEATURES OF POVERTY

The SES recognizes poverty as a multidimensional concept that includes (i) deprivation or lack of access to capital assets essential to livelihoods; and (ii) vulnerability to physical and economic shocks, and to various attributes of seasonality. Poverty is reflected in low standards of living; deprivation of income and nonincome assets; shortfalls in consumption, nutrition, and access to services; and limited means to cope with crisis situations. Poverty also reflects lack of employment opportunities.

Land ownership as an income-generating physical asset has a predictable link with poverty incidence in rural areas, although the size of landholdings is an imperfect measure of wealth. For example, rural poverty in Bangladesh stood at 47.1% in 1995/96, and poverty incidence among the landless was 64%. The extremely poor are completely landless, owning neither homestead land nor arable land and, if not homeless, they live on borrowed land, sometimes in fear of eviction. Those with homestead land of less than 0.2 ha have little food security, suffer from continuous food deficits, and possess insignificant assets to rely on during crises. Among farmers with access to limited land (0.2–0.5 ha), the incidence of poverty in 1995/96 was as high as 44%. Even among those who had access to moderate amounts of land (0.5–1.0 ha), including fishponds, poverty incidence was 34%. Lack of access to employment was a major feature of poverty among disadvantaged women in Chandpur. An overwhelming majority of these women could not find remunerative employment, the major reasons being social barriers, household responsibilities, and inability to work physically as wage laborers. In both Chandpur and Kishoreganj, Bangladesh, small-scale aquaculture households faced food insecurity for up to 4 months a year.

In the Philippines, small landholders, leaseholders, and other tenants are among the rural poor. For example, 43% of the small-scale tilapia farmers surveyed in Central Luzon were below the poverty line. Two thirds of all surveyed farmers there experienced some period of food deficits in 2002.

The period of food deficits coincided with the completion of major farming activities (pond preparation, rice planting, etc.), marked by an absence of income and a slackening of on-farm employment, usually in August and September. Food deficits also coincided with the occurrence of typhoons that frequently affect the area. Similarly at Lake Taal, more than 80% of cage farmers and fish seed nursery operators experienced periods of food inadequacy in 2002, particularly during July and August, coinciding with unfavorable climatic conditions.

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30 ADB. 2002. Poverty Lines Bangladesh, Poverty and Development Indicators Database. Manila. The poverty line represents the total consumption or income at which rural households satisfy their nutritional requirement of 2,122 calories/day/person. Poverty lines are derived through regression of the functional equation that relates per capita per day caloric intake to monthly per capita expenditures. Separate urban and rural poverty lines are computed for 21 regions at threshold per capita per day caloric intakes.

31 The annual per capita poverty line in Central Luzon is P13,843 ($314 at $1=P44.10 in 2000), requiring a family of six to have a minimum annual income of P83,058 to meet food and nonfood needs.
DIMENSIONS OF VULNERABILITY

Vulnerability relates to the ability of individuals to respond to influences of shocks and seasonal patterns. Shocks may encompass natural events (droughts, floods, and climatically related conditions), human health (illness, food deficits, and malnutrition), livestock diseases and crop failures, and various unanticipated events with economic implications on households and individuals. Seasonal patterns, shocks, and trends can have major impacts on capital assets of households and individuals, and consequently on their abilities to generate incomes, to benefit from employment, and to provide food and nutrition for their families. Natural and human-caused disasters can also have significant impacts on natural resources or environmental sustainability on which rural livelihoods heavily rely.

An overwhelming majority of small-scale fish farmers in Kishoreganj, Bangladesh, were exposed to several crisis situations, the most serious of which were illnesses of household members; shortfalls in rice production and shortage of food; and damage from floods, erosion, and cyclones (Table 1). These conditions are common among small-scale freshwater fish farmers in Bangladesh. Existing social safety nets are inadequate. Many farmers who are considered relatively better-off among their peers are precariously above the poverty line and are likely to fall into poverty when faced with crisis situations. Fish farmers in Chandpur experienced similar crisis situations, although they have not suffered from flood damage, because of flood protection infrastructure. Theft of livestock and fish was also cited as a source of crisis.

Fish farmers in the Philippines are generally vulnerable to natural and climatic risks. Tilapia farmers in Central Luzon cited several major crisis situations, including natural calamities, such as typhoons, drought, and floods. Other crisis situations were illness in the family, death of a household member, and financial losses from farming operation. In some instances, illness of a family member depleted financial resources to the extent that affected households could no longer continue with fish farming and were unable to cope with mounting personal debts. Livestock serves as savings and financial reserves when natural calamities occur, and when families have unexpected cash outlays. But these reserves are often inadequate to meet unanticipated heavy burdens when natural disasters and personal misfortunes strike. Tilapia cage farmers and operators of fish seed nurseries at Lake Taal reported similar crisis situations: typhoons, floods, drought, illness in the family, and financial losses from livelihood occupations.

Farmers in Northeastern Thailand face unfavorable climatic conditions. Multipurpose household and village ponds are typical features of the landscape because of unreliable water supply—the effectiveness of erratic monsoon rainfall, with most rain in June–October, is reduced by the predominantly sandy soils. Drinking water is mostly from rainfall collected by the roof of the house and stored in large jars; fish ponds are used for bathing and washing clothes and dishes, as well as for livestock and crops. The problem of drought has intensified over the last 30 years because cash crop cultivation has led to the clearance of forests from the rolling uplands, which has increased run-off and the incidence of flash floods, reduced water tables, and deposited salt dissolved from upland soil layers in surrounding rice lowlands.

Table 1: Examples of Crises Faced by Small-Scale Fish Farmers in Kishoreganj, Bangladesh (n=100)

<table>
<thead>
<tr>
<th>Crisis</th>
<th>Households Experiencing Crisis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illness of Household Members</td>
<td>82</td>
</tr>
<tr>
<td>Shortage of Food</td>
<td>48</td>
</tr>
<tr>
<td>Flood Damage</td>
<td>32</td>
</tr>
<tr>
<td>Poor Production of Rice</td>
<td>29</td>
</tr>
<tr>
<td>River Bank Erosion</td>
<td>24</td>
</tr>
<tr>
<td>Cyclone or Wind Damage</td>
<td>21</td>
</tr>
<tr>
<td>Excess Rain</td>
<td>16</td>
</tr>
<tr>
<td>Loss of Employment</td>
<td>5</td>
</tr>
<tr>
<td>Theft</td>
<td>5</td>
</tr>
<tr>
<td>Loss of Land</td>
<td>5</td>
</tr>
<tr>
<td>Payments for Wedding Dowry</td>
<td>5</td>
</tr>
</tbody>
</table>

n = number of respondents.
Source: Special evaluation study survey.

32 The reduction of forest cover has been dramatic in Northeastern Thailand, from 7.1 million ha in 1961 to 2.1 million ha in 1995.
CHAPTER 4

ANALYZING CAPITAL ASSETS AND TRANSFORMING PROCESSES

CAPITAL ASSETS

Although technology and its demand on capital resources are central issues in the adoption of selected farming practices, poor and small-scale farmers need more than technology options and financial capital if they are to benefit from aquaculture. Different combinations and components of the five types of capital assets (human, social, natural, physical, and financial) are required for people to engage in small-scale aquaculture in different locations. The presence or absence of various components of capital assets can facilitate or hinder, respectively, the likelihood of success. Box 1 lists these components.

Individual farmers and households employ their capital assets in different ways, and use various means to overcome access barriers through combinations of asset components. The extent to which households use their capital assets for fish farming depends on alternative opportunities. Contextual circumstances play an important role in determining how individuals engage in and benefit from aquaculture as fish farmers, care-takers, laborers, or market agents.

The case studies (footnote 22) on small-scale freshwater fish farming revealed a number of key features in the use of capital assets, highlighted in the following sections. Although the conditions described here are not applicable to all case studies, these examples attempt to illustrate key factors and circumstances that are pertinent to capital assets for livelihoods in small-scale aquaculture.

Human Capital

As evidenced in the case studies, the technologies and management systems of the selected fish farming practices do not demand excessively sophisticated skills, although basic knowledge of fish farming is required. Human resource skills, acquisition of skills to narrow knowledge gaps, and access to sources of information are important for farmers to engage in fish farming.

The surveyed fish farmers in Chandpur, Bangladesh, comprising mostly women homemakers in poor households, did not have much formal education; more than half had no more than 5 years of primary school (Table 2). They had little prior experience in fish farming and had acquired the necessary skills from a nongovernment organization.

Box 1: Key Components of Capital Assets

<table>
<thead>
<tr>
<th>Human Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Formal and informal education, and work experience</td>
</tr>
<tr>
<td>• Skills requirement</td>
</tr>
<tr>
<td>• Roles of information providers in developing human capital</td>
</tr>
<tr>
<td>• Employment, including full-time and part-time occupations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Networks, community-based organizations, nongovernment organizations, and others that facilitate exchanges of experience, and dissemination of knowledge and information</td>
</tr>
<tr>
<td>• Social practices that influence cooperation</td>
</tr>
<tr>
<td>• Social attributes and social conditions that affect access to livelihood assets</td>
</tr>
<tr>
<td>• Conflicts and conflict resolution</td>
</tr>
<tr>
<td>• Social and cultural norms and practices, and gender relations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Natural Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tenure and access rights to land and water</td>
</tr>
<tr>
<td>• Characteristics and size of landholdings, fishponds, and fish cages</td>
</tr>
<tr>
<td>• Use of natural resource assets</td>
</tr>
<tr>
<td>• Quality of the natural resource base, aquatic resources management, and the environment</td>
</tr>
<tr>
<td>• Safeguards for natural capital assets</td>
</tr>
<tr>
<td>• Climatic conditions, natural and biophysical risks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Possession of a home and household assets</td>
</tr>
<tr>
<td>• Access to roads and transportation</td>
</tr>
<tr>
<td>• Access to support facilities and infrastructure</td>
</tr>
<tr>
<td>• Access to reliable water supply</td>
</tr>
<tr>
<td>• Communications</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Financial Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Availability and access to financial resources, including credit and incomes</td>
</tr>
<tr>
<td>• Household finance, savings, and remittances</td>
</tr>
<tr>
<td>• Financial risks</td>
</tr>
<tr>
<td>• Profitability of aquaculture operations</td>
</tr>
</tbody>
</table>
Table 2: Educational Status of Surveyed Fish Farmers in Bangladesh

<table>
<thead>
<tr>
<th>Educational Status</th>
<th>Chandpur (%)</th>
<th>Kishoreganj (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Household Head (n=100)</td>
<td>Spouse (n=99) Female Members Fish Farming Groups</td>
</tr>
<tr>
<td>No Education</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Primary (class 1–5)</td>
<td>36</td>
<td>45</td>
</tr>
<tr>
<td>Secondary (class 6–10)</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>Secondary School Certificate</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Higher Secondary Certificate</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Undergraduate, University/College</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

n = number of respondents.
Source: Special evaluation study survey.

Fish farmer respondents in the Philippines had generally not finished high school education. Table 3 illustrates some features of human capital of farmers in the Philippines.

The case studies in Bangladesh and the Philippines indicated that fish farmers generally have several occupations and fish farming is not a full-time task. Having several income sources is a survival strategy among small-scale farmers, as well as a way of spreading risks; most income comes from informal employment. For example, fish farmers in Central Luzon, Philippines, were predominantly male with secondary occupations that included rice farming, vegetable farming, livestock raising, vending/trading, and carpentry. Similarly, fish farmers in Kishoreganj, Bangladesh, were primarily men with several jobs ranging from rice farming, sharecropping, and seasonal wage labor to microenterprise and capture fishing in inland waters. These occupational patterns emphasize (i) the importance of alternative employment opportunities, and (ii) the different ways by which small-scale farmers have responded to opportunities to diversify their livelihoods.

In Kishoreganj, there were few shared roles in fish farming between males and females. In general, women encountered social barriers and were primarily homemakers; they were unable to work physically as laborers outside their homesteads. In Chandpur, women could not find employment apart from fish farming in groups as created by deliberate ADB-financed development initiatives. The opportunities in group-based fish farming enabled these women to generate incomes and to play a significant shared role in activities normally dominated by men. Nevertheless, understanding

Table 3: Characteristics of Small-Scale Fish Farmers and Rice Farmers in Central Luzon, Philippines

<table>
<thead>
<tr>
<th>Variable</th>
<th>Tilapia Farmers (n=124)</th>
<th>Rice Farmers (n=124)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (average years)</td>
<td>51.0</td>
<td>56.9</td>
</tr>
<tr>
<td>Education (average years)</td>
<td>9.6</td>
<td>7.3</td>
</tr>
<tr>
<td>Household Size (average number)</td>
<td>5.3</td>
<td>5.5</td>
</tr>
<tr>
<td>Length of Experience in Present Occupation (average years)</td>
<td>4.7</td>
<td>29.7</td>
</tr>
<tr>
<td>Length of Experience in Previous Occupation (average years)</td>
<td>16.8</td>
<td>8.0</td>
</tr>
</tbody>
</table>

n = number of respondents.
Source: Special evaluation study survey.
gender roles in fish farming is critical in situations when households employ family labor to perform various tasks. Although women were recruited to form fish farming groups in Chandpur, shared roles between females and males were predominant (Table 4). Thus, advisory and extension services could not target women without involving their spouses or other family members.

Social Capital

Social capital in the form of networks, cultural norms, and other social attributes has significantly helped exchanges of experience, sharing of knowledge, and cooperation among rural households. Freshwater aquaculture development in Bangladesh gained substantially from government extension support based on demonstration of feasible technology for carp polyculture, but subsequent spread of improved fish farming practices in the country relied heavily on farmer-to-farmer contacts and favorable social networks among members of the rural communities (footnote 27). Nearly all the surveyed farmers in Kishoreganj said their current fish farming practices originated locally, mostly through information and advice on fish farming from other farmers, and (40% of them) from friends and neighbors.

Access to social capital also fastened the acquisition of information, training, and advisory services for tilapia farming in the Philippines. Most tilapia farmers traced the origin of their tilapia farming practices to their own province, disseminated through an informal network of farmers and private sector groups, such as hatcheries, fish seed nurseries, and feed suppliers. More than two thirds of the surveyed fish farmers in Central Luzon claimed that they received training through such connections, specifically on fishpond preparation, tilapia husbandry, fish nutrition, and seed production. However, most of these tilapia farmers were not affiliated with any livelihood association. Multipurpose cooperatives were the most popular choice among farmers affiliated in a formal association.

The importance of social networks was further evidenced among tilapia cage farmers at Lake Taal, Philippines. An overwhelming majority of the survey respondents acquired their fish farming practices from sources within their province, including a network of fellow farmers, friends, relatives, government agencies, feed suppliers, fish seed suppliers, financiers, media, educational institutions, and NGOs. Among providers of information and advice, the role of government agencies in providing extension services to tilapia farmers at Lake Taal has been significantly overshadowed by the private sector and existing social networks among farmers. Social networking plays a crucial role in accessing assets for tilapia farming, particularly with respect to fish farmers’ dependence on external financiers. Mutual trust is paramount in a financier-farmer relationship. Farmers of good reputation, belonging to a large social network, have good chances of obtaining access to financial and other resources through personal referrals and contacts. Referrals open doors of opportunities, and financiers rely on such indirect assessments to minimize moral hazards in engaging potential small business partners, such as farm caretakers and employees.

In Northeastern Thailand, a farming systems research and extension approach was followed to ensure that the technology developed was relevant, and would be adopted by small-scale farmers in the region. The approach involved (i) situational analysis to assess the needs for, and the potential benefits from, aquaculture technology for small-scale farm households; (ii) identification of appropriate technologies from reviews of knowledge, on-station and on-farm research, as well as adaptive and hands-on field trials with small-scale farmers to test and refine technical recommendations; and (iii) research into the production of extension materials and ways to disseminate them to farmers and potential clients. A distance approach was adopted in view of the lack of government staff for extension delivery. The techniques used have included brochures, radio broadcasts, and television programs. The distance approach took into account key requisites for effective communications, including local farmers’ culture and existing social networks, language, learning experience, and lifestyle. Access to cellular telephones has also greatly helped exchanges of information among farmers and extension agents.

The case studies in Bangladesh and the Philippines indicated that conflicts among fish farmers, and with other users of land and water, were limited. Nevertheless, different interests in the use
of limited land and water resources may result in social conflicts, and the vulnerable poor frequently lose out under such circumstances. For example, there are reports of longstanding conflicts at Lake Taal between the lake’s fishers and tilapia cage farmers. The fishers, their own illegal practices aside, blame tilapia cage farmers for the decline in the lake’s fisheries, citing impeded navigation, lowered water quality, and obstruction of the main outlet river channel.

Unfavorable social environments can pose risk of losses through theft or poaching of fish. These incidents were reported to be significant in the study areas in Bangladesh and the Philippines. Theft risks usually increase when fishponds or fish cages are too far from farmers’ homes to allow surveillance. Full surveillance of fishponds or fish cages requires increased labor inputs and, therefore, costs of fish farm maintenance. Increased theft risks and the associated costs may limit the feasibility of fish farming, especially among households headed by females who, on their own, are unable to protect their assets against an unfavorable social environment. Group-based fish farming among women in Chandpur in Bangladesh has provided collective protection through pooling of labor resources and rotational guard duties around their fishponds.

Natural Capital

Without access to land and water, the poor are unlikely to engage in fish farming directly, although there are employment opportunities for laborers. For inland freshwater aquaculture, access and tenure rights to land and water are major prerequisites. Direct beneficiaries of aquaculture development have largely been fishpond owners or those who have secured access and tenure rights over designated areas of land and water. Innovative arrangements are needed to enable the poor to have secure access to land and water. When the landless gain access to ponds or water bodies through lease or other access arrangements, secure access rights are critical. Without binding and long-term agreements on access rights, fish farmers are vulnerable. Eviction is common when access is not secure, and interrupted operation can result in losses of investments that the poor cannot recover.

Fish farming in low-cost small cages was piloted and introduced in Bangladesh to primarily landless poor people who were provided with access to lakes, rivers, water canals, and seasonal water bodies. Technically feasible, small-scale fish cages allowed

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the landless poor to benefit from aquaculture.\textsuperscript{34} But constraints faced the wider adoption and use of fish cages by the poor, such as initial construction costs, exposure to thefts, unaffordable supplementary feed, and incompatibility between the immediate need to earn daily income among the poorest and the seasonal nature of fish cage income. Providing access to water bodies alone was not sufficient for the poor to continue with fish farming. Thus, the adoption of this technology has remained localized, and has not been widely replicated in Bangladesh.

Access to fishponds among rural households is common in Bangladesh. The majority of fishponds were constructed as borrow pits, which were dug out for the soil to be used to raise the ground level of village settlements and pathways. Thus, the ponds were not deliberately built as fishponds, but as part of excavation works necessary for village and homestead development. The number of small homestead fishponds in Bangladesh probably exceeds 5 million. This reflects the significance of fishponds in the livelihoods and social fabric of rural Bangladeshi households. Fishponds are often multipurpose ponds; villagers use pond water for washing clothes and dishes, bathing, livestock, cooking, and drinking water after filtering. In general, fish farming does not interfere with the multipurpose use of ponds, providing strong incentives for pond owners to safeguard the quality of pond water. The availability of ponds provides an impetus for fish farming development without incurring additional and deliberate costs for pond construction.

As illustrated by the case study on farming carps in leased ponds by groups in Chandpur, group-leasing of ponds was the primary access route for the poor to farm fish. Without this group-based access to leased ponds, the poor would not have been able to farm fish. Several NGOs in Bangladesh have adopted similar arrangements to facilitate access to land and water for the poor and landless; the NGOs have used social influence and financial support, including gaining government support to allow the use of state-owned ponds. Lease arrangements using private and state-owned ponds can provide significant assurance on tenure rights under specific terms and conditions. Ponds are rarely left completely idle in Bangladesh; pond owners offer them for rent when they do not use the ponds themselves.

In Kishoreganj, the respondents were either marginal farmers or small landholders with limited access to land. In contrast to situations in Chandpur, two thirds of respondent households in Kishoreganj acquired their ponds through inheritance, and a quarter claimed to be co-owners under a multiple ownership arrangement. Only 6% of the households had fishpond lease arrangements, and these had durations of 1–5 years. With the growing rural population in Bangladesh and the large number of dependents, land inheritance leads to multiple ownerships of fishponds. This situation generates serious issues related to co-ownership and collective action among land shareholders. Many issues related to underutilized fishponds in Bangladesh were attributed to multiple ownership, when cost sharing, benefit distribution, and assignment of responsibilities for pond management became difficult. While fishpond leasing is an option for the landless poor, the annual lease costs may act as an entry barrier. But this barrier can be overcome as evidenced in Chandpur.\textsuperscript{35}

\textsuperscript{34} CARE Bangladesh introduced the development of small (1 cubic meter) cages as a means of making aquaculture accessible to and overcoming resource constraints among the landless poor. Popular fish species grown in small cages include tilapia (Oreochromis niloticus), grass carp (Ctenopharyngodon idella), and silver barb (Barbodes gonionotus).

\textsuperscript{35} In Bangladesh, annual leasing rates in 2002 were $432–518 (Tk25,000–30,000)/ha in Chandpur, and an average of $444 (Tk25,700)/ha in Kishoreganj. Annual leasing costs were $194–484 (P10,000–25,000)/ha in Central Luzon, Philippines.
Access and tenure rights to land and water are equally fundamental for tilapia farming in the Philippines. In Central Luzon, tilapia farmers had access to land through ownership or lease arrangements. Lands were generally acquired through inheritance and purchase. For tilapia farmers who did not own fishponds, access was acquired through guaranteed user rights, typically lasting 1–5 years. Other arrangements included profit sharing between farmers and landowners, or between pond caretakers and pond owners.

Access to lake waters for fish farming in the Philippines illustrates a different perspective. The waters of Lake Taal are owned by the state. Cage farming sites are leased out by the Government to fish farmers for a fixed term, with provisions that open access to aquaculture should not exceed 5–10% of the total water area of the lake. Zoning is necessary because the lake has several purposes, including capture fisheries, tourism and recreation, fish farming, and environmental protection. A license is needed to operate a fish cage, and must be renewed annually. Licensing for fish cage farming and cage ownership is limited to people who reside in the municipalities surrounding the lake. However, the inability of most local residents to finance fish cage operations has led to arrangements involving non-resident financiers or absentee-investors, while the local residents serve as caretakers or cage workers for cage farms that are registered under their names. Secured access to land and water alone does not necessarily give the ability to operate fish farms; access to other, complementary capital assets is required.

Physical Capital

Surveys conducted in Bangladesh and the Philippines for the SES indicated that fish farmers were not among the poorest or destitute. The poorest people were generally excluded from aquaculture because of the need for capital assets. The fish farmer respondents generally owned their own home or had access to a dwelling with basic sanitation facilities, although many of them were poor or precariously above poverty in terms of vulnerability. For example, fish farmers in Chandpur and Kishoreganj of Bangladesh had access to basic homes or dwelling units made of wood, sheet metal, and light natural materials such as bamboo, paddy straw, jute sticks, leaves, and earth. Most of these farmers owned scavenging poultry and some had other small and large livestock. Possession of household assets was modest: less than half of the surveyed households in Chandpur claimed to have a radio (37%), a television (15%), and a sewing machine (8%). In the Philippines, the great majority of the surveyed small-scale fish farmers owned their homes or dwelling units and almost all owned a television, an electric fan, and water-sealed toilets. More than half of them had access to telephones and/or cellular phones.

Access to roads, transport facilities, communications, reliable water supply, and various support facilities including health services is an important enabling condition for sustainable livelihood development, including for fish farming. In Bangladesh, most respondents reported difficulties with transportation, communications, electricity,
and health services, but they had reasonable access to reliable water supply (Table 5). Fish farmers in the Philippines enjoyed easier access to roads and transport facilities, communications, and other support infrastructure and facilities. Their access to facilities ranged from fair (neither easy nor difficult) to very easy. Most tilapia farmers in Central Luzon had reliable water supplies through deep wells, which lessened water-related conflicts with rice farmers who depended heavily on irrigation.

Financial Capital

Access to financial capital, including household finance and savings, formal and informal credit sources, and income is important for financing fish farming activities. The demand for initial investments and subsequent operating expenses depends on the technology selected, farm management practices, and input requirements. Many factors influence access to financial capital: an individual’s wealth, existence of financial services, suppliers' credit and services, remittances, modes of trade financing, credit terms and conditions, credit worthiness, and conditions that can affect an individual's access (and barriers) to financial capital.

Although carp polyculture systems as commonly practiced in Bangladesh are not capital intensive, the poor in Chandpur would not have been able to farm fish on their own with their limited resources. Collateral-free microcredit has been instrumental in providing groups of poor fish farmers with working capital to complement their meager resources. The farmers’ groups required about $1,330 (Tk77,000)/ha for working capital, which would have taken them an average of 87 months to save. Thus, access to credit and the NGO advisory services that accompanied this credit were very important in this case. In contrast, two thirds of the respondents in Kishoreganj reported that they had relied on their own sources of funds for their fishponds, and the rest claimed that they had received small loans from moneylenders, relatives, friends, NGOs, cooperatives, and government-sponsored programs. Major reasons cited for not obtaining financial assistance were unavailability of credit, unfamiliarity with credit, complex procedures for acquiring credit, high interest rates, and unfavorable repayment conditions. On average, farmers’ groups in Chandpur each leased fishponds covering a total of 1 ha, while individual fish farmers in Kishoreganj had less than 0.2 ha of fishponds. The relatively small pond areas operated by fish farmers in Kishoreganj also explains why they were able to rely on their own financial resources.

With modest financial resources, Bangladeshi households can afford modest working capital requirements to stock fishponds with fish seed, particularly when they use inexpensive feeding methods that rely on natural feed in fertilized ponds. Operating costs vary depending on stocking rates, pond ownership and whether lease payments are required, fertilization rates and supplementary feeding regimes, and the extent to which farmers undertake pond preparation prior to stocking and the level of general maintenance throughout the year. With good management, adequate use of inputs, and multiple stocking and harvests, carp polyculture systems in perennial ponds yield an average of 3.7 t/ha, generating gross revenues of about $3,110 (Tk180,000)/ha and net incomes of $1,555 (Tk90,000)/ha at farm gate in 2002 constant prices. Annual production costs average $1,555 (Tk90,000)/ha, including payments for leased ponds, fish seed, supplementary feed, hired labor, harvesting, and other costs. In general, small-scale farm households own less

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Table 5: Access to Facilities among Fish Farmers in Chandpur (n=100) and Kishoreganj (n=100), Bangladesh

<table>
<thead>
<tr>
<th>Facility</th>
<th>Very Difficult</th>
<th>Difficult</th>
<th>Neither Difficult</th>
<th>Easy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>K</td>
<td>C</td>
<td>K</td>
</tr>
<tr>
<td>Transportation</td>
<td>0</td>
<td>27</td>
<td>99</td>
<td>48</td>
</tr>
<tr>
<td>Communication</td>
<td>97</td>
<td>51</td>
<td>3</td>
<td>41</td>
</tr>
<tr>
<td>Medical</td>
<td>8</td>
<td>31</td>
<td>83</td>
<td>50</td>
</tr>
<tr>
<td>Electricity</td>
<td>16</td>
<td>17</td>
<td>74</td>
<td>59</td>
</tr>
<tr>
<td>Water Supply</td>
<td>0</td>
<td>5</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>Toilet</td>
<td>1</td>
<td>1</td>
<td>22</td>
<td>39</td>
</tr>
</tbody>
</table>

C = Chandpur, K = Kishoreganj, n = number of respondents. Source: Special evaluation study survey.

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36 Customized fishpond management to fit the circumstances of the poor can benefit from a fish farming system that primarily relies on natural feed produced in the pond by capitalizing on sunlight and photosynthesis of phytoplankton, and utilizing organic and inorganic fertilizers.
than 0.2 ha of fishponds and the majority do not lease ponds. These small-scale farms can obtain working capital of $86–259 (Tk5,000–15,000) annually from various sources. Appendix 2 provides illustrative financial farm budgets of carp polyculture farms in Bangladesh.

In the Philippines, two thirds of the small-scale tilapia farmers surveyed in Central Luzon drew on their own limited funds for capital. Constraints in meeting working capital requirements may lead to suboptimal farm performance.37 Impediments to seeking financial assistance were lack of access to formal credit, high interest rates, and lack of financial assistance from government sources; also, some did not need to borrow. Where formal credit from commercial banks and private lending institutions was available, farmers avoided borrowing from these sources because of high interest rates, paper work, requirements for insurance and collateral, and inconveniences that increased transaction costs. Instead, those who did borrow relied mainly on feed suppliers, relatives, and friends. A few received regular remittances.38 However, the long growing period before harvest and sales strained household finance and access to financial capital was generally a major constraint.

Although tilapia farming in fishponds is generally more profitable than rice farming (Table 6), many rice farmers in the Philippines have not adopted tilapia farming because of their limited resources and constraints to meet financial capital requirements. Operating risks associated with tilapia farming also dampen desires of rice farmers to adopt fish farming. The risks have often deterred small-scale farmers from attempting to obtain formal credit, fearing the loss of property or collateral in the event of harvest failure.

The emergence of informal credit schemes from nonbank sources has benefited small-scale farmers, although some of these schemes carry higher interest than bank loans. These nonbank financing arrangements include financier-caretaker arrangements, trader-operator agreements, contract farming, and suppliers’ credit schemes. At Lake Taal, high operating costs and inherent risks of fish farming deter local residents from using and risking their own limited financial assets for fish farming.39 These conditions have led to the emergence of financier-caretaker relationships, which have gained popular local acceptance. About two thirds of the surveyed fish cage farmers at Lake Taal were caretakers and recipients of financial assistance provided by nonresident financiers. The financier provided funds for farming activities, while the caretaker managed the fish farm. Net profits after each crop cycle were distributed between the

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### Table 6: Comparative Net Incomes per Hectare in 2002 from Tilapia Ponds and Rice Farms in Central Luzon, Philippines

<table>
<thead>
<tr>
<th>Cycle/Crop</th>
<th>Mean Gross Income (P)*</th>
<th>Mean Production Cost (P)</th>
<th>Net Income (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tilapia Pond</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>336,582</td>
<td>212,729</td>
<td>123,853</td>
</tr>
<tr>
<td>Second</td>
<td>320,152</td>
<td>208,617</td>
<td>111,535</td>
</tr>
<tr>
<td><strong>Rice Farm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>39,205</td>
<td>17,107</td>
<td>22,098</td>
</tr>
<tr>
<td>Second</td>
<td>47,875</td>
<td>12,104</td>
<td>35,771</td>
</tr>
</tbody>
</table>

*P = Philippine peso.

*Includes both cash and noncash incomes. Noncash income, or the monetary equivalent of fish that were either consumed or given away, accounted for 9%. In the case of rice farmers, the mean cash income from the sale of paddy accounted for 60%, and noncash income or monetary equivalent of rice consumed amounted to 40%.

Source: Special evaluation study survey of 248 farms.

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37 In Central Luzon, operating costs of tilapia fishponds per crop cycle of about 4 months may amount to $4,128 (P213,000)/ha: feeds (72%), fingerlings (11%), labor (7%), water and fuel (6%), and fertilizers and chemicals (4%).

38 Remittances are transfer payments to the Philippines, which are usually salaries and/or wages sent home by Filipinos employed abroad. In Central Luzon, remittances contributed to 5% of household incomes of fish farmers.

39 At Lake Taal in the Philippines, tilapia farming in cages is capital intensive. Typically, farmers operate fish cages (10 meters [m] wide, 10 m long, and 6–10 m depth) for 5–6 months per crop cycle. In 2002, the average annual operating expenses amounted to $2,074 (P107,000) per crop cycle or $4,147 (P214,000) annually for two crops. These expenses comprised feeds (79%), seeds (18%), labor (2%), and fuel and miscellaneous items (1%). With yields of 3 t per cage per crop cycle, a cage can generate net incomes of more than $581 (P30,000) within 5–6 months. However, the operating costs and cash outlay requirements are major entry barriers to local residents.
two parties, based on their initial agreements.\textsuperscript{40} Appendix 3, Tables 3.1–3.3 provides illustrative financial farm budgets of tilapia farming in the Philippines using fishponds and cages.

**TRANSFORMING PROCESSES**

The SES probed several major transforming processes that can facilitate or hinder the generation of desirable outcomes from the employment of capital assets in aquaculture. This section discusses key features of these transforming processes, including markets and marketing, labor market, roles of public and private institutions, support services, facilities and infrastructure, legal framework and policies, aquatic resources management and environment, and safeguards for biosafety and aquatic health. Box 2 lists the components of the transforming processes.

**Markets and Marketing**

Most of the fish do not reach consumers directly from producers. Market intermediaries as enabling agents are critical in the marketing chain. Functioning markets enable the flow of goods and services from producers to consumers. Intermediaries perform postharvest tasks, such as handling, cleaning, sorting and grading, icing, and transportation. This intermediation creates jobs, including for the poor. For example, in Thailand, domestic marketing of freshwater fish comprises several channels and types of markets and intermediaries. Fish marketing is primarily a private sector function. Market participants include (i) farmers who sell their fish to wholesalers, retailers, or collecting agents; (ii) fish collectors who act as intermediaries between fish farmers and fish traders by gathering fish from various farms and benefiting from price differentiation as a result of postharvest grading of fish; (iii) fish agents who earn commission fees from transactions between buyers and sellers at assembly markets; (iv) fish wholesalers who purchase fish from assembly markets or buy directly from fish farmers and sell to retailers; (v) fish processors who buy fish directly from fish farmers, assembly markets, wholesalers, and other processors; and (vi) fish retailers who sell to final fish consumers. Overall, market access by fish farmers, including small-scale producers, is generally not a constraint in Thailand. Prices at the farm gate and in wholesale and retail markets are very competitive, with numerous buyers and sellers from the farm to consumers. The marketing margin, the difference between the price paid by the consumer and that received by the producer, varies by species.

The farmers’ share of retail prices of selected species can amount to 50–60%. With good postharvest support facilities, freshwater fish are easily delivered from production centers to markets throughout the country. Fish transportation benefits from reliable road networks and communications facilities that link all districts and provinces.

In Bangladesh, the market chain from fish farmers to consumers encompasses primary, secondary, and retail/consumers markets, involving

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\textsuperscript{40} Existing financier-caretaker sharing arrangements at Lake Taal include sharing of net profits on the basis of 50:50, 60:40, or 80:20 ratios in favor of the financier. Under some partnerships, financial losses from previous crop cycles are carried forward to the next cycle under an arrangement known as a rollback system. This rollback system requires caretakers and financiers to share the risks of fish farming.
local fish traders, sales agents, wholesalers and distributors, and retailers. Fish farmers usually sell
their fish to local traders and collectors who then sell to wholesalers and distributors with or without
the help of commission-based sales agents. Farmers also sell their fish at village markets to
consumers, but direct sales are usually in small quantities. In Chandpur, the farmers’ groups
overwhelmingly sold fish to local agents and to wholesalers/assemblers. Few farmers sold fish directly to
a retailer. Reasons cited by farmers for choosing a particular market outlet were convenience, price,
and terms of payment. Very few respondent fish farmers in Bangladesh had significant problems
selling fish because market demand was high. However, markets are localized in some areas and
fish farmers had limited ability to reach other markets because of time and distance constraints,
inadequate transportation, and poor road infrastructure. At urban markets, wholesalers sell fish to
other wholesalers who in turn sell to retailers. Finally, retailers sell fish to consumers through
stalls at fish markets, roadside sales, and door-to-door sales to households. Although the physical
conditions (hygiene and sanitation) of fish markets in Bangladesh are deficient, the markets function
well, with competitive market intermediaries and abundant sellers and buyers along the marketing
chain. At the farm gate, farmers obtain not less than 50% of retail prices.

Similarly, domestic fish markets in the Philippines are competitive. Many marketing channels
provide significant roles for market intermediaries, including brokers, wholesalers, and retailers. Fig-
ure 2 illustrates different channels of marketing tilapia in the Philippines. Farmed fish are sold live,
fresh, and (to a lesser extent) chilled or frozen. In Central Luzon, live tilapia command a higher price
than iced or chilled fish. A recent shift in consumer preference for live tilapia has led to the develop-
ment of sales from aerated containers in markets and at the roadside. Some market intermediaries,
particularly wholesalers, finance small-scale farmers to be assured of a steady supply of fish. Buyer
and seller concentration is high. This is beneficial for small-scale farmers because it provides diversi-
fied market outlets for their produce. At the farm gate, small-scale tilapia farmers can expect to re-
cieve not less than 50% of retail prices. Entry and exit of traders to the tilapia market have been rela-
tively easy, especially at the retail level. Product differentiation and pricing are based on fish size
after harvest.

Fish seed markets are competitive in Bangladesh, Philippines, and Thailand, providing critical support to freshwater fish production. Small-scale fish farmers have a wide choice of seed
suppliers. In the Philippines, the SES surveys indicated that fish seed accounts for 11% of total
operating costs for fishpond and 18% of fish cage

![Figure 2. Illustrative marketing channels for tilapia in the Philippines.](image)
operations. Major tilapia seed producers\(^1\) and their accredited suppliers in the Philippines are engaged in competitive marketing campaigns, providing technical assistance and various credit terms to buyers, including small-scale tilapia farmers. Market competition and the increasing choice of tilapia strains of good performance have benefited small-scale fish farmers in the Philippines: they receive competitive prices, have informed choices, and receive added technical services.

Market channels for tilapia seed in the Philippines are relatively short because of the high risks in handling, transporting, and selling fish seed. Consequently, hatchery operators and fish seed nurseries sell seed directly to fish farmers. In contrast, fish seed traders in Bangladesh are the last and critical actors in a network linking hatcheries, fish seed nurseries, and fish farmers. These fish seed traders also provide advice to fish farmers, share knowledge of fish farming with their customers, and bear significant risks of seed losses during handling and transportation.\(^2\) Most itinerant fish seed traders in Bangladesh buy their fish seed directly from private household nurseries and, to some extent, from seed wholesalers.\(^3\) There is adequate carp seed supply from primarily private hatcheries and seed nurseries. Fish seed prices are competitive and have declined in recent years. Clusters of small-scale hatcheries serve freshwater aquaculture farms in Bangladesh, rather than single large hatcheries that require significant capital, knowledge, and managerial skill to operate.\(^4\)

Similarly, in Thailand, a well-established network of local and more distant traders links fish seed producers to customers all over the country. Through well-functioning markets and their distribution networks, private farms produce and nur- 


 Overall, the marketing of freshwater fish in the study areas does not present a major problem. Markets for freshwater fish are predominantly domestic. With growing demand for freshwater fish and their competitive prices relative to animal protein substitutes, small-scale fish farmers do not face serious problems in selling their products. Nevertheless, they face varying degrees of difficulty and constraints related to site-specific conditions of transportation, communications, and support facilities that contribute to functioning markets. Perishability and fragility require speed and care in handling and storage. Damage or deterioration in quality can occur rapidly because of unsatisfactory handling during harvesting, grading, cleaning, washing, transporting, packing, unpacking, and display in the market. Damage to fish products also occurs in unsatisfactory and inadequate icing or refrigeration facilities. Poor hygiene and sanitation are pervasive in fish markets in Bangladesh, necessitating quick disposal of fish at wholesale and retail markets to final consumers to prevent spoilage. Inevitably, outputs of fish farms

\(^1\) Tilapia seed production reached 1.02 billion fish in 2002, with 900 million from private sources and 120 million from state-affiliated hatcheries. Assuming 40% seed mortality and an average market size of 5–6 fish per kilogram, farmed tilapia production in 2002 of 122,316 t would have required at least 942 million fish.

\(^2\) Seed trading in Bangladesh is a seasonal occupation that, in most places, begins in April and ends in September. Seed traders travel on buses and trains and typically carry a few thousand seed in aluminum containers on foot or by bicycle, to reach their farm customers.

\(^3\) A village seed trader may sell 3,000–6,000 fingerlings a day for up to 6 months each year, earning more than Tk300/day, or four times the daily wage rate of agricultural labor.

\(^4\) In 2002, Bangladesh had 630 private and 110 state-owned hatcheries. Small-scale hatcheries and nurseries developed by farmers produce the vast majority of fish seed.

\(^5\) More than 600 million fry of tilapia, the dominant fish in small-scale freshwater aquaculture, both mixed sex and monosex male (through hormone-induced sex reversal), were produced in 2001 in Thailand. This tilapia seed supply was 45% of the total fish seed (1,520 million) produced that year. The Government produced about 17% of the seed, approximately 65% of which were from inland fisheries stations.
on rural livelihoods, including those of farmers who rely on household and seasonal labor. Alternative employment opportunities can seriously affect the availability of farm labor or household/family labor for fish farming. For example, farm households in Northeastern Thailand have increasingly sought to augment their earnings through off-farm employment. This was initially through seasonal migration to sugarcane fields and orchards of Central and Eastern Thailand or for temporary urban employment, but more recently there has been a mass exodus of the agricultural labor force to urban centers, particularly to Central Thailand—for employment in the service, construction, and industrial sectors—and overseas. The Asian financial crisis in 1997 and subsequent economic recession led to a mass layoff of workers, leading to a return migration of the labor force. However, the highly seasonal and unstable farming systems were unable to absorb returning migrants adequately.

Economic recovery and expansion in other sectors in recent years have led to scarcity of farm labor in Northeastern Thailand, causing labor costs to rise and limiting the feasibility of labor-intensive fish farming. Earnings from fish farming there generally contribute less than 20% and off-farm incomes more than 40% of the total household incomes of farmers. Although technology options can successfully increase fish yields, this approach alone may not be feasible in a dynamic economy that has significantly increased the opportunity costs of labor. The labor market plays a significant role in determining the relevance and significance of certain technologies to livelihoods.

Not all rural households and farmers can directly engage themselves in self-employment initiatives as operators or farmers in fish production. Other activities associated with the production and marketing of farmed fish offer employment opportunities for the rural population, including the poor. These opportunities include seasonal and part-time labor for fishpond preparation and maintenance, harvesting, and postharvest activities, including handling, cleaning, sorting and grading, and icing and transportation. For example, harvest and postharvest activities in Bangladesh are labor intensive and generate significant demand for labor, as well as creating opportunities for self-employment in rural areas where the supply of labor is abundant. Part-time and full-time employment in freshwater aquaculture and related services benefit more than 3 million people in Bangladesh—many more if their dependents are included. Because much of the employment benefits accrue in rural areas, the contribution of freshwater
aquaculture to rural livelihoods and the poor is far reaching. For individual households, alternative employment opportunities and diversified sources of incomes are important. The survey of farm households in Kishoreganj, Bangladesh, revealed that fish farming households were engaged in different activities. The most important primary occupations of the household heads (males) in terms of time spent were rice farming and informal microenterprise; only 6% of respondents stated that fish farming was their primary occupation (Table 7). Fish farming was almost equivalent to rice farming among the most important secondary occupations, while two thirds of the respondents reported fish farming as their third most important source of income. Nearly all the spouses (females) were homemakers and 88% held no other job.

In the Philippines, freshwater tilapia farming provides employment opportunities for fishpond operators and fish cage caretakers and their families. Other work opportunities include full-time and part-time employment in pond excavation, cage and net making, boat operation, services, harvesting, fish sorting and grading, marketing, transport, and miscellaneous activities. Small-scale pond and cage farms rely mainly on family labor; larger farms employ regular full-time workers and seasonal or casual workers for pond preparation, stocking, and harvesting. In rural areas, with limited employment opportunities and high unemployment, labor is abundant. This has caused many workers to receive wages effectively lower than legislated minimum wages. With the abundance of labor, exchange labor from members of the local community is also used. Men, women, and even children assist in hatchery/nursery, pond, and cage operations. Heavy physical tasks, such as pond construction and harvesting, remain male dominated. Employment impacts are clearly seen in the local economies where tilapia is farmed.

### The Roles of Public and Private Institutions

The SES case studies show that complementary and collaborative activities of public and private institutions can facilitate aquaculture development for small-scale farmers. For example, in Thailand, the Government has placed strong emphasis on the development of fisheries stations, which have catalyzed the development of the private sector’s dominant role in fish seed production and fish seed

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**Table 7: Occupations of Household Heads and Spouses, and Sources of Household Incomes in Kishoreganj, Bangladesh**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Household Head (n=100)</th>
<th>Spouse (n=99)</th>
<th>Household Income Source (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary (%)</td>
<td>Secondary (%)</td>
<td>Primary (%)</td>
</tr>
<tr>
<td>Fish Farming</td>
<td>6</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Rice Farming</td>
<td>38</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Sharecropping</td>
<td>2</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Livestock</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Wage Labor</td>
<td>7</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Carpenter</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Office Worker</td>
<td>7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Vendor/Trader</td>
<td>4</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Microenterprise</td>
<td>21</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Rickshaw Driver</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Capture Fishing</td>
<td>8</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>School Teacher</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Boat Operator</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cultivation of Other Crops</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Homemaker</td>
<td>0</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

n = number of respondents.
Source: Special evaluation study survey of 100 farm households.

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46 The vast majority of respondents (93%) cultivated rice; 42% of them cultivated one crop annually and 58% had two.

47 Based on surveys at Lake Taal, Philippines, the average monthly salary of regular workers or laborers in tilapia cage farming and nurseries was $39 (P2,090) in 2002. For seasonal laborers, the average daily wage was $2.67 (P138).

48 Neighbors and other members of the community provide labor (for pond preparation or harvesting) without financial payment. The pond or cage owner is expected to reciprocate by helping fellow farmers when needed. If the activity is harvesting, fish are normally given to reward those who participate.
supply in the country. While the Government has played an instrumental role in placing the necessary facilities for initiating and ensuring fish seed supply to promote fish farming, its role does not prevent the private sector from taking over the fish seed supply business. The Government sustains its research and development efforts on fish breeding to maintain good-quality broodstock to ensure open public access to farmed fish species and strains of good performance. Further, the Government realized that the provision of subsidized inputs to promote small-scale aquaculture would not lead to sustainable aquaculture development, and that it was necessary to extend appropriate information on aquaculture technologies to small-scale fish farmers. The development of appropriate technologies and extension to overcome technical constraints facing new entrant small-scale farmers was conducted through research partnership between the Asian Institute of Technology and the Department of Fisheries of Thailand. This research was carried out in resource-poor Northeastern Thailand, involving partnerships with local government agencies, NGOs, and farmers.

Earlier public investments in the fish seed industry in Bangladesh catalyzed the development of freshwater aquaculture. In the past two decades, the private sector has progressively taken over the role of public institutions in fish seed supply and private hatcheries now dominate seed supply in the country. In parallel, the Government has paid increased attention to improving broodstock quality for private hatcheries by establishing a network of broodstock centers. Appropriate interventions to improve fish breeding practices and to provide regular replenishment of high-quality broodstock will require continued cooperative efforts between government agencies and private partners. Similarly, state- and externally-funded extension services to promote improved carp polyculture farming systems over the last two decades contributed to widespread adoption of such practices throughout the country. Conducive social networks have contributed to rapid farmer-to-farmer diffusion and spread of information and advice on fish farming technologies.

In the Philippines, the Government has placed great emphasis on the development of reliable fish seed supply, including genetic improvement to improve the quality of tilapia broodstock and fingerlings. Current tilapia seed production amounts to about 1 billion annually, of which 90% come from private sources (footnote 41). Government hatcheries are expected to remain important
sources of seed amid the growing number of private and corporate hatcheries. The Government
aims to improve food security through better technologies and encouraging the entry of small-scale
farmers to tilapia farming. The Bureau of Fisheries and Aquatic Resources (BFAR) will likely re-
main an adjunct supplier and to some extent a competitor of private seed producers in areas
where private operators dominate. The continued presence and roles of BFAR in the fish seed market
have been debated among observers and stakeholders because of possible conflicts with business
interests of the private sector. Government fish seed prices are competitive vis-à-vis those of other
seed suppliers and do not undercut private seed suppliers. In support of private sector development,
BFAR promotes an accreditation program for private hatcheries that obtain quality tilapia broodstock
from its national breeding program. Efforts by BFAR have contributed to increased access and choices
of fish seed supply among small-scale farmers.

Tilapia genetic improvement has become a highly dynamic and competitive field of research
in the Philippines. Consequently, farmers now have access to a wide range of tilapia strains. Linkages
between public and private organizations are vital to these research and development efforts, little of
which would have taken place if the public sector had not spearheaded the work with external sup-
port, including assistance from ADB. Private fish seed companies and input suppliers are not only
improving their products but are also advising farmers on appropriate farming practices. Initiatives
taken by the private sector to support the effective uptake of genetically improved tilapia include
research (on-station and on-farm trials), extension, farmer financing, risk-sharing arrangements with
feed suppliers and financiers, and collaboration with the public sector. The rapid commercializa-
tion of tilapia farming has been accelerated by all these developments and continuing favorable mar-
ket conditions.

Services, Facilities, and Infrastructure

Support services, facilities, and infrastructure are critical in sustaining both farming and marketing
activities. Service providers, including input suppliers, play important roles in providing information
and advice to farmers; their services complement the roles of government agencies in extension services.

Since 1972, tilapia farming in the Philippines has benefited from substantial and continuous sup-
port services, such as pond systems and husbandry research, technology development, and training
and extension. Noteworthy are the development initiatives undertaken at Central Luzon State Uni-
versity and BFAR’s National Freshwater Fisheries Technology Center.49 Fish seed and feed suppliers
in the Philippines provide advisory technical services to fish farmers. Respondent fish farmers in
Central Luzon said they received advice from other farmers (49%), government sources (35%), feed
dealers (30%), friends (30%), relatives (27%), and fish hatcheries (10%). Input suppliers have emerged
as key players in technology transfer and information dissemination. They complement govern-
ment extension efforts.

At Lake Taal, private service facilities, such as ice plants and transport services, supply the mar-
keting needs of tilapia cage farmers and traders. Ice is regularly used to chill fish and keep products
fresh from the farm to final market destinations. Boat services at the lake provide transportation to
tilapia farmers for ferrying feeds and other supplies, and harvesting services are also available.

In Bangladesh, itinerant seed traders provide advice and share knowledge of fish farming with
their customers. In northwest Bangladesh, the importance of mobilizing and training poor seed traders
to disseminate messages of aquaculture practices that are suited to small-scale and resource-poor
farmers has long been recognized.50

In general, fish farmers do not rely on their own labor for on-farm tasks and requirements. Ser-
vice providers offer a wide range of labor-intensive support services, such as fishpond construction,
customized fishnet making, fish cage construction and repairs, and more essential services, including
input supplies (seed, feed, fertilizers), postharvest activities, and marketing. Fish harvesting itself is a
specialized service in Bangladesh where fish farmers do not generally harvest their own fishponds.51

49 In 2002, these institutions, along with the GIFT Foundation International and Phil-FishGen, established the Tilapia Science Center
at Central Luzon State University, to foster collaboration in supporting tilapia farming in Central Luzon and countrywide. The subsequent
creation of Philippine Tilapia Inc. in 2003, has provided a venue for stakeholders in the tilapia industry to work together through advocacy,
participation in the annual tilapia congress, trade fairs, promotion of tilapia consumption, and implementation of a tilapia industry
development plan.

50 Funded by DFID, the Northwest Fisheries Extension Project operated during 1988–2000 in two phases in the poorest northwest
region of Bangladesh, which is characterized by infertile soils and relative extremes of climate with the lowest agricultural productivity
and pond fish productivity in the country. The extension approach included the use of 1,200 fish seed traders as extension agents, by
training them in fish farming. Each seed trader had contacts with 40 farmers on average, and about 60% of fish farmers purchased fish
seed from these trained seed traders.

51 Fish harvesters typically work year round, with a peak in October–January. On average, harvesters conduct 1–2 harvests per week, and
employ 6–8 laborers who earn daily wages of about Tk100. Harvesters can earn gross incomes, representing 8–12% of the fish value per
harvest, with daily net incomes of up to Tk250 after paying for labor, fishnet rental, transport, and repairs.
Legal Framework and Policies

Enabling development policies and legal instruments can provide incentives for development of small-scale aquaculture to benefit small-scale and poor farmers. However, implementation and enforcement in many situations remain challenging because of issues related to capacities and resources. The following provide some examples of these challenges.

In the Philippines, the Local Government Code of 1991 devolved many of the functions of central Government to local government units, including extension services, regulation and licensing, and law enforcement in local waters. However, constraints on funding and weak institutional capacities have restricted their effective implementation. Official policies for freshwater aquaculture in the Philippines have long been and remain markedly pro-poor, with numerous provisions that favor small-scale operations and community welfare, but these policies are frequently not implemented effectively. The Fisheries Code of 1998 gives to local government units, in consultation with local farmers and subject to review by the appropriate provincial councils, the authority to make ordinances and decisions and to appropriate funds for general welfare and for environmental protection. However, few fish farmers in Central Luzon are aware of the existing fisheries administrative orders. Limited budgets, the voluntary nature of a code of practice for aquaculture, and weak enforcement capabilities of national and local governments constrain implementation of environment-friendly regulations.

In Thailand, the National Fisheries Policy on aquaculture aims to increase fish production to meet the demand for domestic consumption, increase income for fish farmers, and raise the standard of living of small-scale fish farming households. Current strategies also focus on providing technical services and certifying registered hatcheries and farms. The main policy goal for inland freshwater aquaculture in Thailand is to provide fish protein for the rural poor, based on an approach of providing government support under conditions through which the rural people can

The distance and isolation of many small-scale farms contribute to high prices of feed, seed, and other inputs because the costs of transportation are passed on to farmers. Access to inputs is a major problem for small-scale farms in remote locations. Although there may be strong demand for fish in certain rural remote areas, localized fish farming may be severely hampered because of difficulties in accessing critical factors of production, such as feed and seed supplies. Decentralized seed production, the use of natural feed, and increased reliance on homegrown supplementary feed may help fish farming in remote areas. But such efforts are still influenced by other conditions, including access to roads and transportation and other basic infrastructure.

Rural roads can help address various nonincome aspects of poverty by improving access to education and health services. Weak infrastructure can increase transaction costs and become barriers to market transactions on a large scale. The majority of fish farmers in Central Luzon and Lake Taal, Philippines, regarded as fair their present access to roads, transportation, and markets. In addition, access to cellular telephones (especially text messaging capability) has improved communications tremendously in the Philippines and Thailand, and more recently in Bangladesh, allowing farmers to acquire market information from their contacts in different locations.

53 For instance, farmers with fishponds of 300 square meters or larger are required to secure an environmental compliance certificate from the Department of Environment and Natural Resources; those with smaller fishponds are not.
participate and become self-reliant. The National Fisheries Policy hinges on the assumption that future rural freshwater aquaculture development remains at a small-scale level, mainly for domestic consumption and local household food security, especially for the rural poor. In 2001, the Government decentralized authority for management of fishery resources in all community waters to sub-district governments. Decentralization has also given communities a stronger voice in decision making regarding use of local natural resources. To date, the local authorities have limited experience in natural resources management and need to develop their capacity in order to attain the trust of the communities. Likewise, the communities have not had experience in making enforceable decisions about ways in which the resources should be managed. There are opportunities for building capacity and forging partnerships between the communities and government services.

In Bangladesh, major policy issues pertaining to freshwater aquaculture have largely been on improvement and development of fish farming technology to increase fish production on a sustainable basis, and to educate and motivate people to undertake aquaculture.55 The inland open-water fish stocks have declined and fish farming is favored as a means of increasing fish production levels. Aquaculture behind water retention structures can provide new livelihood options for those who have lost access to capture fisheries. However, enclosure of floodplains for fish stocking can have serious implications on access by the poor to the traditionally open-water resources. Expansion of aquaculture into open waters without adequate attention to access and property rights and the implications for local communities, can generate serious social issues related to equity and distribution of benefits.

**Safeguards for Aquatic Resources, Environment, and Health**

Small-scale and poor fish farmers are extremely vulnerable to various types of risk that can lead to harvest failures. A crop failure can offset profits gained from 4–5 harvests. Site suitability and selection are key elements for minimizing risks, while climatic conditions and seasonality factors bring unavoidable natural risks. Safeguarding natural assets through careful management can

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help to ensure continuing water supply of acceptable quality for fish farming, and to minimize conflicts between the different users of limited resources. The following illustrates the importance of safeguards.

Small-scale fishponds generally do not pose adverse environmental impacts. However, discharges of nutrient-rich water from groups of medium- and large-scale ponds into watercourses can cause pollution (high biochemical oxygen demand and elevated nitrogen, phosphate, and suspended solids), especially in the dry season. Environmental issues that can adversely affect fishponds relate both to conditions within the farming system and external effects. For example, one third of fish farmers interviewed in Central Luzon believed that the sustainability of tilapia farming was threatened by water pollution in ponds. Measures to address environmental threats include waste treatment, reduction in chemical use, improvement of infrastructure/pond repair, and control of the water entering the pond. However, such measures have not been effectively implemented.

For fish farming in cages in lake waters to be sustainable, natural resources management (including water quality, environmental influences, and considerations of climatic and natural risks) is a critical factor. Lake Taal is not a stable environment for tilapia farming. The lake is the deep, flooded caldera of one of the Philippines’ largest and still active volcanoes. The unpredictability of this volcano and associated seismic activity, with sulfide and ammonia releases from the lake floor, mean that fish in the lake are always potentially at risk. Clearly, the volcano poses the main threat of a major disaster to the fish farming industry in the lake. Further, the daily addition of large quantities of artificial feeds to the cages places large nitrogen and phosphorus loadings on the lake. Despite overriding external risks from natural causes, safeguards are required to minimize losses from potential human causes by paying close attention to site selection and feasibility, taking into account other, competing uses of the lake waters.

Allocation of space through zoning and licensing, and designation of allowable activities are important to ensure sustainable use of water resources and to minimize social conflicts among diverse users. Many measures have been designed to contribute to the sustainable management and conservation of the Lake Taal fisheries. In 1996, the entire lake was designated under the Philippine National Integrated Protected Areas System as a protected area, in which ecological processes, genetic diversity, and sustainable use of natural resources must be maintained. Local government units are expected to take the lead in implementing policies and regulations. A major challenge has been on how to reconcile and to strike a balance among the competing uses of the lake, particularly aquaculture, fisheries, and tourism. The existing Tagaytay-Taal Integrated Master Plan was conceived for this purpose. To date, however, tilapia cage farming has not been adequately managed in terms of its relationships with other lake users and its environmental impacts. The number of fish cages increased from 1,601 in 1993 to 6,843 in 2002, with the highest number recorded in 1999 at 10,567. The total number is greater than these official records because of illegal cages. These are clearly visible, particularly in areas where cages are prohibited.

Introduction of alien aquatic species can pose threats not only to biodiversity and the natural environment but also to fish farming because of the risks of introducing diseases and parasites. In the rural economy, freshwater aquaculture has become indispensable in the context of household food security, employment, and incomes for the poor. However, freshwater aquaculture is constantly exposed to risks because at present there are no effective measures to protect it from possible adverse impacts of future introductions of alien species and farmed organisms, particularly from the introduction of diseases and parasites. In Thailand, introductions and transfers of alien aquatic species have been made deliberately and accidentally. Alien species were introduced mainly for aquaculture and the aquarium trade, and in many cases were imported illegally without adequate quarantine.

In the Philippines, the introduction and use of alien aquatic species, and related inspections and

54 For example, in 1993, the Provincial Council of Batangas approved Fisheries Ordinance 4, Series of 1993, “Ordinance Providing for the Protection and Rehabilitation of Taal Lake’s Fisheries and Ecosystem,” which prohibits “active and other forms of destructive fishing gear/method” and delineates areas in which fish cages and fish traps can be operated. It also set limits for structures in the Pansipit River that would impede fish migrations and recruitment to fished populations in the lake—one among many instruments enacted to protect this river’s role in sustaining the lake’s fisheries.


56 The construction of illegal cages, particularly at the edges of the Pansipit River, has been a perennial problem for local government officials, exacerbated by lack of effective monitoring and political will to control the situation.

57 For example, Bangladesh, Philippines, and Thailand have imported the alien predator African catfish (Clarias gariepinus). Potential devastating impacts may occur when entrepreneurs introduce alien species; government authorities may be unaware of these devastating effects on ecology and farming in other countries.

quarantine, have long been regulated—under the 1998 Fisheries Code and preexisting legislation—but the controls have been inadequate because of lack of resources and lack of public awareness and concern. Philippine fish farmers, institutions, and the aquarium fish trade introduce alien aquatic species in contravention of national regulations and of the international conventions and codes of conduct to which the Philippines is a party.51 This situation poses potential threats not only to biodiversity and the natural environment but also to tilapia farming in the country because of the risks of introducing diseases and parasites. Overall, these deficiencies call for disease prevention capability, including the development of diagnostic and mitigation facilities. Further, adoption and implementation of aquaculture health management guidelines for transboundary movements of live aquatic animals through health certification, quarantine, and diagnostic procedures are imperative. Safeguards need to be developed, based on recommended biosafety measures.62

The products of freshwater aquaculture are mainly sold domestically near the areas of production, as whole, uncut fish, fresh killed, live, or chilled on ice. Nevertheless, the application of quality-control functions and inspection services to comply with international standards for HACCP will facilitate the development of safeguards for food safety.63 Hygiene and sanitation standards at market places vary. For example, quality control at landing, handling, distribution, and market places in Bangladesh is only periodically carried out.64 This is largely because of a shortage of food-quality inspectors and lack of emphasis on food-quality control for domestic marketing. Consequently, issues such as cleanliness, hygiene, and applications of chemicals, including preservatives on fish, are not monitored. With the increasing importance of aquaculture in the supply of fish products for domestic consumption and human nutrition, countries will need to pay increasing attention to food safety standards, including hygiene standards for domestic fish markets.65

OUTCOMES

The contribution of freshwater aquaculture to human nutrition is significant. In Bangladesh, where annual fish consumption was about 14 kilograms (kg)/person in 2000,66 fish account for 60–80% of the animal protein consumed by the population and provide essential vitamins, minerals, and fatty acids. Inland fisheries and freshwater aquaculture are the main sources of these nutrients for most of the rural and urban poor.67 Freshwater aquaculture, comprising mostly small-scale fish farms, produced 850,000 t of fish in 2002, 37% of the country’s total fisheries production.68

Similarly, fish is an important component of the diet and a valuable source of animal protein and other nutrients in the Philippines. The annual per capita consumption of fish and fish products was 36 kg in 1993, based on the most recent data from the Food and Nutrition Research Institute of the Philippines. Although per capita tilapia consumption is a relatively small part of total fish consumption—which comprises mostly marine fish—tilapia is the dominant freshwater fish; its average annual per capita consumption increased from 0.66 kg during 1979–1988 to 1.61 kg in 1989–1997, a decadal increase of 145%.69

In Thailand, fish and rice consumption is high, although the diet is becoming more diversified with increased consumption of wheat and meat. More than 20 fish species are farmed with total

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61 The 1993 Convention on Biological Diversity (www.biodiversity.org), ratified by the Philippines, requires parties to “Prevent the introduction of, control, or eradicate those alien species which threaten ecosystems, habitats or species.” Responsible use and control of species introduced for aquaculture and fisheries are guided by FAO, of which the Philippines is a member state. They are part of the FAO Code of Conduct for Responsible Fisheries (http://www.fao.org/3/a-aj261e.pdf). Prior appraisal of the possible impacts of alien species introductions is a major aspect of the FAO Technical Guidelines for Responsible Fisheries-Precautionary Approach to Capture Fisheries and Species Introductions (http://www.fao.org/docrep/003/w3592e00.htm). These have not yet been adequately applied in the Philippines.


63 HACCP is a systematic approach to the identification, evaluation, and control of food safety hazards. The hazard analysis involves the assessment of the critical control point, defined as the step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.


68 Over the last 2 decades, there has been a dramatic increase in inland freshwater aquaculture production in Bangladesh, rising sharply from 125,800 t in 1986 to 561,000 t in 2000.

69 This average per capita consumption of tilapia hides a wide variation in tilapia consumption in the Philippines; tilapia production is concentrated in provinces of the Central Luzon and Southern Tagalog regions. In areas where marine fish are not readily available, freshwater fish consumption (mainly tilapia) can be significantly higher than the national per capita consumption.
freshwater fish production of 271,000 t in 2000.\textsuperscript{70} Estimated average, annual per capita consumption of fish in 1998–1999 was 28.8 kg.\textsuperscript{71} Freshwater fish from inland capture fisheries and aquaculture accounted for 70–90% of the total quantity of fish consumed in all regions. The highest fish consumption by region was 33.8 kg per capita in resource-poor Northeastern Thailand. Fish was the main animal protein source, followed by chicken, pork, and beef. However, consumption varies considerably among different groups; for example, annual per capita fish consumption in communities of remote areas in Northern Thailand is about 3–5 kg.

Outcomes of freshwater aquaculture development in terms of income and employment generation in rural economies are significant. At farm gate, freshwater aquaculture generated an output of about $700 million in 2002 in Bangladesh. Including postharvest handling and marketing, freshwater aquaculture contributed more than $1 billion to the rural economy in 2002. With as much as 400,000 ha under fish farming, covering possibly more than 5 million fishponds, direct employment may have reached the full-time equivalent of more than 800,000 people, assuming a minimum requirement of 2 people/ha. Current employment figures for freshwater aquaculture and its associated activities are grossly underestimated. Part-time and full-time employment in freshwater aquaculture and related services may benefit 5 million or more people in Bangladesh.

Survey respondents in Bangladesh overwhelmingly believed that aquaculture had improved their welfare through fish consumption, nutrition, and increased incomes. The incomes enabled farmers to improve their housing and sanitation conditions and pay for clothes, medical and health services, and their children’s education. The respondents also emphasized that they had gained employment from fish farming. The surveyed fish farmers also confirmed that they had gained access to fish farming technology and that there had been an increase in the adoption of fish farming technology. Overall, the respondents were optimistic about their future in fish farming, mainly because of profitability, having fish for their own consumption, and employment. They felt that the major threats to the environment were flooding, soil erosion, and cyclones.

In 2001, freshwater\textsuperscript{72} fishponds and cages accounted for more than 90% of total tilapia aquaculture production in the Philippines of 106,618 t, with a total farm gate value of P5.13 billion ($102 million) in 2001. Tilapia ranked second after milkfish among major fish species farmed in the Philippines. Tilapia production exceeded 120,000 t in 2002, when at least 280,000 farmers and their families benefited directly and indirectly from employment generated by the freshwater tilapia industry. The total number of people benefiting directly and indirectly from employment generation associated with tilapia aquaculture in the Philippines may be more than half a million when full-time, part-time, and seasonal labor is taken into account, including labor for tilapia feed processing, fertilizer, and other supplies, and various processing and distribution jobs.

Surveyed tilapia farmers in the Philippines benefited from increased cash incomes, employment, and improved nutrition from tilapia consumption. Increased cash income was primarily attributed to profitable tilapia farming and good harvests. At Lake Taal, fish cage farmers produced an annual average of 18,850 t of tilapia during 1995–2002 valued at P952 million (footnote 72). Surveys in Central Luzon provided evidence that fish farming offers self-employment for farmers and their family members as well as for caretakers and laborers.\textsuperscript{73} A third of the surveyed fish farmers in Central Luzon said that their personal capacity to invest in fish farming had increased over the last 5 years because of savings. They had gained from technology dissemination and adoption. Although the respondents were generally optimistic about their future in fish farming, they were cautious about the overall condition of natural resources. Acidic soils, polluted water, and floods were perceived as the main future concerns for fishpond operations in the Philippines.

\textsuperscript{70} Department of Fisheries. 2003. Freshwater Fish Farm Production 2000. Bangkok. Herbivorous and omnivorous fish species with greatest relevance for small-scale aquaculture, such as carps, gouramis, and tilapias, comprise about 60% of total freshwater aquaculture production.


\textsuperscript{73} In the study area of 4,745 ha, fishpond operations alone generated employment for about 7,300 farmers, or about 24,000 people including household members.
CHAPTER 5

SUMMARY OF KEY FINDINGS FROM CASE STUDIES

This section summarizes key findings and lessons from the country case studies (footnote 22), offering considerations for making small-scale freshwater aquaculture development beneficial to the poor. These findings and lessons are generalized from the eight case studies and do not represent every situation. However, the contextual issues are significant and may be applicable elsewhere.

**Improving Human Nutrition.** Freshwater fish farming has developed rapidly in the last two decades, partly in response to a decline in capture fisheries and to a rising demand for fish as an important component of human diet. Although fisheries may contribute a small amount in relative terms to national gross domestic products, fish contribute significantly to human nutrition by providing affordable animal protein, important micronutrients, and healthy lipids to consumers, including the poor. The contribution of fish to total animal protein consumption among poor households is high.

**Recognizing Vulnerabilities.** The poor typically have limited access to land and water. They can still benefit from small-scale aquaculture albeit also with significant constraints in accessing capital resources. However, the poor are vulnerable in many aspects. They have limited capacity to cope with crisis situations and risks. Although small-scale fish farmers or landholders with fishponds may not be categorized as marginally poor or the poorest, most of them are precariously above the poverty line when their vulnerabilities are taken into account.

**Understanding Binding Constraints and Demand for Capital Assets.** Conventional aquaculture development initiatives are unlikely to reach the landless and the poorest. Without access to land and water, the poor are unlikely to engage directly in fish farming. Secure access and tenure rights to land and water are critical, although generally not sufficient, conditions. Fish farming also requires human capital, social capital, financial capital, and a vital operating environment that can facilitate access to markets, support services, facilities, and infrastructure. For the poor to engage in and benefit from aquaculture, the contextual demand for capital assets must also be well understood—do the intended participants, including the poor, have the means to operate and maintain aquaculture operations? The poorest people may be generally excluded from engaging directly as operators in aquaculture production not only because of limited access to land and reliable supply of water and lack of access to financial capital to meet investment and operating costs, but also
because of inability to meet specific requirements for technology adoption and inadequate capacity to overcome these constraints.

Because of vulnerabilities and limited means to cope with risks, many of the poor prefer livelihood opportunities with less perceived risks. Moreover, many of the poor are not in a position to have ready access to markets and essential factors of production because of their locations or exclusions for various reasons. Aggregate supply and demand analyses can mask the difficulties that the poor as individuals face in terms of barriers to meet the operating requirements of a particular type of aquaculture. The existence of an operating and efficient market does not automatically translate into a system that serves the poor. Relevants concerns for poverty reduction are the conditions that influence accessibility to markets and services and the extent to which individual circumstances that characterize the prevailing features of poverty contribute to inaccessibility of markets and other services.

Benefiting from Group Formation and Collective Action. While the poor often lack the means to undertake aquaculture on their own, group efforts—with appropriate organizational and management arrangements and an incentive structure based on sharing costs, benefits, and risks—can make their entry into aquaculture possible. Community-based organizations can mobilize resources and capital among the poor to overcome the barriers. Community-based group efforts may also require outside help to overcome such constraints as access to financial capital, property and tenure rights, skill acquisition, and issues related to systemic exclusion of the poor from gainful economic activities.

Considering Costs of Labor. Rural households comprise producers, consumers, and suppliers of labor. In the context of small-scale aquaculture, the rising opportunity cost of labor because of rapid economic development and employment opportunities elsewhere implies that on-farm productivity needs to rise for fish farms to remain financially attractive. Low-cost and affordable technology does not necessarily provide high returns on labor inputs, while a more intensive mode of farming can create a greater demand for financial and other resources that the poor do not have. The dynamics of the labor market, alternative employment opportunities, and labor migration have become important factors of consideration in the development of feasible technology options for small-scale aquaculture. For example, in many areas of Northeastern Thailand, labor migration to urban areas and particularly to Bangkok and its vicinity has caused a scarcity of on-farm labor, and such conditions restrict farm households from adopting labor-intensive farming techniques.

Understanding Market Dimensions. Markets provide key channels for the exchange of goods and services to generate incomes. For producers, capital assets and factors of production have alternative uses, and markets can provide important signals for producers to respond to demand. Functioning markets enable the flow of goods and services from producers to consumers, providing information on (i) products and their features; (ii) prices of goods and services; (iii) places or locations of market transactions; (iv) promotion of sales; and (v) various people, including producers, intermediaries and consumers, who are involved in these markets. Major factors that contribute to functioning markets include transportation and communications. Freshwater fish farming cannot succeed if pioneered and left to sustain itself in isolated areas where essential support services and markets are absent. Roads, transportation, and communications play important roles in the flow of goods, services, and information. Rural infrastructure makes access to and expansion of markets possible.

Enabling Access to Credit. Small-scale farmers need access to credit to enter fish farming. However, they are frequently ineligible or discouraged to apply for bank loans because of stringent and inflexible requirements for loan application, unfavorable repayment terms, and inability to meet requirements for farm insurance and collateral. Aquaculture insurance has almost no history or current market. By contrast the emergence and increasing relevance of informal credit from nonbank sources have benefited small-scale fish farmers, although such credit may carry higher interest than bank loans. Nonbank financing schemes, such as financier-caretaker arrangements, trader-operator agreements, contract farming, and suppliers' credit, can provide farmers with the required financial capital for aquaculture. Microfinance services can also complement the requirements of the poor, although the overall viability of such services should be emphasized to ensure sustained delivery of credit and savings services.

Technology Implications. Fish farming technologies can offer livelihood options for the landless poor who can secure access to land and water, although such options face socioeconomic constraints. For example, feeding fish may require substantial time for food gathering, preparation, and feeding. Moreover, returns from fish farming are seasonal, while the poor generally require more immediate income. The poor cannot easily afford
cash expenses, no matter how small the amounts. Cash expenditures, coupled with difficulties in accessing financial capital, can become insurmountable barriers for the poor to sustain aquaculture. Further, although requirements for physical labor may be shared and minimized through collective action among farmers, such organizational arrangements are not easy. The choice of technology requires the matching of requirements and availability of resources. This matching becomes more difficult, of course, the deeper the degree of poverty. Focusing attention on appropriate low-cost technology options may be necessary to help farmers with limited access to capital assets and to allow progressive improvements in technology as they gain experience, confidence, and profits.

**Rising Feed Costs.** A shift from intensive to semi-intensive fish culture by increasing reliance on natural food produced in fishponds through fertilization, with supplementation of rather than total reliance on commercial feed, can reduce feed costs. Because much of the feed ingredients is imported, depreciation of local currencies against major currencies has triggered domestic prices of fish feed to rise. Production costs can be lowered by promoting a fish farming system that relies primarily on natural feed produced in the pond, supplemented by organic and inorganic fertilizers to stimulate further growth of the natural feed. Technology options for such systems are available and provide cost-effective means of increasing farm productivity.

**Securing Fish Seed Supply.** Access to a reliable fish seed supply is critical to fish farming. Strategic linkages between fish breeding centers and private hatcheries/fish seed nurseries can enable fish farmers in major production areas to gain access to a range of fish seed. The case studies have indicated that the development of a reliable seed supply to support an expanding fish farming industry can benefit both small- and large-scale fish farms and consequently generate rural employment and incomes for many people.

**Making Extension More Effective.** Small-scale fish farmers need access to information and technology, and to a network of service providers, both public and private. In an environment that calls for decentralized roles of governments, the immediate impact of the devolution of responsibilities for extension services from central authorities to local government units is often the deterioration of extension quality and frequency of contacts during the transition period. Local governments are invariably confronted with budgetary constraints when responsibilities are decentralized without accompanying financial resources. Further, decentralization of roles often results in inadequate human resources and gaps in required skills. A distance extension approach with technologies appropriate for household-level and pond-based aquaculture is one way to reduce costs of extension delivery. Such an approach was developed in Northeastern Thailand. The extension materials developed took into account key requisites for effective communications, and local farmers’ culture and language, learning experience, and lifestyle. Most local communities and individual farming households have limited resources at their disposal; thus, less technically-oriented but demand-led approaches, including farming systems research, are required to reach poor target groups.

**Benefiting from Private Extension Services.** Challenges in developing viable technology options for aquaculture have continued to emerge with the rapidly changing conditions of rural economies. Although government agencies have remained important sources of technical advice to small-scale farmers, favorable market conditions have expanded opportunities for fish farmers to receive advisory services from private service providers, including suppliers of fish seed and feed. Government support for research and development, and maintenance of public access to appropriate aquaculture technologies have remained important enabling instruments. Social networks and other contributing features of social capital have enabled farmers to benefit from information exchange and knowledge sharing through farmer-to-farmer contacts. This flow of information often overshadows the conventional government extension services.

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74 Farmers were involved in all stages of research, including the development and dissemination of extension materials in the Northeastern Thailand case. While this approach has proven effective, the participatory processes and the time taken to develop the extension materials may not be readily acceptable to institutions with entrenched top-down approaches.
CHAPTER 6

LESSONS FROM ADB OPERATIONS IN FRESHWATER AQUACULTURE

This chapter draws lessons from completed ADB projects with freshwater aquaculture components, based on project/program performance audit reports. These lessons complement the findings of the case studies discussed earlier. Taken as a whole, the project completion reports and project/program performance audit reports reveal the importance of (i) realistic assessment of operating risks and the extent to which project designs address these risks, (ii) recognition of actual operating requirements and the extent to which targeted participants can meet these requirements, and (iii) other enabling conditions for achieving success.

OPERATING RISKS

Underestimation and ignorance of operating risks can result in debilitating losses to fish farmers. For example, the promotion of fish cage farming of carps at Kaptai Lake in Bangladesh was done without adequate understanding of such risks: cyclones damaged fish cages, surviving cages experienced poor fish growth, and operators did not repair or replace damaged cages. In the Philippines, ADB supported the development of milkfish pen and tilapia cage culture in Laguna de Bay in 1979–1988 (footnote 29 [i]) to improve the socioeconomic conditions of small-scale fish farmers and to increase fish supply to Metropolitan Manila. Two typhoons, in 1986 and 1987, damaged 95% of the fish pen modules and cages, inflicting heavy losses and incurring onerous debt burdens among fish farmers. Assisting the poor called for careful planning, particularly where this assistance involved acquisition of capital assets involving credit in a high-risk situation. Moreover, these fish farmers suffered from and contributed to social problems that beset the development of the fish pen industry at the lake, particularly the largely uncontrolled development of fish pens that resulted in conflicts between their operators and open-water fishers. The typhoon damage was exacerbated by the lake’s physical, chemical, and biological conditions that

Small tilapia in a rural market

contributed to increased fish mortality and poor fish growth rates. ADB experience calls for realistic risk assessments, including an analysis of stakeholders’ willingness and capacity to face such risks under varied scenarios.

APPROPRIATENESS OF DESIGN AND TECHNOLOGY

Proven fish farming technology without adequate local adaptation may result in serious shortcomings in its adoption and farm performance. Introduction of technologies requires good understanding of their multidimensional requirements. For example, the introduction of improved aquaculture techniques to inland fish production in Myanmar was unsuccessful because of inadequate water supply for fish hatchery operations, inadequate skills and experience with the newly introduced cage farming techniques, porous soil conditions, deficient pond design, and poor water management.

In Bangladesh, an aquaculture development project (footnote 75) promoted several aquaculture developments during 1978–1988, including the establishment and development of carp hatcheries, freshwater shrimp hatchery and farms, fish pens, fish cages, brackishwater shrimp and fish culture, fish-net-making plant, fish salting and drying facilities, and ice plants. The project was based on highly optimistic assessments of technology potential without adequate investigation of (i) the complexity of the components, (ii) institutional ramifications, and (iii) the demand for and availability of skilled people to adopt and operate the recommended technology. The results were inappropriate design features and technologies (i.e., fish processing facilities, fish pens, and fish cages), compounded by a general lack of commitment to the project by the executing agencies. Despite flexible efforts by ADB to address these issues, the combined effects led to reduced project benefits. In contrast, under the second aquaculture development project (footnote 27), the promotion of carp polyculture in fishponds benefited many farmers in Bangladesh. The sociocultural conditions in the villages facilitated the dissemination of the technology. Diffusion of information was effective because the extension services relied on feasible, simple, and low-cost technology to improve aquaculture practices.

Experience in Pakistan (1980–1989) indicated that the poor faced significant constraints in accessing capital resources to engage directly as operators of fish farms, but that wealthy landlords, including absentee landowners, shifted land use into fish farming because of its attractive financial returns. Subsequently (1989–1996), farm-produced fish became one of the high-value cash crops in Pakistan because of the successful establishment of demonstration fish farms and dissemination of information on fish farming that did not compete with existing livestock and agriculture production activities. Favorable returns were achieved through simple farming techniques, using abundant and relatively cheap animal manure for fertilizing fishponds, and using affordable cereal bran for fish feed.

OPERATING REQUIREMENTS

Recognizing the capital asset requirements of fish farming is essential for making aquaculture work for the poor. ADB experience indicates that numerous small-scale aquaculture farmers have not been able to use project services because (i) they did not own a pond or land area large enough to construct a viable pond, (ii) they lacked access to property rights to allow use of land and water resources, (iii) they were unable to meet established eligibility criteria for credit, (iv) they had inadequate skills or expertise, and/or (v) they lacked access to production input supplies. For example, in Nepal, the national government policy in the 1980s on leasing water bodies did not allow the poor to acquire leases. Without timely access to suitable water bodies or land for constructing fishponds, the poor were unable to acquire credit, inputs, and other services provided by a project there in the 1980s. Small-scale and poor Nepalese farmers were effectively disadvantaged when they could not fulfill collateral requirements for acquiring credit. Larger and wealthier farmers were, however, ready and qualified to receive project services. Further experience in Nepal (1987–1994) also failed to prove that fish farming was a viable option for the poor: on the one hand it was costly to construct new fishponds; on the other hand, natural water bodies, such as reservoirs, rivers, and irrigated sites, were underused but not readily accessible for fish farming. The poorest households benefited from employment in harvesting

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and marketing fish, but had neither land for a fishpond nor adequate collateral for acquiring credit to engage in aquaculture. This experience in Nepal drew attention to the need for deliberate efforts to enable the landless, marginal, and small-scale farmers to benefit from aquaculture development. Although the projects provided technology, training, credit, extension, and other services, the issue of access was not adequately addressed during project preparation and implementation.

ADB experience in Indonesia, Nepal, Philippines, Sri Lanka, and Thailand has underscored the need for rigorous assessment of credit demand, realistic identification of potential credit users, and socioeconomic analysis of potential borrowers, including the extent to which potential credit users can comply with requirements stipulated for loan applicants. ADB experience in credit operations under aquaculture development projects showed that lending requirements led to low credit use; the requirements were not in favor of the landless and small-scale poor farmers. The objective of providing credit to aquaculture farmers who did not have substantive collateral contradicted the operating principles of commercial banks that insisted on secured lending to reduce repayment risks. Requirements imposed by project credit operations also undermined commercial lending principles, when participating banks did not have the flexibility to set their own interest rates based on lending risks. In Bangladesh (footnote 27), the interest rate was fixed for all clients with no distinction between short-term loans, long-term loans, working capital, and investments. In general, bank credit officers perceived small-scale farmers without previous credit records as major risks. Access barriers to credit were greatest for those who were intended to benefit most from the projects. Collateral requirement for aquaculture credit was an issue in the Philippines, when fishpond lease agreements were unacceptable to banks as loan collateral, despite government efforts for stakeholders to consider leases as an enabling instrument for providing fish farmers with access to land and water.

In an ADB-funded program in the Philippines, aquaculture development plans were made on the basis of fishponds that were covered by lease agreements, aiming to intensify fish farming to raise yields and consequently to increase domestic fish consumption. Most of the fishpond operators were unable to shift from extensive to intensive culture because they lacked resources, such as regular supply of fish seed and working capital to buy inputs, especially commercial feeds. The program advocated the use of more intensive fish culture, but did not provide adequate analysis of whether farmers would have the means and resources to change their farming systems. This reflected deficient understanding of the requirements and incentives for change. In comparison, project initiatives in Sri Lanka (1984–1991) to increase fish production by growing carps in seasonal tanks (reservoirs for irrigation) initially showed promising results, but fish seed supply from government-owned hatcheries was discontinued in 1990 and there was no alternative supply of fish seed, resulting in an abrupt end to this form of aquaculture in the country. Inland freshwater aquaculture was developed for producing ornamental fish for export, rather than for growing fish for domestic consumption as intended by the project. This again reflected inadequate understanding of purpose and the requirements for achieving the desired objectives.

Appropriateness and selection of sites suitable for aquaculture development also have a critical role to play. The performance of aquaculture development projects has been lowered by unsuitable environmental conditions for aquaculture, adverse conditions within the culture system, and effects of surrounding environments. Long-term sustainability of aquaculture depends on effective prevention of environmental degradation, appropriate aquaculture system maintenance, and adequate management of water quality, including effluents.

Experience from ADB-financed projects has confirmed that mitigation of risks of diseases and their potential devastating impacts on aquaculture production should be seriously considered in aquaculture development. Aquaculture health and sanitation management, including issues related to diagnostcics, health certification, and quarantine, is equally important to minimize risks of epidemics. Food safety and hygiene are also important in aquaculture. Appropriate legal instruments for and enforcement of food safety and hygiene, and harmonization of standards for food safety are key challenges for improving human nutrition and health.

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This SES has examined the channels through which small-scale freshwater aquaculture farmers are affected in their operations. Based on this examination, the following recommendations are aimed at improving ADB operations in aquaculture development and making them more relevant for poverty reduction.

**Analyze Channels of Effects for Poverty Reduction.** Contextual understanding of the major ways in which various types of small-scale freshwater rural aquaculture can benefit the poor is critical for determining the conditions for making aquaculture work for them. Project preparation and design activities for aquaculture development should consider using the conceptual framework utilized in this study (footnote 19). This framework for improving diagnostic assessment is consistent with and complementary to the logical framework approach, which emphasizes problem-tree and cause-effect analysis\(^ {84} \) and key areas of economic analysis of projects.\(^ {85} \)

**Recognize Barriers, Requirements, and Risks.** Assessing the characteristics of farm households and analyzing their poverty features are part of an appraisal process of finding ways to make aquaculture work for the poor. The appraisal should consider the following:


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Harvesting fish in Bangladesh
(i) Benefits derived from aquaculture are primarily for those who can mobilize and use a combination of capital assets to gain from available opportunities.

(ii) When aimed at poverty reduction, aquaculture development efforts should be designed carefully by (a) clearly defining people intended to benefit from these efforts, and (b) devising appropriate strategies to help them benefit from the interventions.

(iii) Design features for such interventions need to recognize (a) specific features of poverty; (b) options and feasible means to overcome key barriers for entry into and remain in aquaculture; and (c) risks that the poor have little capacity to cope with, and ways to mitigate these risks.

**Assess Specific Demands on Users’ Capacity to Operate Aquaculture Systems.** An assessment is required of (i) technology options for selected farming practices and their demand for capital assets, (ii) users’ access to capital assets, and (iii) the extent to which intended users of selected aquaculture systems have the required capacity to operate and sustain the systems.

**Analyze Available Options for Providing Access to Land and Water.** Without land and water, the poor are unlikely to engage directly in fish farming. Secure access and tenure rights are critical. Access options may include

(i) leasing of existing ponds without new construction, although such an arrangement may require a third party to facilitate;

(ii) provision of limited tenure rights over state-owned water bodies (such as lakes, rivers, reservoirs, and seasonal water bodies) through licensing, zoning, and enforcement of appropriate rules and regulations;

(iii) use of common-property water bodies (such as community and village ponds) when sharing costs, benefits, risks, and responsibilities are feasible; and

(iv) group-based access arrangements, such as joint leasing of private ponds and licensed use of state-owned water bodies, taking into account lease costs, permit fees, users’ affordability, and viable arrangements for collective action.

**Consider Options for Financing Aquaculture Investments and Operations.** Small-scale farmers need access to financial capital to enter fish farming. Affordable access to credit is an important feature of farmers’ household finance. Small-scale farmers frequently do not borrow from banks because of inflexible requirements for collateral and various administrative hurdles. Instead, they rely on nonbank sources, including suppliers’ credit, traders’/buyers’ credit, contract farming, and partnership arrangements with financiers/investors. Microfinance can also make a difference to the poor.

**Analyze Markets and Marketing of Aquaculture Products and Factors of Production.** Small-scale farmers, including fish farmers, need to generate satisfactory returns by providing goods and services for which there is effective demand, at prices and costs that can justify their supply. A thorough assessment is required of markets and marketing of farm outputs and factors of production. This assessment should include, but should not be limited to

(i) demand analysis, including localized conditions for highly perishable, seasonal, and variable products that characterize aquaculture products;

(ii) the marketing chain, market intermediation, and the roles of market intermediaries in linking producers with consumers;

(iii) producers’ access to markets;

(iv) key factors influencing transaction costs;

(v) availability and supply of factors of production and associated services; and

(vi) support infrastructure and facilities contributing to the flow of goods, information, and services.

**Analyze the Labor Market.** A labor market assessment should be conducted to analyze formal and informal employment opportunities, wage rates, and other labor market characteristics, including labor migration and seasonal patterns that influence households’ decisions on employment. Farm households rarely have a single source of income. Livelihood choices including various sources of household incomes should be assessed to ensure that aquaculture as a livelihood option is not analyzed in isolation.

**Understand the Roles of Services, Facilities, and Support Infrastructure.** Small-scale farm households have limited resources at their disposal. Demand-led and innovative approaches are required to reach the poor among them. Government agencies may remain important sources of technical advice for small-scale farmers, but the roles of other players—farm input suppliers, social networks in information exchange and knowledge sharing—and the extent to which farmer-to-farmer contacts contribute to the flow of information should be assessed and should complement the government extension services. Aquaculture development cannot succeed without adequate support services and markets. Roads, transportation, and communications play important roles in the flow of goods, services, and information.
Assess the Roles of Public and Private Institutions. The complementary roles of public and private institutions are important in aquaculture development. Public institutions can catalyze and facilitate development in the private sector, but they must not hinder or replace the private sector. Partnerships and collaborations in research and development in key support areas, such as fish breeding, genetic improvement, farming systems, and aquaculture husbandry should be explored as part of an assessment of sector context.

Assess the Policy Environment, Legal Framework, and their Conditions. Appropriate policies, legal instruments, and their enforcement can act as enabling agents to aquaculture development. Licensing requirements, rules, and regulations for aquaculture operators, associated agents, and labor can influence the extent to which the poor are affected.

Protect Aquatic Resources, Environment, and Aquatic Health. The development of aquaculture cannot be sustained without adequate attention to aquatic resources management, environment, and aquatic health. Steps must be taken to ensure sustainability of the environment by taking measures for biosafety, disease prevention, and environmental protection.

Recognize Multiple Uses of Water and Minimize Conflicts. Freshwater aquaculture co-exists with other water uses, with potential conflicts, for example, between fish farmers and rice farmers, and between lake fishers, fish cage farmers, and tourism operators. Relationships between freshwater aquaculture and other sectors need to be based on recognizing the limited availability of freshwater bodies and finding ways to benefit as many co-users of water as possible. Growing fish before, during, and after the use of waters for other purposes can add greatly to those benefits.
PART 2
The Case Studies
CASE STUDY 1

OVERVIEW OF SMALL-SCALE FRESHWATER AQUACULTURE IN BANGLADESH

BACKGROUND

This case study was undertaken to provide a contextual overview of small-scale freshwater aquaculture in Bangladesh, including the significance of freshwater aquaculture, social dimensions of rural poverty among farmers, different aquaculture systems, freshwater fish markets, employment, safeguards to sustain aquaculture, relevant lessons, and ways in which the poor can benefit from small-scale aquaculture.1

Fish play an important role among the population in Bangladesh as indicated by the proverb machte bhate Bangali (fish and rice make a Bengali). Situated in the delta of the Brahmaputra, Meghna, and Ganges rivers, the climate, water, and soil conditions of Bangladesh are favorable for inland fisheries and aquaculture. At the height of the rainy season, more than a third of the total land area (147,570 square kilometers) of the country is submerged.2 According to the Bangladesh Bureau of Statistics (BBS), the fisheries sector, including aquaculture and capture fisheries, has had an annual growth exceeding 7% since 1995 and contributed 6% to the country’s GDP in 2000.3 Freshwater aquaculture led this with an annual growth exceeding 10% over the last decade. With annual fish consumption of about 14 kilograms (kg)/person in 2000,4 fish account for 60–80% of the animal protein consumed by the population, and also provide essential vitamins, minerals, and fatty acids. Inland fisheries and freshwater aquaculture are the main source of these nutrients for most of the rural and urban poor.5

According to the Fisheries Sector Review and Future Development Study conducted in collaboration with the Department of Fisheries (DOF),6 the total fisheries production of 2.3 million metric tons (t) in 2002 comprised 850,000 t (37%) from inland freshwater aquaculture, 95,000 t (4%) from coastal aquaculture, 750,000 t (33%) from inland capture fisheries, and 590,000 t (26%) from marine capture fisheries. Over the last 2 decades, there has been a dramatic increase in inland freshwater aquaculture production. DOF statistics indicate that fishpond production in Bangladesh increased sharply from 123,800 t in 1986 to 561,000 t in 2000, and average yields nationwide rose from 840 kilograms/hectare (kg/ha) to 2,440 kg/ha. With farm gate prices of farmed fish of about $0.80/kg (Tk45–50/kg), freshwater aquaculture production contributes about $700 million/year at farm gate value to the rural economy, or more than $1 billion annually when postharvest handling and marketing are included.

The domestic demand for fish has continued to rise with the rapid increase in population, which grew at 1.8% annually on average in the 1990s and reached 128.1 million in 1999. Many seasonal ditches have been converted into perennial fishponds through deepening and area expansion. The total fishpond area in the country is currently unclear: DOF statistics indicate that there are 230,000 ha of fishponds, while the Fisheries Sector Review and Future Development Study estimated the total at 400,000 ha, including ditches and small ponds of 50 square meters (m²) or more in surface area. Survey results of selected sites of the Mymensingh Aquaculture Extension Project (MAEP) financed by Danish International Development Assistance (DANIDA) showed that DOF

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1 N. Bestari undertook this country case study in collaboration with N. Ahmed, P. Edwards, and R. Pullin.
2 Khan M. S., E. Haq, S. Huq, A. A. Rahman, S. M. A. Rashid, and H. Ahmed. 1994. Wetlands of Bangladesh. Bangladesh Centre for Advanced Studies and Nature Conservation Movement. Varying significantly with seasonal changes, the total average water surface of Bangladesh was estimated at 7–8 million hectares (ha), or about 50% of the total land surface, comprising rivers and streams, freshwater lakes and marshes, reservoirs, fishponds, cultivated fields, and estuarine systems.
6 DOF. June 2003. The Future for Fisheries: Findings and Recommendations from the Fisheries Sector Review and Future Development Study. This study was commissioned with the assistance of the Danish International Development Assistance (DANIDA), Department for International Development (DFID) of the United Kingdom, Food and Agriculture Organization (FAO) of the United Nations, United States Agency for International Development, and World Bank.
statistics on fishpond areas significantly underestimated the total. Including all sizes, the number of small homestead fishponds in Bangladesh may be more than 5 million, reflecting their importance in the livelihoods, nutrition, and social fabric of rural households.

Most fishponds were originally ponds constructed as borrow pits, which were dug out for the soil to be used to raise the ground level of village settlements and pathways. Thus, the ponds were not deliberately built as fishponds, but as part of excavation works necessary for village and homestead development. In the past, fish farming was extensive and predominantly involved stocking of ponds with so-called riverine seed (wild fish fry and fingerlings caught from rivers), without substantial use of fish feeds to supplement natural pond organisms or fertilizers to stimulate the growth of these organisms. Following the introduction of technology for induced spawning of carp, coupled with improved and semi-intensive fishpond management from the early 1980s, fish farming became widespread, gaining unprecedented productivity improvement. Small-scale freshwater pond aquaculture has benefited from sustained efforts in various development projects funded by bilateral agencies, such as DANIDA and the Department for International Development (DFID) of the United Kingdom, and multilateral support from the Asian Development Bank (ADB) and World Bank in collaboration with DOF. Apart from technology development, including fish seed production and growout, these development initiatives emphasized dissemination of technology, farmer-to-farmer contacts and diffusion of knowledge, awareness building, capacity development of seed producers, enhancement of seed traders’ roles, and engagement of nongovernment organizations (NGOs).

**SOCIAL DIMENSIONS OF RURAL POVERTY**

Poverty in rural Bangladesh is multifaceted, reflected in low standards of living, lack of education, poor health, and vulnerability of most households to natural and human-induced disasters. The basic causes of poverty are lack of access to (i) productive resources, primarily land and water; (ii) public resources, such as health services and education services; and (iii) employment. Inadequate social safety nets make the landless particularly vulnerable. Land ownership, as an income-generating physical asset, has a predictable link with poverty incidence in the rural areas, but the size of landholdings is an imperfect measure of wealth. Poverty also means insecurity against shocks (such as accidents, illness, and deaths in the family), lack of opportunities, and disempowerment.

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7 Commencing in 1989 and in ending in 2003 with three phases, the DANIDA-funded MAEP was instrumental in the dissemination of improved carp pond polyculture technology throughout the Greater Mymensingh area, as a means of increasing fish production, raising incomes, and reducing poverty among rural households. A recent impact study (2003) undertaken by Winrock International indicated that MAEP beneficiaries with ponds made up 10% of the overall population of the area, and 34% of households reported using ponds for fish cultivation. The seven districts of MAEP represent about 10% of the surface area of Bangladesh, but their annual fish production was estimated at 329,000 t, representing about 39% of the total freshwater aquaculture production of 850,000 t. Average yields were reported to have increased from 1 t/ha in 1989 to 3.3 t/ha in 2002. The region has relatively good road networks and access to major fish markets in Bangladesh.

8 The DFID-financed Northwest Fisheries Extension Project (NFEP) in two phases operated during 1988-2000 in the country’s poorest Northwest region, characterized by infertile soils and relative extremes of climate, with the lowest agricultural and pond fish productivity. Sandy soils and a 6-month dry season have constrained the development of the pond polyculture of carp that is prevalent elsewhere in Bangladesh. Large areas of the Northwest are recognized as famine-prone. NFEP’s extension approach (i) established more than 260 model villages in which more than 9,000 farmers received training in aquaculture; (ii) used more than 1,000 seed traders as extension agents; and (iii) trained more than 250 secondary teachers in extension.

9 In Bangladesh, fish seed is categorized and named according to size. Fish fry are defined as juvenile fish larger than newly hatched fish (locally known as hatchlings) but smaller than fingerlings, which are defined as juvenile fish normally longer than 2.5 centimeters. Raising fish seed to fish of marketable size is termed “growout.”

Wealth ranking in rural Bangladesh is relative and wealthier households may still be vulnerable. In 1995/96, rural poverty stood at 47.1% and national poverty incidence was 47.5%. Some features of poverty include (i) malnutrition among children under 5-years old, at 56% (1992–1998), (ii) poor access to sanitation among the rural population, at 30% (1990–1996), and (iii) low adult literacy rates of females and males, at 43% and 59%, respectively (1998). Nearly two thirds (64%) of the landless are poor. Extremely poor households (the poorest of the poor) are completely landless, owning neither homestead land nor arable land and, if not homeless, live on borrowed land, sometimes in fear of eviction. These households are always food insecure, and often engage in food foraging. With no social capital, the poorest include destitute people who often resort to begging as an occupation. The functionally landless are next in rank, those who usually live on land owned by other people or have access to very small areas of homestead land (less than 0.2 ha) with poor housing conditions. They have little food security, suffer from continuous food deficits, work as daily wage and/or seasonal laborers, and have very few or no assets to fall back on during crises.

Among marginal households, the incidence of poverty is 44%. These are households with access to limited amounts of land (0.2–0.5 ha) and that may have small fishponds or a share of fishpond(s) in multiple ownership. Marginal households suffer from food deficits for several months each year. They adopt alternative livelihood strategies to meet their needs. They sharecrop and work as casual laborers. Although they have homesteads, their housing conditions are generally very basic with poor access to sanitation facilities. To some extent, the marginally poor can obtain credit by seeking informal loans through interactions with wealthier households and links with NGOs.

Next in rank are small landholders, of whom 34% live below the poverty line. They have access to moderate amounts of land for farming (0.5–1 ha), often including fishponds; they tend cattle and small livestock, and live in basic houses. They do not produce much surplus. They may have some access to financial capital and credit, but are vulnerable to crisis conditions. Some fishpond owners may also be categorized as medium-sized landholders, those who possess 1–2 ha of land, produce some surplus, and employ seasonal wage laborers. Yet, 25% of these medium-size landholders live below the poverty line, with the rest precariously above it. They can easily slide into poverty situations when faced with an unexpected crisis. Among landowners with more than 2 ha, the incidence of poverty is 16%, although they are among the elite in the local power structure.

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11 The poverty line represents the total consumption or income at which households satisfy their nutritional requirement of 2,122 calories/day/person. Separate urban and rural poverty lines are computed for 21 regions at threshold per capita per day calorie intakes.


13 With the growing rural population, land inheritance leads to multiple ownership of fishponds, presenting an array of issues related to co-ownership.
FRESHWATER AQUACULTURE SYSTEMS

Carp Pond Polyculture. The main production systems for freshwater aquaculture in Bangladesh are extensive and semi-intensive pond polycultures of carps. Indian, Chinese, and common carp polycultures in small ponds produced 700,000 t in 2002, about 80% of the total freshwater aquaculture production in Bangladesh. The remaining 20% were mainly from commercial fishponds, fish cages, and integrated farming in ricefields. According to DOF statistics, silver carp (Hypophthalmichthys molitrix) contributed 23% of total fishpond production in 2001 and has become an important food fish for the poor, together with silver barb (Barbodes gonionotus) and, increasingly, Nile tilapia (Oreochromis niloticus), which were initially promoted for farming in seasonal ditches. Opportunities for the poor stem from extensive and semi-intensive fishpond systems that depend on natural feed, such as plankton and detrital organisms whose growth can be stimulated by moderate use of inorganic (mainly urea and triple superphosphate) and organic fertilizers, including animal manure. These protein- and micronutrient-rich natural feeds can be supplemented with readily available, locally produced, cheap, energy-rich fish feeds (chiefly rice bran) and protein-rich fish feeds (mainly mustard oilcake).

There are no significant adverse environmental impacts from these polycultures of carps in ponds. The system helps to maintain water quality and promotes efficient use and recycling of nutrients. The risk of environmental degradation in the ponds because of supplementary fish feed is minimal. Villagers frequently use pond water for household purposes, including washing. Fish farming does not normally interfere with the multipurpose use of ponds and this provides strong incentives for pond owners to safeguard pond water quality.

14 Popular species are the indigenous Indian major carps [catla (Catla catla), rohu (Labeo rohita), and mrigal (Cirrhinus mrigala)], and alien species, including the Chinese silver carp (Hypophthalmichthys molitrix), grass carp (Ctenopharyngodon idella), and common carp (Cyprinus carpio). Other alien species grown in fishponds include the silver barb, locally called shorputi (Barbodes gonionotus), and bighead carp (Aristichthys nobilis).


16 Silver carp is fast growing; it can be harvested after 3 months when it reaches 300–400 g.
Small-Scale Aquaculture Enterprises. Owner-operated small enterprises with intensive fishponds have rapidly increased since 1995 along the Dhaka-Mymensingh corridor and elsewhere in the country. Their current total contribution to freshwater aquaculture production is limited, although there is much scope for future growth. A more intensive fish farming system has emerged in some small areas, in which ricefields in low lying areas have been converted into ponds and existing ponds made more productive with the use of commercial feeds; the feeds dominate farmers’ production costs. These enterprises often lease land for fish farming at Tk50,000–70,000/ha. Current estimates show that there are at least 500 small enterprises producing more than 20,000 t of fish per year; yields reach 10–15 t/ha with 1–2 crops/year. Such enterprises employ 2–4 persons/ha. The main species grown is the catfish, pangas (Pangasius hypophthalmus). However, farm gate prices of pangas have fallen below Tk5/kg and some farms have recently switched to higher-priced tilapia to maintain profitability, albeit with lower fish yields. Although tilapia is being adopted by an increasing number of entrepreneurs and commercial fish farms in Bangladesh, commercial farming of tilapia is constrained by the limited availability of seed.17

Small-Scale Cage Farming. Fish farming in low-cost small cages was piloted and introduced in Bangladesh primarily to landless poor with access to lakes, rivers, water canals, and seasonal water bodies.18 Many fish species can be farmed in low-cost cages, using feeds gathered by household members from their surroundings, vegetable wastes, and supplementary feed, such as rice bran and oilcake.19 Small-scale fish cages allow the landless poor to benefit from aquaculture because there are limited investment requirements—provided there is access to water bodies. Available low-cost feed, ease of handling and harvesting, as well as income potential and food security, are the main benefits. But there are constraints facing the wider adoption and sustained use of fish cages by the poor. These constraints include construction costs, thefts, unaffordable cash requirements for supplementary feed, and incompatibility between the immediate need to earn daily income among the poorest and the seasonal income that cage culture can offer. Thus, although fish-cage farming has been introduced among the poor, its adoption has remained localized.

Rice-Fish Farming. The production of fish in ricefields has been promoted by development projects as a way to obtain incremental benefits with little additional investment, but the contribution of rice-fish farming to total fish production has been marginal.20 However, the harvested fish when consumed by the farmers themselves can improve the nutritional status of their households significantly. Direct involvement is limited to those with sufficient landholdings among better-off farmers. Key constraints to the development of rice-fish farming include water management practices to fit both fish and rice requirements, coupled with risks of flooding and fish losses, poaching, and drought. Rice-fish farming requires low inputs of fertilizers and integrated pest management, in which chemical pesticide application and contamination are reduced. However, risks remain from the higher use of such pesticides by neighbors. Other challenges include harmonization of the fish production cycle with the rice-crop calendar, dictating timely availability of fish seed. The risks associated with rice-fish farming and the extent to which farmers’ risk

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17 Tilapia fingerling prices are relatively high at Tk0.80–1.00 (size 4–5 cm), about 4–5 times the price of carp fingerlings.
18 CARE Bangladesh introduced the development of 1-cubic-meter cages as a means of making aquaculture accessible to and overcoming the resource constraints of the landless poor.
19 Popular fish species grown in small cages include tilapia, grass carp, and silver barb.
20 An estimated 280,000 ha of ricefields where integrated pest management is practiced are considered suitable for rice-fish farming. With an optimistic assumption that 20% of the areas are double cropped with rice and fish for one growing season per year, and with fish yields of 50 kg/ha, this practice could yield a total of 2,800 t of fish annually, representing an incremental income of Tk140 million at the farm gate. This type of fish production accounted for only 0.3% of the estimated national freshwater aquaculture production of 850,000 t in 2002. Source: Footnote 15.
averageness has influenced the uptake of such technology in Bangladesh have not been fully studied. Despite successfully demonstrated rice-fish technologies and the large number of farmers who have been trained through various projects, rice-fish farming has yet to be widely adopted.

**Other Fish Farming Systems.** Fish pens and enclosure of water bodies for fish farming are also widespread in Bangladesh. Fish pens in canals, small rivers, and lakes can generate attractive returns to labor, land, and investments, but with significant risks of theft, poaching, natural predation, floods, and other weather risks. Extensive low-lying areas that flood during the monsoon are subdivided with barriers of various kinds—bamboo fences, dikes, and nets—creating enclosed and semi-enclosed areas suitable for fish farming. These areas are stocked with fish when flooded and cultivated with rice during the dry season. Crop shareholders are generally landowners. The enclosure of extensive areas for fish farming is constrained by social as well as organizational and management issues. Such enclosure generally restricts open access of the poor to floodplains on which some of the poorest rely for their livelihood. Further, multiple ownership and shareholding of fish pens lead to issues of collective action related to cost sharing and benefit distribution arrangements, roles and responsibilities of co-owners, equitable access to land and tenure rights, and various interests in water use and management, including those of neighboring water users.

**Fish Seed Supply.** At present, there is adequate carp seed supply in Bangladesh from about 630 private and 110 government-owned finfish hatcheries. Fish seed prices have declined in recent years. In 2002, these hatcheries produced more than 21 Current experience indicates that when small areas are fertilized, they can generate fish production of 500–700 kg/ha, and yield significant returns to fish farmers. With production costs of Tk10-15/kg of fish produced, farmers derive attractive returns from farm gate fish prices that exceed Tk50/kg.
200,000 kg of fish seed as larvae (hatchlings). They are produced by induced spawning of fish in hatcheries that have been developed in clusters by private sector entrepreneurs in better endowed areas, such as Bogra, Jessore, and Greater Mymensingh. In 1998, only 2,885 kg of riverine seed were collected, compared with 118,100 kg of seed produced by hatcheries.

Nursing of fish larvae to fry and fingerlings is commonly carried out in small-scale, private, household fish seed nurseries in villages, providing employment for both owners and laborers. Various observers have claimed that hatcheries in Bangladesh have faced problems related to negative selection of fish broodstock, indiscriminate hybridization, and inbreeding, but such claims, and how they are specifically related to seed quality and seed performance, have not been rigorously and comprehensively investigated. Clusters of small-scale hatcheries developed by farmers serve freshwater aquaculture in Bangladesh, rather than single large hatcheries that require significant capital, knowledge, and managerial skill to operate. If better quality genetic stock could be introduced to, and maintained by, small-scale hatcheries, these hatcheries would provide benefits to a wide range of fish farmers, most of whom are marginal farmers and small landholders. In recent years, increased attention has been given to broodstock management and fish breeding to minimize negative selection and inbreeding in hatcheries.

DOF has recently emphasized development efforts to improve broodstock quality through the establishment of a network of broodstock centers. Fish seed performance depends on many factors, including the conditions in the hatcheries and during transportation to final users, and handling and acclimatization prior to stocking. Transportation modes and distances vary widely.

Fish seed traders are the last and most critical actors in a complex network linking hatcheries and seed nurseries to fish farmers. In addition to selling seed, these traders often provide advice to fish farmers and disseminate knowledge of fish farming to their customers. Seed trading is a seasonal occupation that, in most places, begins in April and ends in September. Seed traders travel on buses and trains, and typically carry a few thousand seed in aluminum containers on foot or by bicycle, to reach their farm customers. Seed traders face significant risks of seed losses during long journeys. Most retail seed traders buy their fish seed directly from private household nurseries and, to some extent, from seed wholesalers.

Strategies for decentralized seed production are being developed in Northwest Bangladesh, the poorest region of the country, involving the more easily bred and fast-growing species (common carp, silver barb, and tilapia) that are appropriate for farming by the poor. Seed of these species can be produced without access to major hatchery facilities, by using a small hapa (fine mesh net cage) suspended in a water body, or in a flooded ricefield. The small investment enables resource-poor farmers to adopt the technology. Local production and seed trading networks can reduce the need for long-distance seed transport, thereby lowering delivery cost and improving seed survival. However, there are potential constraints to basing fish seed supply on small, isolated fish broodstock populations. Unless decentralized fish seed production includes appropriate breeding strategies to maintain the genetic quality of broodstock, the performance of the production stocks will decline.

Appropriate interventions to improve management practices and regular replenishment of high-quality seed for broodstock require concerted efforts through participatory approaches with farmers, government agencies, and NGO stakeholders to develop and institutionalize improved rural fish seed supply.

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25 These initiatives are supported by the World Bank-financed Fourth Fisheries Project, including a grant from the Global Environment Facility for aquatic resources development, management, and conservation.
26 In the Greater Mymensingh Area, carp seed prices at nurseries are currently at Tk0.10–0.15 per fingerling (size 4–5 cm), while seed traders sell these fingerlings to farmers at Tk0.20–0.25 each. A village seed trader may sell 3,000–6,000 fingerlings each day for up to 6 months a year, earning more than Tk300/day or four times the daily wage rate of agricultural labor.
29 The reasons include inadvertent negative selection, inbreeding, genetic drift, and introgressive hybridization.
**Fish Health.** Fish farming in Bangladesh is still mostly extensive and semi-extensive. The stocking densities and amounts of fertilizer and feeds added to fishponds are relatively low. Consequently, fish health is generally good from seed to harvested adults. The only exception to this has been sporadic outbreaks of epizootic ulcerative syndrome (EUS), a complex of primary and secondary infections by viruses, bacteria, and fungi that can result in ulcerated fish or cause mass mortality. EUS can affect a wide range of carp, barb, catfish, and snakehead species, but does not affect tilapias. Outbreaks of EUS appear to be much less severe now than in previous years. The only known preventive treatment is liming of ponds, which farmers confirm as effective. Farmers do not seem to regard the continuing risk of EUS outbreaks as very serious.

**FRESHWATER FISH MARKETS**

The market chain from fish farmers to consumers encompasses primary, secondary, and retail markets, involving local fish traders, sales agents, wholesalers-distributors, and retailers. Depending on the transaction volumes, fish farmers usually sell their fish to local traders or fish collectors who then sell to wholesalers-distributors with or without the help of commission-based sales agents. Farmers and local traders also sell their fish at village markets to consumers. Local traders-collectors usually sell their fish beyond their villages at **upazila** markets to wholesalers, who transport the fish to urban fish markets by road, rail, or boat. Auction sales at villages and other markets are common.

At urban fish markets, wholesalers also sell to other wholesalers who sell to retailers. Retail sales are made at retail stalls in fish markets, roadside stands, and door-to-door to household customers. The intermediaries perform postharvest tasks that include handling, cleaning, sorting, grading, icing, and transportation. In general, facilities at fish markets are minimal with poor hygiene and sanitation. There are currently no standard practices for handling, washing, sorting, grading, cleaning, and icing of fish. In villages, fish are commonly

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30 An *upazila* is an administrative government unit consisting of unions, each of which consists of several villages.
placed on the soil floor or in bamboo baskets. Access to ice is generally not a problem. Although the physical conditions of fish markets are poor, they function efficiently and market intermediaries are competitive. Fish farmers’ prices at farm gate are no less than 50% of the consumer retail prices, reflecting a short chain of intermediaries between primary suppliers and consumers. Freshwater fish are traded whole, ungutted, and fresh without processing apart from sorting and icing. The duration between harvest and retail for local markets is usually less than 24 hours.

**EMPLOYMENT**

Apart from direct self-employment opportunities from fish farming, freshwater aquaculture offers diverse livelihood opportunities for operators and employees of hatcheries and seed nurseries, and for seed traders and other intermediaries. Labor is needed for pond construction, repairs, and fish harvesting. The total number of people benefiting from direct employment in aquaculture is difficult to estimate because households are rarely engaged full time in fish farming. With as much as 400,000 ha under fish farming, direct, full-time employment may reach more than 800,000 people, assuming a minimum requirement of 2 persons/ha. Most of the work is part time, however, and the number of people directly involved is probably much more than 2 million. When related services are included, freshwater aquaculture may benefit 3 million or more people, and much more again if their dependents are included as indirect household beneficiaries. Much of the employment benefits accrue in rural areas and include the poor. Thus, the contribution of freshwater aquaculture to rural livelihoods is far reaching in Bangladesh.

**ADB SUPPORT TO FRESHWATER AQUACULTURE DEVELOPMENT**

**Aquaculture Development Project.**31 ADB first supported aquaculture development in Bangladesh in the late 1970s. The project supported largely independent subprojects, including the establishment of carp hatcheries, development of a freshwater shrimp hatchery and farms, development of fish pens, development of fish cages, brackishwater shrimp and fish culture, fishnet making, fish salting and drying facilities, and ice plants. The project was based on optimistic assessments of technology potential and led to the selection of inappropriate technologies.32 The main constraints were the complexity of the components, inadequate implementation capacity, and the related institutional ramifications. Poor performance was attributed to an overambitious project design, which had not fully taken into account the technical, social, and economic feasibility of aquaculture investments.

**Second Aquaculture Development Project.**33 Drawing on experience from its predecessor, a less complex design was adopted in the second ADB project (implemented during 1988–1997) to support Bangladesh aquaculture. The main objectives were to increase shrimp production in ponds to generate foreign exchange earnings, increase freshwater fish production for domestic consumption, and expand employment and increase incomes in the rural areas. In freshwater aquaculture, 1,498 demonstration fishponds were established in 22 districts, focusing on dissemination of fish farming technology that benefited small-scale farmers. The social structure and networks in the villages helped to spread the introduced technology. Visits to demonstration ponds were made possible through neighbors, friends, relatives, and local contacts. The improved fish farming techniques benefited small household farms and their household members—who consumed up to a quarter of the fish produced.34 The

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project promoted aquaculture practices that yielded high financial returns to farmers, largely pond owners, who adopted such practices.

There is evidence that farms have improved their productivity through better pond management and rational use of fertilizers, supplementary feed, and other inputs. Average fish yields are 1.2–3.2 t/ha for different categories of ponds. At 2002 constant prices, perennial carp polyculture ponds can provide an annual net income of Tk100,000/ha with good management, before debt service. When small-scale farmers operate improved ponds, they can gain an annualized net return of more than 50% of their total operating expenses. In comparison, unimproved carp farming with little husbandry generates an annual net income of less than Tk20,000/ha before debt service, and totally neglected ponds or derelict ponds may not yield significant returns. The project trained more than 600 DOF staff, in addition to training demonstration farmers. About 28,000 fish farmers attended organized events to promote carp polyculture during 1994–1996 in more than 180 upazilas.

Command Area Development Project. This project comprised (i) command area development aimed at developing on-farm field irrigation channels, improving the existing distribution and drainage systems, and providing minor flood protection works, within the command areas of Pabna and Meghna-Dhonagoda irrigation systems; (ii) promotion of integrated pest management to reduce the use of chemical pesticides through training of trainers, extension among farmers, and demonstration of alternative cropping practices; and (iii) small-scale fisheries development within the irrigation command areas to compensate for the loss in capture fisheries by providing extension services, organizational and management development support, and credit inputs to facilitate freshwater aquaculture development, primarily in small ponds and canals. DOF engaged NGOs to organize and develop the capacity of the poor in selected project areas in Pabna and Chandpur to adopt fish farming as a livelihood option. The development approach comprised interventions that motivated eligible beneficiaries, primarily women, organized them into groups, trained them in fish farming, provided the groups with access to fishponds by leasing private ponds, delivered microcredit for fish farming, and promoted savings.

First and Second Small-Scale Water Resources Development Sector Projects. These projects included small-scale freshwater aquaculture development initiatives in irrigation command areas. The first project included mitigation activities to reduce and to compensate for loss of floodplain fisheries by promoting freshwater aquaculture extension and organizing services with the help of NGOs to motivate and organize the poor to engage in pond aquaculture. The ongoing second project, under its water resources-oriented support program, includes freshwater aquaculture opportunities as livelihood improvement options for the poor, particularly those who lost access to floodplain fisheries. Relevant project initiatives for freshwater aquaculture include (i) micro-infrastructure development, such as excavation of small ponds to be leased to groups of poor for fish farming; (ii) livelihood support to the poor by providing access to inputs, fertilizers and seeds, small tools, and equipment for productive activities, including fish farming; and (iii) skills development for income-generating activities.

Fish Genetic Improvement. Mozambique tilapia (Oreochromis mossambicus) was introduced into Bangladesh in 1954 from Thailand, and tilapia seed was distributed all over the country. The species thrived mainly in ponds and open waters in central and southern areas. Nile tilapia (O. niloticus) was first introduced in 1974, also from Thailand, and initially stocked in a sewage-fed lake in Dhaka and in ponds at fishery research facilities in Chandpur. Seed of Nile tilapia was also distributed throughout the country. A survey of

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35 According to DOF, there are three classes of fishponds in Bangladesh: (i) actively managed ponds, (ii) moderately managed ponds, and (iii) ponds with no management and neglected, derelict ponds. DOF estimated that 16% of ponds in 2000 were derelict, while 28% were categorized as ponds with moderate management.

36 ADB. 1995. Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the People’s Republic of Bangladesh for the Command Area Development Project. Manila. (Loan 1399-BAN(SF): Command Area Development Project, for $30 million, approved on 7 November 1995.) The project was originally designed for implementation over 5 years, but the loan closing date was extended for 2 years from 30 June 2001 to 30 June 2003.

37 The selection criteria, although flexible, gave preference to women and marginal farmers whose households generally owned less than 0.5 acres of land (0.2 ha). Other considerations included unemployment, irregular employment, and limited access to cultivable land.

38 ADB. 1995. Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the People’s Republic of Bangladesh for the Small-Scale Water Resources Development Sector Project. Manila. (Loan 1381-BAN(SF): Small-Scale Water Resources Development Sector Project, for $32 million, approved on 26 September 1995.) The purpose of the project was to promote sustainable growth of rural incomes of the poor by developing community-based water management organizations and small-scale infrastructure in 300 locations in the western part of Bangladesh.


60 farming households in five upazilas of Mymensingh and 40 households from one upazila in Joypurhat district showed that tilapia was cultured in monoculture or polyculture in 29% of these household-level ponds in Mymensingh and 18% in Joypurhat. About half the farmers (54%) reported that uncontrolled breeding in the pond was a problem in tilapia production, while the others (46%) considered this breeding to be an advantage because it provided seed.

Earlier studies have indicated that resource-poor small-scale farmers can potentially benefit from the advances of research if institutional support is provided. Subsequently, with ADB assistance, the Bangladesh Fisheries Research Institute (BFRI) received genetically improved farmed tilapia (GIFT) in 1994 from collaborative research undertaken in the Philippines. Since then, BFRI has taken further steps to promote selective breeding of the GIFT strain and has disseminated tilapia seed to selected hatcheries, seed nurseries, and growout farmers. However, the role of BFRI in the dissemination of GIFT has been constrained by its limited resources. The presence of the GIFT strain in Bangladesh has been augmented by emerging private hatcheries that have acquired additional GIFT seed from Thailand.

ADB also contributed to the genetic improvement of carp species in Asia. It is a complex process because of the diversity of species, farming systems, and socioeconomic dimensions of Asian carp farming nations. The widely farmed carp species all have a longer generation interval than tilapia. ADB assistance was intended to determine priority carp species for genetic improvement, develop a research approach and methodology, initiate a training program, and develop improved carp breeds. Approved in late 2003, a second phase of assistance focuses on the dissemination of improved carp species and establishing national carp breeding programs in several countries, including Bangladesh.

**SAFEGUARDING FRESHWATER AQUACULTURE**

**Environmental Carrying Capacity.** The inland aquatic resource systems of Bangladesh are among the world’s richest and most diverse, comprising floodplain watercourses, associated natural water bodies (perennial and seasonal), fishponds, ditches, and canals. Two main features of this floodplain ecosystem are (i) its natural seasonal and longer-term changeability, as rivers change course with consequent erosion and silt deposition; and (ii) near full exploitation for agriculture, aquaculture, industry, and human settlements. These conditions have left very few areas in a natural state. Inland capture fisheries are heavily overexploited, with significant reliance on annual stocking of indigenous and alien fish species, and increasing use of barriers to enclose waters for fish enhancement for specific user groups. Inland capture fisheries continue to contribute significantly to national fish supply and employment; the adverse impacts of flood control structures and water management on floodplain fisheries must be mitigated to prevent undue hardship for those who have lost access to capture fisheries. However, there is potential for increasing the carrying capacity of the environment for fish through expansion of freshwater aquaculture and enhancement of enclosed fisheries. Aquaculture behind water retention structures can provide new livelihood options for those who have lost access to capture fisheries.

**Fish Seed Quality.** Broodstock management and recording of breeding histories are currently inadequate, and both inbreeding and accidental hybridization are thought to be widespread. Typically, hatcheries keep small numbers of broodstock for (i) larger and highly fecund species of indigenous carp such as rohu, catla, and mrigal; and (ii) alien silver and bighhead carps. For the latter,

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43 TA 5558-REG: Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia, for $600,000, approved on 14 December 1993. The development of the GIFT strain, through selective breeding, was partly financed earlier by ADB under TA 5279-REG: Genetic Improvement of Tilapia Species in Asia, for $475,000, approved on 8 March 1988. The main collaborating institutions were the International Center for Living Aquatic Resources Management (ICLARM; now known as the WorldFish Center), the Philippine Bureau of Fisheries and Aquatic Resources, the Freshwater Aquaculture Center of the Central Luzon State University of the Philippines, and the Norwegian Institute of Aquaculture Research. The GIFT strain was first disseminated to Bangladesh, People’s Republic of China (PRC), Philippines, Thailand, and Viet Nam, under the ADB-financed TA 5558, implemented by ICLARM.

44 TA 5711-REG: Genetic Improvement of Carp Species in Asia, for $1.3 million, approved on 12 December 1996. In the context of this technical assistance, the WorldFish Center collaborated with the national research institutions in six countries to initiate a coordinated program for genetic improvement of carp species. Genetic improvement experiments were conducted for the common carp in PRC, India, Indonesia, Thailand, and Viet Nam; for silver barb in Bangladesh, Thailand, and Viet Nam; for blunt snout bream in the PRC; and for rohu in India.

45 TA 6136-REG: Achieving Greater Food Security and Eliminating Poverty by Dissemination of Improved Carp Species to Fish Farmers, for $0.95 million, approved on 11 November 2003.

unintentional production of hybrids occurs through lax sorting of broodstock and cross-fertilization. Seed suppliers are obliged to produce quality seed from broodstock that are managed as part of ongoing, well-designed breeding programs, but at present there is no fish seed certification system. 47 Productive freshwater aquaculture production requires quality fish seed for fast growth, robustness, and survival. DOF’s current initiatives to improve broodstock quality through the establishment of broodstock centers can potentially improve the genetic pool of broodstock. However, there is a need for stronger operational links between research and development, extension services, and on-farm practices. Sustained government support in collaboration with the private sector is required for the establishment, operation, and maintenance of broodstock centers.

**Conservation of Genetic Diversity.** The stocking of open waters with indigenous and alien fish species, the mixing of farmed and wild or feral fish populations through flooding, and the modifications made to fish habitats for flood control and water management have undoubtedly changed the genetic diversity of some food fish species in Bangladesh. With freshwater fish coming increasingly from aquaculture and from floodplain fisheries enhanced by stocking fingerlings, the population genetics of some exploited species are probably much changed from the natural state and are subject to further change. The extent to which this has affected genetic distinctiveness, importance for conservation, and possible use in breeding programs of key commercial species in Bangladesh, is not known. This applies to at least 13 indigenous carp species and many species of catfish, airbreathers, and small indigenous species (SIS; i.e., fish species that attain a length of less than 10 cm). Documentation and conservation of the genetic diversity of these fish are important in identifying and securing genetic resources for the future, but this importance is not adequately recognized and funding is lacking.

**Rationalization of Farmed Fish Species.** Freshwater aquaculture and open water stock enhancement involve many species: indigenous and alien carp, catfishes, tilapias, and numerous SIS. For any farmed fish species, domestication, establishment of well-managed breeding programs, genetic improvement, and conservation of genetic resources are substantial undertakings that have ongoing costs. Bangladesh may not be able to afford to invest the resources needed to develop domestication, breeding, and conservation programs for 20 or more fish species. Rationalization and prioritization are required, based upon what is feasible and affordable. Fish species that have short generation times and are easy to breed and/or widely accepted by consumers are the most likely choices, for example, common carp, Nile tilapia, and silver barb, which are already domesticated species. The current farming practices that require stocking of ponds with 7 or more species, need to be reassessed, taking into account the difficulties of maintaining and developing seed quality and supply, especially for the larger carp species.

**Food Safety.** The products of freshwater aquaculture in Bangladesh are mostly sold close to the areas of production as whole, ungotunk fish, fresh killed, live or iced. None of the species of freshwater fish currently farmed is of significant interest for export to world markets in the way that shrimp is exported from coastal aquaculture—with the application of quality control functions and inspection services to comply with international standards for hazard analysis critical control point (HACCP). 48 Large tilapia from advanced private sector farms might, however, become exportable in the future. Given the importance of fish products and their marketing for domestic consumption, Bangladesh will need to pay adequate attention to food safety standards, including hygiene standards for domestic fish markets. 49 There are no indications to date that fish in the human food chain significantly increase human exposure to arsenic in Bangladesh but more research is needed, as recommended in recent studies. 50

**Biosafety and Disease Prevention.** The productivity of freshwater aquaculture and stocked waters in Bangladesh relies on indigenous and alien fish species. In the rural economy, freshwater

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47 Ahmed, M. 2002. Implementation of the Code of Conduct in Aquaculture. In Report of the National Workshop on the Code of Conduct for Responsible Fisheries—Bangladesh. Bay of Bengal Programme, edited by Y.S. Yadava. Report BOBP/REP/93. Chennai, Tamil Nadu: Bay of Bengal Programme; and Rome: FAO. p. 59–70. 48 HACCP encompasses a systematic approach to the identification, evaluation, and control of food safety hazards. The hazard analysis involves the assessment of the critical control point, defined as the step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. The process of collecting and evaluating information on hazards associated with the food under consideration to decide which are significant must be addressed in the HACCP plan.


50 Joint Consortium: National Centre for Epidemiology and Population Health, Australian National University, Australia; NGO Forum for Drinking Water Supply and Sanitation, Bangladesh; National Research Centre for Environmental Toxicology, University of Queensland, Australia; and the Occupational and Environmental Health Unit, Department of Epidemiology and Preventive Medicine, Monash University, Australia. March 2002. *Arsenic Mitigation in Bangladesh Pilot Project*, Report on the Intervention Trial to Assess the Contribution of Foodchain to Total Arsenic Exposure.
aquaculture is indispensable in the context of household food security, employment, and incomes for the poor. However, at present there are no effective biosafety measures to protect it from possible adverse impacts from future introductions of alien species and farmed organisms, particularly from the introduction of diseases and parasites. The Food and Agriculture Organization (FAO) of the United Nations recognizes, in its Code of Conduct for Responsible Fisheries and accompanying guidelines, the current importance and future potential of aquaculture for rural communities and for food security. Safeguards need to be developed and remedies can be based on recommended biosafety measures. Risks of disease propagation are high. Disease prevention capability, including diagnostic and mitigation facilities, needs to be developed, along with adoption and implementation of aquaculture health management guidelines for transboundary movements of live aquatic animals through health certification and quarantine procedures. Such measures depend not only on political will and adequate investment, but also on the behavior of farmers, researchers, and the general public. All parties need to become fully aware of what is at risk from irresponsible introductions and dissemination of alien aquatic species and farmed organisms.

LESSONS LEARNED

Access to Land and Water. Direct beneficiaries of aquaculture development have largely been pond owners among small- (0.5–1.0 ha) and medium-scale landholders (1–2 ha). Access to land and water is the key requisite for fish farming. Conventional aquaculture development initiatives that emphasize the promotion of technology and provision of targeted extension services are unlikely to reach the functionally landless and the extremely poor. Without access to land and water, the poorest are unlikely to engage in fish farming directly.

Access to Other Livelihood Assets. Apart from access to land and water, fish farming requires human capital and skills, social capital, financial capital, and a vital operating environment that includes support infrastructure, facilities, and access to markets. Access to financial and human capital assets is necessary for households to benefit from aquaculture. The ability to pay for pond development and fish farming, including seed and feed, requires financial capital, access to credit or both. Human capital, in terms of basic education and capacity to learn, is required for people to gain from training and extension services.

Leasing a Pond. When the landless gain access to water bodies or ponds through lease or other access arrangements for fish farming, secure access rights are critical. Without binding and long-term agreements on access rights, fish farmers are vulnerable. Eviction is common when access is not secure, and interrupted operation can result in loss of investment that the poor cannot recover. Demonstrated profitability of fish farming may also increase the price of pond leasing because of an increasing demand for fishponds by entrepreneurs. With annual pond leases reaching as high as Tk70,000/ha, the financial barrier for entry into aquaculture by the landless is significant. Further, the profitability of fish farming may entice landowners to operate fishponds on their own or through caretaker arrangements, and this affects the possibility of renewal of pond leases for landless people without long-term and secure tenure rights.

Pond Sharing. With the growing rural population and large number of dependents per family (typically, a family has 5–8 members), land inheritance leads to a multiple ownership of fishponds, presenting an array of issues related to co-ownership and collective action among shareholders. Arguably, many of the issues related to undervalued or derelict fishponds stem from the social dimensions of multiple ownership, when cost sharing, benefit distribution, and assignment of responsibilities and accountabilities for pond management become difficult.

Living Marginally with Risks. Marginal farmers or the marginally poor with access to limited amounts of land (0.2–0.5 ha) can still benefit from small-scale aquaculture but they have significant constraints in accessing resources. Most direct beneficiaries of fish seed and growout technologies in Bangladesh are not the poorest people. Small-scale landholders with fishponds may have limited assets and may not be categorized as marginally

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51 For example, Bangladesh has already imported an alien predatory fish species, the African catfish or magur (Clarias gariepinus) that has failed to meet utility expectations in aquaculture; DOF now discourages its use. Potential devastating impacts may occur when entrepreneurs introduce alien species, while the authorities are unaware of their devastating effects on ecology and farming in other countries.


55 Hallman K., David J. Lewis, and Suraiya Begum. 2003. An Integrated Economic and Social Analysis to Assess the Impact of Vegetable and Fishpond Technologies on Poverty in Rural Bangladesh. Food Consumption and Nutrition Division Discussion Paper No. 163. Washington, DC: International Food Policy Research Institute. The study found that households farming owned ponds in the Greater Mymensingh area were not the poorest people. Only small landholders and better-off households tend to own ponds. Group fishpond technology, although potentially beneficial to poor households, was undermined by collective action problems.
poor or the poorest, but most small-scale landholders are only precariously above the poverty line.

**Targeting the Poor.** Few aquaculture development initiatives reach the poorest. When aimed at poverty reduction, development assistance should be targeted carefully by clearly defining the intended beneficiaries and devising appropriate strategies to help them benefit. The assistance needs to recognize specific and prevalent features of poverty among the intended beneficiaries, including the means of overcoming key barriers for entry into aquaculture and adoption of technologies, and to mitigate risks to which the poor are particularly vulnerable.

**Labor and Cash Inputs.** Although fish farming technologies can offer potential solutions for the landless poor who can secure access to water bodies, there may be socioeconomic constraints. For example, feeding fish in small cages may require several hours of daily labor for food gathering, preparation, and feeding. Moreover, returns from fish farming are often highly seasonal. When the scale of operations increases, feed requirements cannot be always met by pond fertilization and collection of feed from the immediate vicinity. Supplementary feed may require cash outlays, which the poorest cannot easily afford. Lack of cash and difficulties in accessing credit are major barriers for the poor to undertaking aquaculture on their own. Although labor may be shared and minimized through collective action among farmers, organizational arrangements are not easy to meet. Different interests in the use of the water bodies may result in social conflicts; the vulnerable poor frequently lose out under such circumstances.

**Theft.** Fishpond owners and cage operators often face the threat of poaching. Theft risks increase when fishponds or cages are far from farmers’ households. Surveillance requires labor inputs for which the returns are not immediate. These constraints have limited the feasibility of fish farming to some extent, especially among households headed by females, who, on their own, are unable to protect their assets against an unfavorable social environment.

**Different Fish, Different Roles.** Nationwide, carp polyculture has long been popular, providing a significant source of animal protein and other nutrients for household nutrition. Mixed carp species remain dominant while tilapia has had relatively little impact yet on aquaculture in Bangladesh as a whole. However, the role of farmed tilapia in meeting poor people’s needs and its demand in formal markets are becoming more apparent. The misconception that tilapia are unimportant in Northwest Bangladesh arose because few of them were seen in markets. Most small-scale farmers were found to stock tilapia in polyculture with carp in small ditches and borrow pits near the households. Among poorer households, carp are mainly sold on the market for income and tilapia are mostly consumed by the households. The small size of the tilapia and their ability to breed in ponds to provide seed were both viewed positively by poorer households.

**WAYS TO REACH THE POOR**

One of the first major attempts to use technology in aquaculture to benefit the landless poor directly was the Grameen Bank’s Joyshagar Fisheries Project in 1986. The project developed a community-based model capable of mobilizing the landless poor to grow fish in underutilized freshwater ponds. Groups of landless people were guaranteed secure access to state-owned ponds, allowing specific tenure rights. The main lesson learned was the need to develop innovative organizational arrangements for the poor

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to have secure access to resources for them to benefit from aquaculture technology. The relationships between aquaculture and the poor were elucidated by a study of fish farming in Northwest Bangladesh to identify possible poverty-focused activities. The poorest were generally excluded from aquaculture production, but two types of poverty-focused benefits were identified in the fish farming system: (i) employment opportunities through fish seed trading and (ii) increased availability of fish in poor people’s diets.

Group leasing arrangements for ponds have been identified as a primary access route for the poor to farm fish. To date, several NGOs have developed projects to help the poor get access to land and water, using social influence and financial support. Under the ADB-financed Command Area Development Project (footnote 36), NGOs were engaged to organize the poor—mainly women—into groups, provide them with access to ponds for fish farming through private lease arrangements, help the groups acquire skills in fish farming and marketing, and provide them with microfinance services, including microcredit and savings facilities.

The DFID-financed Northwest Fisheries Extension Project (footnote 8) customized interventions for the poor by (i) promoting a fish farming system that relied primarily on stimulating the growth of natural feed (plankton) produced in the pond using organic and inorganic fertilizers and (ii) mobilizing and training poor seed traders to disseminate information on aquaculture practices suited to the Northwest region. During 1989–2000, the project trained more than 1,200 seed traders in fish farming. Reportedly, each seed trader had contacts with 40 farmers on average, and about 60% of fish farmers purchased fish seed from NFPE-trained seed traders. However, poor seed traders favored relatively wealthier farmers—those who could purchase seed in cash—and did not offer to sell seed on credit to marginal fishpond operators. Thus, access to working capital, including credit, is crucial for fishpond operators.

Microfinance can help the poor meet their financial needs to engage in aquaculture. An increasing number of NGOs are providing microfinance services to rural customers, including those who are unable to obtain a loan from other sources. Interventions aimed at aquaculture development for the poor should be based on a microenterprise development approach, taking into account access to and availability of rural financial services. The feasibility and viability of the microfinance services themselves should be emphasized to ensure sustained delivery of credit and savings services to the targeted groups.

Extension services for fish farming can be highly effective when provided by trained and adequately equipped staff. However, funding for such services is compartmentalized and made available through separate projects rather than on a program basis. With the growing importance of freshwater aquaculture for rural livelihood and poverty reduction, there is a clear need for stronger and well-funded government extension services, including innovative means to help the poor in partnership with NGOs. Although NGOs have been engaged by DOF in projects to promote fish farming among the poor, greater and long-term effort will be required to help them overcome constraints to adopting fish farming as a livelihood option. The vast numbers of small seasonal ponds

61 Fisheries Sector Review and Future Development Study. 2003. Theme Study: Livelihoods, Social Development and Environment. Dhaka. Since 1994, the Grameen Matlab Foundation (GMF) has taken leases on 652 state-owned ponds and organized 4,200 poor people in groups to develop these ponds for aquaculture. Group members have landholdings of less than 0.4 ha, and the groups comprise poor people, including those considered among the poorest; women make up 28% of all group members. Members contribute their labor, while GMF bears all input costs, including the costs of pond leases, and provides technical and social development training to the groups. The members and GMF operate on a profit-sharing basis.
62 The natural productivity of ponds in Northwest Bangladesh is, however, lower than elsewhere in the country because of a 4-month cold season (Nov–Feb) when water temperature may drop to 12 degrees Celsius and fish growth declines. During the 3-month monsoon period (Jun–Sep), clouds reduce sunlight on ponds, which limits plankton growth.
in Bangladesh owned by poor and marginal farmers are an underutilized resource for fish production.

Seasonal ponds are a natural habitat for SIS, and potentially suitable for their farming in combination with other species, including the cultured carps.63 There is potential for integrating SIS in the development of small-scale freshwater aquaculture in Bangladesh, with an important role in enhancing nutrition security for the rural poor, particularly in providing increased intake of vitamin A, calcium, and other essential nutrients. However, market prices of some SIS have reached levels above those of carps and other commercial species because of increasing demand and scarcity. The relatively high prices of these SIS may discourage their consumption by poor farmers and encourage them to sell SIS in the market. Challenges in farming SIS also include developing good quality broodstock for seed supply and improving the knowledge of researchers and fishpond operators on the most appropriate stocking combinations among SIS, carps, and other species.

CASE STUDY 2
FARMING CARPS IN LEASED PONDS BY GROUPS IN CHANDPUR, BANGLADESH

BACKGROUND

Scope and Purpose

This case study was undertaken to examine small-scale freshwater aquaculture development that took place as part of an Asian Development Bank (ADB)-supported project in an irrigation area in Bangladesh. The study used primary and secondary data and published information to document the human, social, natural, physical, and financial capital available to poor people involved in the production and consumption of freshwater farmed fish and to identify channels through which the poor can benefit, such as through access to livelihood assets, markets and prices, access to services and facilities, and key institutions and processes.¹

The study is based on a part of the small-scale fisheries development component of the ADB-financed Command Area Development Project (CACP).² This project had 3 parts: (i) to develop on-farm field irrigation channels, improve the existing water distribution and drainage systems, and provide minor flood protection in the Pabna irrigation system in Pabna District and in the Meghna-Dhonagoda irrigation system (MDIS) in Chandpur District; (ii) promotion of integrated pest management to reduce the use of chemical pesticides through training of trainers, extension services to farmers, and demonstration of alternative cropping practices; and (iii) small-scale fisheries and aquaculture development within the irrigation command areas through extension services, organizational and management development support, and credit inputs to initiate small-scale freshwater aquaculture, primarily in small ponds, for the poor. The two irrigation systems were earlier developed and financed by ADB.³ This case study focuses on small-scale freshwater aquaculture development in Matlab, an upazila⁴ in the MDIS area.

Relevance

Poverty Incidence. The MDIS area had a population of 139,900 people in 1995 and poverty incidence a little higher than the national level, at 50%. Poverty among the landless was much higher, 74%. According to the project benchmark survey in 1997, 34% of the households were landless at that time, 43% owned less than 0.4 hectares (ha) of land, 16% had landholdings of 0.4–1.0 ha, and 7% had more than 1 ha of land.⁵

¹ N. Ahmed led a survey of fish farming groups in Matlab, Chandpur. N. Ahmed, N. Bestari, P. Edwards, B. Katon, and R. Pullin collaborated on the methodology, information analyses, and preparation of this report.
² ADB. 1995. Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the People’s Republic of Bangladesh for the Command Area Development Project, Manila. (Loan 1399-BAN(SF): Command Area Development Project, for $30 million, approved on 7 November 1995.) The project was originally designed for implementation over 5 years, and the loan closing date was extended for 2 years from 30 June 2001 to 30 June 2003.
⁴ An upazila is an administrative government unit consisting of unions, each of which consists of villages.
⁵ The unit of account for land in Bangladesh is commonly expressed in decimals. 1 acre of land = 100 decimals; 1 hectare (ha) = 2.47 acres.
Mitigating the Loss of Capture Fisheries. The small-scale freshwater aquaculture development component was designed to compensate for the decline of fisheries that accompanied the construction of flood embankments in the past. The CADP, in collaboration with the Department of Fisheries (DOF), promoted a semi-intensive fishpond culture in Matlab by adapting the increasingly popular carp polyculture farming system, which uses a mixture of endemic and alien carp species. In practice, this system has not varied much in Bangladesh, except for differences in fish seed stocking density, maintenance, harvesting schedules, and the types of ponds used, namely rainfed seasonal ponds and perennial ponds. DOF promoted carp polyculture nationwide through many aquaculture development projects, including a component of the ADB-financed Second Aquaculture Development Project (implemented during 1988–1997), by establishing demonstration fishponds and promoting dissemination of fish farming technology in 22 districts including Chandpur.

Establishing Groups of Fish Farmers. In November 1999, DOF engaged a nongovernment organization (NGO), the Voluntary Organization for Social Development (VOSD), to develop the capacity of the poor in Matlab Upazila through fish farming. The approach taken was to (i) organize the poor, primarily women, into groups of 10–15; (ii) equip these groups with fish farming techniques and skills by training and extension; (iii) provide the groups with access to ponds by leasing private ponds; and (iv) provide the groups with microcredit and savings facilities. The selection criteria gave preference to women and marginal and landless farmers with land of less than 0.2 ha. Other criteria included unemployment, irregular employment, and people with limited access to cultivable land. The project group took about 6 months. The project established 175 groups during 2000–2001, comprising 2,590 members including 2,440 women in 165 groups in 14 unions covering 77 villages in Matlab Upazila. Typically, each group acquired access to several fishponds covering a total of 1 ha of water surface. The lease value of the ponds was Tk25,000–30,000/ha annually, with leases of 1–5 years. Overall, VOSD helped the groups to gain livelihood assets: (i) skills, personal motivation, and confidence; (ii) organizational development and group formation; (iii) ponds leased from individuals or multiple owners with tenure rights; (iv) access to markets; and (v) financial capital through microfinance services.

Providing Microcredit to the Poor. The groups were new, with no previous access to alternative and affordable credit sources. Their own resources were limited and their assets, including savings, were not adequate to meet the investment and operating costs of fish farming. VOSD provided

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6. Popular endemic species include catla (Catla catla), rohu (Labeo rohita), and mrigal (Cirrhinus mrigala); and exotic species include silver carp (Hypophthalmichthys molitrix), grass carp (Ctenopharyngodon idella), and common carp (Cyprinus carpio).

7. In Bangladesh, fish fry are defined as juvenile fish, larger than newly hatched fish (locally known as hatchlings) but smaller than fingerlings, which are defined as juvenile fish normally longer than 2.5 cm.

8. The fish culture typically requires (i) a stocking density of about 10,000 fingerlings per hectare, with fingerlings of up to about 12 cm long; (ii) pond fertilization using inorganic fertilizers, such as urea and triple superphosphate and manure (chicken manure and cow manure); and (iii) supplementary feeding using rice bran, wheat bran, and mustard oil cake. With perennial ponds, multiple stocking and harvests throughout the year are feasible. When a high density of fish is stocked initially, partial harvests at intervals allow thinning of the fish population to optimize biomass production of fish.

9. ADB. 2002. Project Performance Audit Report on the Second Aquaculture Development Project in Bangladesh. Manila. A total of 1,498 demonstration ponds were established in 22 districts. Dissemination of fish culture techniques benefited small farmers. The social structure in the villages helped to spread the introduced technology. Visits to demonstration ponds were made possible through neighbors, friends, relatives and local contacts.

10. VOSD was awarded a contract of Tk5.93 million for the period 30 November 1999–30 November 2001, a contract extension of Tk2.20 million for 1 December 2001–30 June 2002, and another contract extension of Tk1.46 million for 1 July 2002–30 June 2003. These contracts covered the costs of training, group formation, other capacity-building initiatives, and the operating costs of VOSD staff.

11. In many cases, several people owned the same ponds, and the lease arrangements involved users in a group and a group of owners. Absentee pond owners found leasing to be a convenient arrangement.
the groups with credit for working capital, with a limit of Tk50,000 per group. In all, Tk8.75 million were disbursed to the groups, who used the funds to pay for fish seed, feed, fertilizers, and hired labor for pond preparation and harvesting. The group members paid for the costs of pond leases, using their savings and proceeds from the sales of household assets. The credit facility did not require any collateral. Credit delivery began in early 2001. The credit terms were for 12 months, with an interest rate of 15% for the year and equal quarterly repayments of loan principal. Interest charges were calculated on the declining balance of the loan principal. In practice, the repayment terms were flexible and not strictly bound by the requirement for equal quarterly repayments. The group members each were required to save a minimum of Tk5/week. In September 2003, DOF renewed its agreement with VOSD for the operation of the credit facility on a revolving basis for 5 more years.

VOSD obtained no further grant assistance to finance its advisory and extension services in Matlab Upazila after July 2003. The organization opted to cover its operating costs from earnings gained from the interest rate spread, but predicted that it would face increasing pressure to minimize its operating costs and to reduce lending risks by extending the credit facility to various other income-generating initiatives.

**METHODS AND SOURCES**

For the preparation of this case study, site visits and key informant interviews were conducted intermittently during June–November 2003. Information gathering included a survey in Matlab Upazila: (i) 100 fish farming groups were selected randomly as group respondents out of the total of 175 groups; (ii) 100 households were randomly selected, 1 household from each of the selected 100 groups; and (iii) market intermediaries comprising 10 fish traders, 10 seed traders, and 10 fish harvesters were interviewed. Secondary data came from DOF, VOSD, the Bangladesh Bureau of Statistics, and the Bangladesh Water Development Board.

**BIOPHYSICAL FEATURES OF THE CASE STUDY AREA**

Forming an island, MDIS is located on the Meghna River at its junction with Padma River and is surrounded by the branches of the Meghna and Dhonogoda rivers. The case study area is located in the MDIS covering 13,600 ha in Matlab Upazila. Prior to 1981, this entire area (human settlements, agricultural lands, and fishponds) was under several meters of floodwater for about 4 months every year. The construction of a flood protection embankment with associated peripheral roads and irrigation canals greatly improved the living conditions of its communities. Flooding had occurred only twice since then: in 1987 in common with most of Bangladesh, and in 1988 because of a breach in the embankment during major flooding in the country. Occasional flooding seems inevitable with the continuing possibility of exceptional rains, sea level rise, and embankment failures. There are continuing efforts to cope with shifts in the courses of the rivers and threats of land erosion in Chandpur by the Bangladesh Water Development Board, which considers the embanked area as an important and strategic flood-protected area to be maintained.

Flood control structures here, as in other areas of Bangladesh, have contributed to the decline of inland capture fisheries, which also suffer from overfishing and general unmanageability. Reportedly, the production of inland capture fisheries declined from 962 t in 1983/84 to 336 t in 1991/92 at Meghna-Dhonogoda. The development of freshwater aquaculture was an effort to compensate for the decline in inland capture fisheries. Within the MDIS embankment, the change from annual to exceptional flooding reduced inland capture fisheries but increased opportunities for agriculture and aquaculture with lower risks. The cessation of annual flooding will have long-term effects on the ecology and on the aquatic and terrestrial biodiversity of the area, from soil microorganisms to plants and animals, including fish. The overall effect is increased retention of nutrients (from organic and inorganic fertilizers, human settlements, and livestock). The main change in agriculture since flood protection has been the assurance of two rice crops per year. The embankment has become a site for growing trees.

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12 VOSD charges 15% interest per annum to clients and pays an interest of 3% per annum to the Government for the credit facility. Thus, VOSD receives a spread of 12% per annum, and bears the full risks of lending and credit recovery.


14 Ali, M.Y. 1997 Fish, Water and People. Reflections on Inland Openwater Fisheries Resources of Bangladesh. Dhaka. Losses in capture fisheries were estimated at 2,800 t per year based on optimistic fisheries productivity of the floodplains and open waters, while a much lower estimate indicated annual losses at between 506 and 584 t.

15 The VOSD recognizes that land use in the area should maintain a balance between rice farming, pond aquaculture, vegetable crops, and fishing.

16 It is possible that livestock and poultry populations have also increased, but time series data cannot be obtained. Ducks are common on and around fishponds.
There are possibly more than 10,000 ponds as well as numerous ditches and open water areas in Matlab Upazila, although there are no accurate statistics. Some of the fishponds are more than 75 years old and were originally excavated to raise the level of land for the village as well as for bathing, watering livestock, domestic water supply, and traditional fish farming. Other ponds are 15–20 years old, and there is evidence of excavation of newer ponds and ditches along the embankment and roads.

The water quality of fishponds and ditches in the area is suitable for fish farming. Integrated pest management has been promoted, but heavy use of pesticides continues, as is common in irrigated areas growing high-yielding rice varieties. This condition does not appear likely to threaten fish health, but pesticide residues in fish might be a cause for concern. Farmers are not fertilizing or feeding at rates that could cause oxygen or other water quality problems for fish, and there appear to be no significant risks from off-farm sources of pollution. However, some tubewells in the area are regarded as arsenic-contaminated, and some villagers are appealing for wells deeper than 250 meters to be dug to find arsenic-free water. Groundwater is used in this area for both agriculture and aquaculture, but there are no indications to date that fish consumption has significantly increased human exposure to arsenic.

FISH FARMING TECHNOLOGY AND MANAGEMENT

Seed Supply. The fish farmers in this area obtain almost all of their fish seed (fry and fingerlings) for stocking in ponds from hatcheries and nurseries operated by others. The only exceptions to this are that some Nile tilapia and common carp fingerlings are produced locally (they breed in ponds and ditches) and there is undoubtedly some natural recruitment of small indigenous species. Most farmers believe it is necessary to stock ponds with a mix of 7 or more carp species, although they have varying ideas about stocking tilapia with carp species.

Growout. All 100 groups in the survey farmed a mixture of carps for 9–11 months each year. The groups generally complied with the recommended stocking density—an average stocking rate of 11,250/ha. Ponds were fertilized with urea, triple superphosphate (TSP), and cow manure, and fed rice bran, mustard oil cake, and to lesser extent grass, banana leaves, and wheat bran. These simple feeds also act as pond fertilizers to some extent, and the basal fertility of ponds is usually significant as well because of inputs from their surroundings. The groups did not fully follow the recommended fertilizer use and supplementary feed, in that less cow manure was used, but the groups compensated for this with more urea and TSP. About two thirds of the respondents drained their ponds, nearly always by pumping, and usually every 2–3 years.

Individual Group Members and Fish Farming. Of the 100 individual group members surveyed, 64% were not involved in any other aquaculture activity than the group-based fish farming. A third (33%) farmed fish in household ponds and ditches, and 3% nursed fry. All members were attracted to fish farming because of its profitability and the possibility of having fish for household consumption. Other reasons for fish farming included prior knowledge of aquaculture (11%), availability of fish seed (2%), availability of fertilizers (1%), and availability of feed (1%). Individual members used pond water for multiple purposes: washing clothes (98%), washing dishes (95%), bathing (93%), livestock (30%), cooking (26%), and watering crops (14%). Nevertheless, there were relatively few water-use conflicts. Most respondents (86%) milled their own rice and used

17 Farmers recall this traditional fish farming as haphazard stocking of fish seed in ponds and harvesting whatever resulted from natural productivity, with little or no feeding or fertilization. Fish yields, following the stocking, husbandry, and harvesting methods promoted by VOSD, were reported by farmers to be 5–10 times higher than those of the previously unmanaged ponds.

18 Carp seed of all farmed species can be obtained from seed traders, who purchase seed from hatcheries located in Chandpur and Comilla. Several households in the villages where the groups farmed fish also nursed fry to fingerlings in ponds, from which the groups purchased seed. There is one local private hatchery and one local state-owned hatchery in Matlab. Nile tilapia (Oreochromis niloticus) fingerlings are less common, but local sources of supply are emerging. For example, a local farmer in Shabaz Khandi village of East Fathpur Union currently produces about 70,000 tilapia fingerlings a year (70–100 pieces per kg; at Tk80/kg) from free breeding broodstock in ponds, fed regularly on rice bran and mustard oil cake. This farmer sells tilapia fingerlings to 50–60 farmers in the vicinity, some of whom stock tilapia with carps. His tilapia broodstock were obtained from his grandfather’s pond, which came from a tilapia hatchery in Myemangin. He is keen to obtain genetically improved farmed tilapia (GIFT) after hearing about their good performance though a television program (“Mabshi-o-Manush”; meaning “Land and People”). He has received no training in tilapia seed production and is unaware of the reduced fecundity of tilapia broodstock after 2 years of use.

19 There are, however, some indications that new tilapia farmers are stocking tilapia with common carp and rohu (Labeo rohita) and fewer species in polyculture.

20 The recommended VOSD fertilization rates/ha/week were equivalent to 270 kg cow manure, 5.2 kg urea, and 6.9 kg of triple superphosphate (TSP). The recommended feeding rates were rice bran, wheat bran, and oil cake in a 1:1:1 ratio fed at 5% body weight for newly stocked 7.5–12.5 cm long fish for 1.5 months, 4% of body weight for the next 1.5 months, and 2–3% of body weight up to harvest. The average annual fertilization rates actually used were 3.1 t/ha of cow manure, 420 kg/ha of urea, and 520 kg/ha of TSP.
the rice bran to feed fish (84%), cattle (15%), and poultry (1%). About half (47%) of the respondents had enough rice bran to feed their fish, and most of the others (47%) reported buying rice bran for this purpose.

LIVELIHOOD ASSETS

Human Capital

The respondent households had an average family size of 6.3 persons, 52% male and 48% female. Ninety-two percent were Muslim and the others were Hindu. The respondents reported that 53% of their family members were 18-years old or more, and 32% attended school. Although primary education is compulsory in Bangladesh, not all children could attend school because of poverty. Children provided household labor and, in some cases, schooling costs were unaffordable. With the sole exception of a widow, all household heads were male. Only 6% of the household heads were 30-years old or younger, 83% were 31–50 years old, and the rest were more than 50-years old. Excluding the widow, spouses of household heads were generally younger than the household heads: 21% were 30 years old or younger, and 71% were 31–50 years. The educational status of household heads and their spouses is presented in Table 1.

Fish farming was not a full-time occupation or the sole source of income for the households. Among the household heads, the most important primary occupations were rice farming (32%) and self-employment in microenterprises (28%), compared with only 9% for fish farming. Fish farming was a significant secondary occupation for household heads (24%) after rice farming (33%). Nearly all the spouses were primarily homemakers and 94% of them reported fish farming as their secondary occupation. Table 2 presents the occupations of household heads and their spouses.

<table>
<thead>
<tr>
<th>Table 1: Educational Status of Respondent Household Heads and Their Spouses in Chandpur</th>
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<tbody>
<tr>
<td>Educational Status</td>
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<tr>
<td>(%) (n=100)</td>
</tr>
<tr>
<td>No Education</td>
</tr>
<tr>
<td>Primary (class 1–5)</td>
</tr>
<tr>
<td>Secondary (class 6–10)</td>
</tr>
<tr>
<td>SSC (class 10 pass)</td>
</tr>
<tr>
<td>HSC (class 12 pass)</td>
</tr>
<tr>
<td>Undergraduate, University/College</td>
</tr>
</tbody>
</table>

n = number of respondents, SSC = secondary school certificate, HSC = higher secondary certificate.

<table>
<thead>
<tr>
<th>Table 2: Occupations of Respondent Household Heads and Their Spouses in Chandpur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation/Source of Income</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Fish Farming</td>
</tr>
<tr>
<td>Rice Farming</td>
</tr>
<tr>
<td>Wage Labor</td>
</tr>
<tr>
<td>Carpenter</td>
</tr>
<tr>
<td>Office Worker</td>
</tr>
<tr>
<td>Vendor/Trader</td>
</tr>
<tr>
<td>Microenterprise</td>
</tr>
<tr>
<td>Rickshaw Driver</td>
</tr>
<tr>
<td>Capture Fishing</td>
</tr>
<tr>
<td>Working Abroad</td>
</tr>
<tr>
<td>Other Crops</td>
</tr>
<tr>
<td>Sharecropper</td>
</tr>
<tr>
<td>Livestock</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Homemaker</td>
</tr>
<tr>
<td>Remittances</td>
</tr>
<tr>
<td>School Teacher</td>
</tr>
<tr>
<td>Others</td>
</tr>
</tbody>
</table>

n = number of respondents.
The participating people were only recently formed into groups. They had relatively little prior experience in fish farming; only 4% had more than 5 years of experience. None of them considered that fish farming had ever placed their health at risk. Women and men shared many of the tasks associated with fish farming, although males did nearly all the harvesting and marketing and most of the grading of fish (Table 3).

**Natural Capital: Access to Land and Ponds**

Some respondents had no land; the maximum landholding was 0.8 ha. Thus, the groups comprised landless and marginal farmers. The number of ponds leased by each group was 2–9 with a mean of 3.4 ponds. Only 10% owned a pond. All groups had access to 1 ha of ponds (water surface area), which was the targeted lease size under the project. In general, the leased ponds had 1–18 owners, with an average of 5 owners per pond. Lease durations were 1–5 years with renewal options. Almost all the ponds were more than 10 years old and had previously been used for fish farming, but mainly only by stocking without fertilization or supplementary feeding. Groundwater was the main water source (84%), together with water from an irrigation canal (40%) and rainwater (16%). The ponds were perennial and the groups reported no conflicts over water.

All the respondent households had a small plot of homestead land; most had small ponds or ditches (77%) and a small area of agricultural land (76%). Few households had an orchard (12%) or fallow land (6%), and many (35%) leased land. The average area of owned land (excluding leased land) was only 0.21 ha. All these households cultivated 2–3 crops of rice per year, with yields averaging 4.5 t/ha/crop. Only 18% reported catching wild fish from their own ponds. However, 79% caught wild fish from elsewhere, although catches have reportedly decreased over the last 10 years.

**Social Capital**

The respondents were almost entirely local people, but only 21% of them were born in the village where they now resided: 72% were born in a different union within their upazila, and 5% from a different upazila within Chandpur. Only 2% came from a different district. All of the 79% who had moved to their present village had done so because of marriage.

The interviewed groups all had 10 members. Members of all groups met once per week, and also met members of other groups occasionally. All groups reported that other women in the area were interested in setting up a group. There were no major issues in the functioning of the groups and
only 4 identified specific problems in management. All groups received training on fish farming from VOSD for 3 days. In addition, 30% of the groups received 2 days of training from DOF, and 2% received a further 30 days of training from DOF. Nevertheless, the groups perceived that the training was inadequate. All groups reported that they met VOSD staff weekly, suggesting that formal training had been complemented with advisory services through regular visits and meetings. The survey indicated that 56% of the sampled groups received handouts of training material. Although the extension workers were predominantly male, none of the groups reported that it was as a problem to be advised by a male extension worker. A few women expressed reluctance to talk to male extension workers, but this situation was overcome with the help of women extension workers. Among the interviewed group members, 47% indicated that they would be willing to pay for good extension advice if it could significantly increase their fish harvest. Among those expressing a willingness to pay for extension, 74% indicated that they could pay the equivalent of Tk12,350/ha, and they were willing to pay for the advice with a portion of their harvest.

**Physical Capital and Access to Facilities**

All of the interviewed group members owned their homes, although none were well constructed. Two thirds (62%) were of wood and galvanized sheet metal, and the others of light natural materials (such as bamboo, rice straw, jute sticks, leaves, earth, and wood) with galvanized sheet metal. Major assets owned by group members were a radio (37%), a cassette player (24%), a television (15%), a fan (19%), and a sewing machine (8%) among household items; and a bicycle (39%), a boat (2%), and a rickshaw (2%) for transportation. Almost all had scavenging poultry (96%), a few had goats (5%), and 66% had a cow used for plowing and milk. Bullocks (9%) were not used for plowing, but for sale for meat during religious festivals. Most group members reported some difficulties in accessing facilities (Table 4).

All of the interviewed group members had access to a tubewell as their main source of drinking water (62% owned a tubewell, 12% partly owned one, and 24% used a community tubewell). Probably all wells had been arsenic tested—97% responded affirmatively and the others did not know if their wells had been tested—and 66% reported that their wells were arsenic free, while 29% reported contamination, and 5% were not aware of the results of testing. All individual group members had access to a toilet of generally inadequate sanitation. Fuels used for cooking included fuelwood (100%), rice straw (54%), jute sticks (50%), cow manure (28%), leaf litter (26%), and kerosene (2%).

### Financial Capital and Returns from Fish Farming

With about 175 ha of fishponds, the 175 groups harvested 756.7 t during November 2000–April 2003. These harvests were valued at Tk34.3 million at an average farm gate price of Tk45/kg. The cumulative total production, including estimated stocks remaining in the ponds as of April 2003, was 1,225 t valued at Tk55.5 million (about $1 million). The average annual yield was 3.7 t/ha, worth Tk170,000–180,000 at the farm gate. At 2002 constant prices, annual production costs would be Tk83,000/ha, including lease payments, inputs, hired labor, and harvesting costs. Net incomes of not less than Tk80,000/ha could be attained, providing minimum net returns of Tk8,000 per person, depending on the group size. With minimum required savings of Tk260/person/year, each member could gain a disposable income of up to Tk7,740/year, allowing increased spending on basic needs.

All the surveyed groups harvested fish four times per year, with increasing amounts harvested as the fish grew: the first harvest averaged 277 kg/ha, the second 492 kg/ha, third 683 kg/ha, and fourth 2,240 kg/ha (total 3,692 kg/ha/year).

**Table 4: Access to Facilities by Respondents in Chandpur (n=100)**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Very Difficult</th>
<th>Difficult</th>
<th>Neither Difficult</th>
<th>Easy</th>
<th>Very Easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>0</td>
<td>93</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Transportation</td>
<td>0</td>
<td>99</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Communication</td>
<td>97</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Medical</td>
<td>8</td>
<td>83</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electricity</td>
<td>16</td>
<td>74</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reliable Water Supply</td>
<td>0</td>
<td>27</td>
<td>73</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Toilet</td>
<td>1</td>
<td>22</td>
<td>76</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

n = number of respondents.

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21 These were probably of limited use to group members, many of whom had limited education. The two handouts were (i) a 30-page “Training Module on Fish Farming” with no illustrations; and (ii) a 32-page technical report “Fish Farming in Flood Control, Drainage and Irrigation Project Water Bodies, Command Area Development Project: Part-C (Fisheries).”

22 Among the respondents, 54% reported that they had access to a kacha (made of bamboo with a thatched shelter and inadequate drainage disposal), and 46% to a semi-pacca (made of wood/ galvanized metal with a squat plate over a pit latrine). None had access to a pacca (made of brick with a water seal squat plate).

These yields are comparable to those achieved among the top performers in Bangladesh. Only 2% of the groups harvested fish on their own, with the majority hiring a local harvesting team, and relying to a small extent on fish buyers. None experienced any major fish kill in the ponds. The vast majority of fish (94%) was sold; 4% were eaten by the household members, and the rest given away and for other use. The surveyed groups reported average gross earnings of Tk158,877, and net incomes of Tk82,818 per group, excluding the fish for their own consumption and other disposal.

The major constraints to the groups were inadequate technical knowledge (92%), lack of transport facilities (93%), poor road quality (93%), and inadequate credit (83%). The groups also perceived that they could produce more fish through better management (39%), more inputs (32%), and better fingerlings (29%). All groups intended to continue to farm fish, with 96% indicating that they would continue with their current operation, 3% intending to produce more fish, and 1% intending to increase the pond area. The groups quoted profitability as their primary reason for continuing to farm fish.

Each group borrowed Tk50,000 per year from VOSD for fish farming. Only 2% of the groups experienced difficulties in repaying the loan—because of lower than expected fish production during the first 3 months of the growing cycle. Weekly savings among the surveyed groups reached a mean of Tk81, reflecting a savings rate of Tk5–10/person/week. Overall, the groups indicated that the credit of Tk50,000 was not enough to cover all operating expenses, which included Tk25,000–30,000 spent annually for leasing ponds.

None of the groups felt that they could manage their fish farms without credit. They needed an average of Tk76,670/ha of working capital, which would take an average of 87 months to save. However, if sufficient working capital were available to the groups, all said they would be able to obtain their own fish seed, fertilizers, and feeds. This condition emphasizes the importance of access to credit, without which the groups would have stopped farming fish. Financial resources among the groups were generally minimal. Only 11% received remittances from family members, at a mean of Tk25,236 per year. All had savings, but only 20% could save from sources other than fish farming. Among the latter, additional savings amounted to a mean of Tk5,593 per year. Savings from fish farming were used for various purposes, including for children's education (50%), food purchase (44%), house improvement (40%), and health (39%).

Vulnerability, Coping Strategies, and Perceived Benefits

The surveyed group members faced a variety of crises (Table 5). The most serious were illnesses of household members, shortage of food, low production of rice, loss of livestock or poultry, and theft. When a household member becomes ill, the time and other resources required to care for this person reduce the household’s capacity to earn and often deplete their savings. The main coping strategies for crisis situations were taking a loan from friends, neighbors or relatives (90%), adjustments to meals (68%), consumption of low-cost food (28%), and sale of livestock (24%). Sampled group members reported that they faced food shortages for a certain period each year: from 1 month (27%), 2 months (57%), to 3–4 months (16%). Months with the largest incidence of food insecurity were June–August and December–February. All members said that they had consumed fish in the 7 days before being interviewed, as well as vegetables (98%), eggs (92%), fruit (82%), milk (51%), beef (34%), chicken (23%) and mutton (2%). However, the amounts consumed could not be easily determined.

The surveyed groups felt that aquaculture had improved their welfare in the context of food consumption (100%), home improvement (99%), children’s education (99%), clothes (87%), sanitation (46%), and increased access to health services (25%) and drinking water (12%). The same pattern was seen when the groups ranked the three most important benefits of fish farming (Table 6).

<table>
<thead>
<tr>
<th>Types of Crisis</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illness of Household Members</td>
<td>89</td>
</tr>
<tr>
<td>Shortage of Food</td>
<td>61</td>
</tr>
<tr>
<td>Poor Production of Rice</td>
<td>24</td>
</tr>
<tr>
<td>Loss of Livestock/Poultry</td>
<td>21</td>
</tr>
<tr>
<td>Theft</td>
<td>14</td>
</tr>
<tr>
<td>Excess Rain</td>
<td>9</td>
</tr>
<tr>
<td>Accident of Household Members</td>
<td>9</td>
</tr>
<tr>
<td>Death of Household Members</td>
<td>7</td>
</tr>
<tr>
<td>Dowry/Wedding</td>
<td>5</td>
</tr>
<tr>
<td>Wind Damage</td>
<td>4</td>
</tr>
<tr>
<td>Loss of Job</td>
<td>4</td>
</tr>
<tr>
<td>Loss of Land</td>
<td>4</td>
</tr>
<tr>
<td>Market Fluctuation of Farmed Produce</td>
<td>3</td>
</tr>
<tr>
<td>Loss of Assets to Powerful Person</td>
<td>2</td>
</tr>
<tr>
<td>Inter/Intra Community Conflict</td>
<td>1</td>
</tr>
<tr>
<td>Loss of Business</td>
<td>1</td>
</tr>
</tbody>
</table>

n = number of respondents.
overwhelmingly perceived that (i) their overall food and fish consumption had improved, (ii) they had gained from employment and cash incomes from fish farming, (iii) the natural resource conditions for fish farming had improved, (iv) they had acquired means to finance fish farming, (v) their housing conditions had improved, (vi) they had gained access to fish farming technology, (vii) there had been an increase in the adoption of fish farming technology, and (viii) their access to credit had improved. They were also optimistic for the future on these aspects.

MARKETS AND MARKETING AGENTS

The groups mostly sold fish locally at the village markets (81%) or at the upazila market. They sold fish mainly to local agents (57%) or wholesalers-assemblers (41%), with only 2% selling fish directly to a retailer. Because they sold relatively large amounts of fish, the groups wanted to sell directly to a wholesaler rather than to a local agent. Their most important reason for choosing a particular market outlet was convenience (76%), with price a relatively minor consideration (22%), as was cash payment (2%). Most of the groups (79%) claimed that they set the sales price of their fish, while buyers/traders determined the sales price for 21% of the groups. None had significant problems in selling fish; demand was high. The groups reported that they were, however, restricted from seeking other markets because of the distance (45%), inadequate transportation (34%), poor roads (17%), or time constraints (4%).

**Fish Traders.** At local markets, retail fish trading may be considered as a small business activity that does not provide a full-time occupation. Market agents and fish harvesters bring their fish from various villages to the traders (wholesalers and retailers) in market centers, and on occasions take small amounts of credit (dadon)\(^{24}\) from wholesalers to ensure a steady supply of fish from farmers. All 10 fish traders interviewed at Changerchar market in Chandpur were male, 25–40 years old. They had minimal education: 8 of them had less than 5 years of primary school and 2 had 6–10 years of school. Although the religion in the area is predominantly Muslim, half of these fish traders were Hindu. Their average family size was 6 persons, ranging from 4 to 9 persons. Household assets included a radio (9 traders), a cassette player (4), a television (3), and a fan (1). Fish trading was neither a full-time nor a primary occupation for most—only 2 said fish trading was their primary occupation—6 were farmers and 2 fish farmers. Half had been trading fish for more than 7 years, with a range of experience of 2–20 years. Although fish trading is not usually a full-time job, it takes place all year with a peak in November–February. Typically, fish traders sell their fish in the morning for about 4 hours, 7 days per week. The number of fish traders in the market ranged from 19 to 27 people. Farmed fish came mainly from the vicinity: 98% from fish farms and 2% from capture fisheries.

\(^{24}\) *Dadon* is a system of tied credit through which fish traders advance money to the agents in exchange for assured supply of fish.
The fish traders handled 35–45 kg of fish a day, selling them to customers on the same day. In fact, all transactions, from harvests to fish traders and final consumers, normally took place within a day. Depending on fish species, fish traders sold their fish at average prices of Tk64/kg. Fish traders earned net incomes of about Tk170/day; their main expenses were hired labor, transportation, ice, electricity, and shop rental at the market. They typically operated with little working capital, Tk10,000–20,000, and their sources of capital included informal loans from friends or relatives, savings, and sales of personal assets. All fish traders employed wage laborers, with an average of 2 laborers per trader. Major problems reported by the fish traders included transportation (6) and ice supply (4). However, they all felt that trading fish had improved their welfare through increased food security, children’s education, clothing, and housing.

Fish Seed Traders. Seed traders maintain a strong network and relations with client farmers and owners of hatcheries and nurseries, providing a critical link between seed producers and fish farmers. The 10 seed traders interviewed had very little working capital, Tk2,000–5,000. They often took short-term renewable loans of several days from hatchery owners instead of paying cash each time they obtained seed from the hatcheries. They were all male, 32–45 years old, with little education: half had less than 5 years of primary schooling, and the remainder had generally less than 10 years. One was Hindu, and the rest Muslim. Family size was 4–10 people, with a mean of 5.2, and their household assets included a radio (10 traders), a fan (9), a television (7), and a cassette player (2). Only 1 sold fry as a primary occupation, while 5 were farmers, 3 were fish farmers, and the rest had other jobs. However, 9 reported fry trading as their secondary occupation.

Most traders had considerable experience trading fry, and 4 of them had more than 7 years experience. Their average length of experience was 7.1 years, with a range of 4–13 years. The peak fry-trading season was March–July, extending up to September and October because farmers practice multiple stocking. Fish seed mainly came from Comilla, Chandpur, and Laxipur districts, and was supplied by hatcheries and nurseries. Fry were transported on foot, bicycle, rickshaw, and pickup trucks. The volume of fry sold daily was 1,000–2,000 pieces per trader (average 1,360), at prices of Tk295–520 per 1,000 pieces depending on the fish species. Daily net incomes of these traders were Tk136–275. Fry traders reported two major problems: poor road and transport, and fry mortality due to elevated water temperature and from changing water. They reported fry mortality of 2–10% during transportation. All fry traders reported that seed trading had improved their socioeconomic conditions.

Fish Harvesters. Fish farmers do not generally harvest their own fishponds, but rely on fish harvesters. The 10 fish harvesters interviewed were Muslim men, 25–40 years of age, with low levels of education: only 2 had more than 5 years of schooling. Their family size was 3–5 members. Nine of them had a radio, 6 had a fan, and 2 a cassette player; none had a television. Seven reported harvesting fish as their primary occupation, and the other 3 as a secondary occupation.

The fish harvesters interviewed had an average length of experience of 5.2 years, range 3–10 years. They worked year round, with a peak in October–January. Harvesting usually took place in the morning before noon. On average, the harvesters did 1–2 harvests per week. They employed 6–8 laborers in a harvesting team. The gross income was 8–12% of the fish value per harvest. Daily net income of fish harvesters, after paying for labor, fishnet rental, repairs, and fishnet transport, was
They reported two major constraints to their activities: poor access to transportation (6 traders) and a high fishnet rental cost (4). Nevertheless, they all said that their occupation had improved their socioeconomic conditions.

**CONCLUSIONS**

Fish farming brought profits, generated cash, and significantly improved households’ incomes among the 175 groups surveyed, at a scale of production that represented a sizable contribution to the local rural economy. Marketable fish could easily reach 650 t annually with farm gate value of Tk29.3 million (more than $0.5 million), providing direct employment to 2,590 group members, and spinning off employment benefits to seed traders, small-scale input suppliers, fish harvesters, and market intermediaries. Fish marketing activities through various intermediaries to final consumers added 100% to the farm gate value of the fish and provided significant self-employment opportunities to market intermediaries and their wage laborers.

The project initiatives benefited the poor, primarily disadvantaged women who were not heads of households. These spouses, nearly all homemakers, could not have earned their own incomes if they had not been assisted by the project. The major barriers to women for seeking other employment included social barriers (45%), household work responsibilities (34%), and inability to work physically as wage laborer (7%).

Fish farming significantly empowered the women group members, providing them with lucrative opportunities in pursuing income-generating activities and allowing them to play a significant shared role with men in social and cultural contexts normally dominated by men. Group members gained skills and confidence in operating and maintaining fish farms, including skills in marketing.

The project helped the disadvantaged poor by overcoming barriers and providing access to opportunities. The key channels by which the poor benefited from fish farming were primarily through accessing livelihood assets, extension/advisory services, and markets.

The project developed human and social capital in skill acquisition, promoting confidence building, and establishing groups and motivating them. The project also helped the groups in accessing land and water (fishponds) by securing renewable lease arrangements. Without these leases, the disadvantaged poor would not have had access to fishponds.

Limited financial capital was another barrier for the poor. Microcredit helped them access working capital to complement their meager resources. Without credit and the NGO advisory services that accompanied this credit, the poor would not have been able to start and sustain their fish farms. Although the group members started saving a portion of their incomes, their savings alone would not be able to replace their reliance on credit. The groups indicated that it would take them on average more than 7 years to save enough working capital (an average of Tk76,670/ha). Thus, the continuation of access to credit with affordable terms and conditions is one of the key channels for enabling the poor to engage in small-scale aquaculture.

Access to markets, for input supplies and fish, made fish farming feasible and profitable. Although access to facilities and infrastructure (road, transportation, and water supply) was not optimal, the existing facilities were sufficient to make fish farming feasible. Rainfall, the use of wells, and water retention in ponds enabled farmers to farm fish all year round in Matlab Upazila. With high demand for fish, the harvested fish were mostly sold in local village and upazila markets. Thus, fish farming contributed to local food security.

Considerable project support was required and mobilized to develop the requisite human and social capital of the fish farming groups. The use of a local NGO familiar with the social dimensions of poverty affecting the area, was instrumental to the positive outcomes to date. Coupled with microfinance services, capacity building with practical training in aquaculture for the groups in the context of feasible income-generating initiatives provided a breakthrough in providing self-help employment opportunities for the disadvantaged.
CASE STUDY 3
LIVELIHOOD PROFILES OF FISH FARMERS IN KISHOREGANJ, BANGLADESH

BACKGROUND

Scope and Purpose

This case study examined livelihood conditions of fish farmers in Kishoreganj, a district in the Greater Mymensingh area receiving Asian Development Bank (ADB) support for aquaculture during 1988–1997. The study used primary and secondary data and published information to document the human, social, natural, physical, and financial capital available to the poor involved in the production and consumption of freshwater farmed fish, and to identify various channels through which the poor can benefit, such as through access to livelihood assets, markets and prices, and services and facilities. This case study was designed to highlight the operating environment of small-scale fish farmers in rural Bangladesh and their livelihood profiles.¹

Relevance

Freshwater aquaculture plays an important role in rural livelihoods in Bangladesh. Fish account for 60–80% of the animal protein consumed by the population and also provide essential vitamins, minerals, and fatty acids. Freshwater aquaculture, primarily the farming of carps, provides more than one third of the total fisheries production in Bangladesh. Traditionally, much farmed fish came from ponds constructed as borrow pits, dug to raise the level of land for village homesteads and roads. Most of the country is deltaic and a large portion of the land is inundated in the monsoon season. There has been a dramatic increase in freshwater aquaculture production from 123,800

metric tons (t) in 1986 to 850,000 t in 2002. Of present production, 80% come from the polyculture of Indian, Chinese, common, and other carps in ponds.\(^2\) The population of Bangladesh is rapidly increasing and domestic demand for fish is continuing to rise. With the growing importance of freshwater aquaculture, ditches that were formerly flooded seasonally have been converted into perennial ponds through deepening and expansion in area.

Kishoreganj was one of the 22 districts targeted by the Department of Fisheries (DOF) during 1988–1997 under the ADB-financed Second Aquaculture Development Project for the dissemination of improved fish culture practices, using semi-intensive carp polyculture pond technology, through the establishment of demonstration fishponds and farmer-to-farmer contact.\(^3\) Kishoreganj District, in the Greater Mymensingh area, has a population of 2.5 million, with a land area of 2,689 square kilometers covering 13 upazilas, 105 unions, 1,774 villages, and 4 towns.\(^4\) There were more than 254,000 farm households in 1996, comprising 61% of the total households in the district.\(^5\) Of these farm households, 81% were categorized as small farms with landholding of less than 1 hectare (ha). In 2000, fishponds in Kishoreganj had a total area of 3,771 ha and an estimated production of 13,089 t.\(^6\) Kishoreganj has benefited from the Mymensingh Aquaculture Extension Project (MAEP) financed by Danish International Development Assistance.\(^7\) Small-scale freshwater pond aquaculture has also benefited from sustained efforts of extension services through various development projects funded by the Government, bilateral agencies, and multilateral organizations in collaboration with DOF. Aquaculture development initiatives in the Greater Mymensingh area have focused on the dissemination of technology for fish seed\(^8\) production and growout.\(^9\)

**METHODS AND SOURCES**

The study was based on a survey of fish farming households, secondary data, and key informant interviews with farmers, fish traders, seed traders, and fish harvesters. The survey involved 100 fish farming households owning individually managed ponds. Household respondents were selected randomly from 3 upazilas (Bajitpur, Nikli, and Katiadi) where there had not been intensive extension support and which were typical of the Greater Mymensingh area where small-scale pond fish farming was practiced.\(^10\) In order to avoid bias due to direct assistance, the respondents were selected among those who had not been appointed by DOF as demonstration farmers or as extension contact agents. The survey, including the preparation and testing of questionnaires, took place in June–August 2003.

**FISH FARM OPERATION AND MANAGEMENT**

Most households, including those of marginal and small-scale farmers, have ponds. The former seasonal ditches have nearly all been converted into at least traditional extensive aquaculture by stocking them with the readily available fingerlings distributed by itinerant seed traders. In extensive farming, little pond management is undertaken following the stocking of fingerlings. However, fertilizers and supplementary feeds for pond culture are readily available. As a result of widespread promotion of improved pond management practices, fish farming has become generally semi-intensive with provision of nutritional inputs for stocked fish through pond fertilization and provision of supplementary feed. Fertilization of fishponds with cattle manure stimulates the growth of plankton in the water and of microorganisms and invertebrate animals on the bottom. The plankton and benthic organisms serve as food for filter-feeding carps and


\(^7\) Danish International Development Assistance has provided support to the DOF since 1977, commencing with the establishment of the Aquaculture Experiment Station, which was renamed the Freshwater Aquaculture Research Station, currently known as the Bangladesh Fisheries Research Institute (BFRI). The MAEP Phase I began in 1989 with the main objective of disseminating the BFRI research results to the Greater Mymensingh area as a means of increasing fish production and reducing poverty. MAEP Phase 2 started in July 1993, and a consolidation phase was carried out during July 2000–December 2003.

\(^8\) In Bangladesh, fish seed is categorized and named according to size. Fish fry are defined as juvenile fish, larger than newly hatched fish (locally known as hatchlings) but smaller than fingerlings, which are defined as juvenile fish normally longer than 2.5 cm.

\(^9\) The farming of fish seed to marketable size is called growout.

\(^10\) The rest of the upazilas were excluded from the survey for the following reasons: (i) Itna, Mithamoin, and Astragram were in floodplain areas with significant populations of wild fish and where pond fish culture was not common, and Kuliachar was not promising for pond aquaculture because of its sandy soil; and (ii) the remaining 6 upazilas had been receiving intensive extension and assistance from the MAEP since 1993.
Fish seed trader

bottom-feeding carps, respectively. Although manure has alternative uses as a fuel and a crop fertilizer, many villagers use it as a pond fertilizer because of the profitability of fish farming. Households generally own livestock that are fed on wayside vegetation, rice straw obtained from sharecropping, and other agricultural wastes. The most common supplementary feeds used in fishponds are rice bran and mustard oil cake, which are readily available on-farm or in local markets. In addition, grass carp (*Ctenopharyngodon idella*), a common component of polycultures of indigenous and alien carps, is commonly fed with on-farm vegetation such as grass, banana leaves, and duckweed.

In this study, extensive fishponds were found to produce 1.0–1.5 t/ha and semi-intensive ponds, 3–5 t/ha. Yields of 6–10 t/ha were achieved from semi-intensive culture with multiple stocking of fingerlings and multiple harvesting of fish throughout the year. With such high yields of fish production, farmers have increasingly sold fish as a cash crop, over and above their household consumption. The majority of fish farmers stocked their ponds from April to June and began harvesting some fish after 3 months, with subsequent harvests at intervals until the end of the year, thereby providing food and cash for the households for much of the year.

**Seed Supply.** At present, there is abundant carp seed supply in many parts of Bangladesh, including Kishoreganj, from a large number of hatcheries, and carp seed prices have declined in recent years. Nursing fish larvae to fingerlings is commonly carried out in small-scale household nurseries in villages, providing employment to owners and hired labor. Seed traders carry a few thousand fingerlings each in aluminum containers, traveling on foot, bicycle, bus, and train to reach their customers.¹¹

**Popularity of Carp Polyculture.** Of the 100 fish farming households included in this study, 98 (98%) were involved in carp polyculture, and 2% in the culture of a single species, the catfish pangas (*Pangasius hypophthalmus*). Only 11% said they were involved in other aquaculture activities and 7% nurser fry. Most (87%) were attracted to fish farming because of its profitability and almost half (48%) because it provided fish for household consumption (Table 1).

**Stocking Rates.** Fingerlings of up to 9 fish species were stocked at varying densities with a mean of 14,130 fingerlings/ha (Table 2).¹²

The size of fingerlings stocked varied. Only 17% of respondents stocked fingerlings shorter than 5 centimeters (cm). The majority (58%) stocked 5–7 cm fingerlings, and the others (25%) stocked fingerlings of 8–10 cm or larger. Most commonly

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¹¹ In the Greater Mymensingh area, carp seed prices at nurseries in 2003 were Tk0.10–0.15 per fingerling (4–5 cm long); seed traders sold these fingerlings to farmers at Tk0.20–0.25 each.

¹² The unit of account for land in Bangladesh is commonly expressed in decimals. 1 acre of land = 100 decimals; and 1 hectare (ha) = 2.47 acres.

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**Table 1: Reasons of Respondents in Kishoreganj for Farming Fish (n=100)**

<table>
<thead>
<tr>
<th>Influence</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profitability</td>
<td>87</td>
</tr>
<tr>
<td>Household Consumption of Fish</td>
<td>48</td>
</tr>
<tr>
<td>Availability of Fish Seed</td>
<td>3</td>
</tr>
<tr>
<td>Availability of Pond</td>
<td>1</td>
</tr>
<tr>
<td>No Other Income Source</td>
<td>1</td>
</tr>
</tbody>
</table>

*n = number of respondents.

**Table 2: Stocking Densities of Species by Respondents in Kishoreganj (number of fingerlings per hectare)**

<table>
<thead>
<tr>
<th>Species</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catla (<em>Catla catla</em>)</td>
<td>692</td>
</tr>
<tr>
<td>Mrigal (<em>Cirrhinus mrigala</em>)</td>
<td>2,124</td>
</tr>
<tr>
<td>Rohu (<em>Labeo rohita</em>)</td>
<td>2,690</td>
</tr>
<tr>
<td>Calbasu (<em>Labeo calbasu</em>)</td>
<td>2,470</td>
</tr>
<tr>
<td>Grass carp (<em>Ctenopharyngodon idella</em>)</td>
<td>1,383</td>
</tr>
<tr>
<td>Silver carp (<em>Hypophthalmichthys molitrix</em>)</td>
<td>3,384</td>
</tr>
<tr>
<td>Common carp (<em>Cyprinus carpio</em>)</td>
<td>1,778</td>
</tr>
<tr>
<td>Sarputi (<em>Barbodes gonionotus</em>)</td>
<td>2,149</td>
</tr>
<tr>
<td>Pangas (<em>Pangasius hypophthalmus</em>)</td>
<td>3,112</td>
</tr>
<tr>
<td>Total</td>
<td>14,130</td>
</tr>
</tbody>
</table>

---
(62%), ponds were stocked once per year, 15% of respondents stocked twice per year, 22% stocked three times per year, and 1% stocked five times per year. The length of the culture period was 9–12 months.

**Fertilizers and Feeds.** Nearly all the respondents (98%) used fertilizers in pond culture, mainly cow manure (87%) and urea (88%), but also poultry manure (15%) and triple superphosphate (59%) at varying frequencies. Supplementary feeds were used by 99% of the respondents, rice bran by all 100%, oil cake by 91%, banana leaves by 22%, grass by 21%, and wheat bran by 5%.14

**Frequency of Harvest.** Frequent partial harvests were practiced by 42% of the households. Three partial harvests per year were made by 34% of the respondents. Less common were harvesting once per year (6%), twice per year (15%), and four times per year (3%). Almost half of the respondents did not harvest fish by themselves. They hired local laborers specialized in harvesting. A few (8%) respondents reported that traders arranged fish harvesting for them and 2% had help from relatives.

**Perennial Ponds.** Although fishponds in Kishoreganj are popularly referred to as perennial ponds, 42% of the respondents reported that their ponds were either drained or dried up on some occasions. Among those who reported dry ponds, 74% said their ponds dried up during winter; the others (26%) pumped water out of their ponds. In terms of frequency of drying, only 5% experienced dry ponds every year for a limited period, 67% for a limited period every 2–3 years, and 28% every 4 years or more.

**Fish Yields and Incomes.** The productivity of fishponds of the surveyed farmers was high. The average extrapolated annual fishpond yield in this study was 3.1 t/ha. This is comparable to yields of fishponds in the Greater Mymensingh area, which averaged 3.3 t/ha in 2001.15 Almost all respondents practiced good pond management with high stocking rates because fingerlings, feeds, and fertilizers were readily available and accessible by the majority of farmers. The respondent farmers benefited from sales and consumption of fish (Table 3). In 2002, they received an average farm gate price of Tk39 per kilogram (kg), gross revenues of Tk9,500/household, and net incomes of Tk5,400/household from fish farming.

**Marketing.** The marketing chain for fish is short, with most of the farmers selling their fish locally, either in their own village or at an upazila market. Farmers sold their fish at the farm gate to collectors, wholesalers, and local agents, and at the village or upazila markets directly to consumers.

Most of the surveyed farmers (70%) did not sell directly to consumers, but dealt with market intermediaries. None of the surveyed farmers sold fish beyond their upazila because of distances, inconvenience, and transportation constraints.

**Alternative Uses of On-Farm Resources.** An important feature of the use of on-farm resources is their alternative uses. For example, farmers use cow manure for both aquaculture and agricultural crops. Two thirds of the respondents (69%) reported that they had enough cow manure for aquaculture, but only 4% purchased manure. Rice bran also has alternative competing uses. Nearly all the respondents (90%) milled their own rice and used the bran to feed fish as a primary use (89%); 11% used rice bran to feed their livestock as a primary use.

### Table 3: Disposal of Fish by Respondents in Kishoreganj

<table>
<thead>
<tr>
<th>Disposal</th>
<th>Mean (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Amount Sold as Reported by Respondents (n=100)</td>
<td>243.7</td>
</tr>
<tr>
<td>Annual Amount Consumed as Reported by Respondents (n=99)</td>
<td>56.0</td>
</tr>
</tbody>
</table>

*kg = kilogram, n = number of respondents.

---

13 On average, annual fertilization rates were 2.5 t of cow manure/ha, 570 kg/ha of poultry manure, 495 kg/ha of urea, and 320 kg/ha of triple superphosphate.

14 Annual feeding rates per ha were on average using 474 kg of rice bran, 536 kg wheat bran, and 665 kg of oil cake.

Multipurpose Ponds. All of the surveyed households used their fishponds for several other purposes: washing clothes (94%), bathing (87%), washing dishes (62%), livestock (21%), cooking (18%), and drinking water after filtering (1%). None used pond water for irrigating crops. There were few water-use conflicts.

Constraints and Risks. About half (54%) of the respondents believed that they could produce more fish mainly by improving pond management, using more inputs and better seed, and acquiring further knowledge of fish farming. One constraint was that they felt they had inadequate technical knowledge, despite the generally good performance of their fishponds (Table 4). There were no serious problems in feed supply, labor availability, water quality and supply, fish diseases, fish predation and mortality, or marketing. However, farmers faced constraints related to access to credit, transportation, access to ponds, and prices of inorganic fertilizers. The major risks were floods, cyclones, and theft. None of the respondents considered that fish farming posed any health risks.

**PROFILE OF SMALL-SCALE FISH FARMERS**

**Human Capital**

Nearly all (97%) the respondents were born in the village in which they currently resided, and most were Muslim (83%), the others being Hindu. Households were large, comprising an average of 7.1 family members with males and females in equal proportions. An average of 40% of family members were below 18-years old but only 19% of family members were in school. Although primary education is compulsory, not all children attend school. They often have to work in the home; for some households, schooling and its associated costs are unaffordable.

All the respondent household heads were male. Most (76%) were 31–50 years old; a few were younger (9%) or older (15%). Of the spouses, 42% were less than 30-years old, half (53%) were 31–50 years old, and 5% more than 50-years old. Overall, the educational status of the households was low, with a quarter of the household heads and fully two thirds of the spouses having no education (Table 5).

The most important primary occupations of the household heads, in terms of time spent, were rice farming\(^\text{16}\) and microenterprise; only a few respondents said that fish farming was their main occupation (Table 6). However, fish farming and rice farming were their two most important secondary occupations. Nearly all the spouses (94%)

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\(^{16}\) Nearly all respondents (93%) cultivated rice, with an average production of 4.4 t (unmilled) per crop per ha; 42% of these households grew one crop annually, and 58% grew two crops per year.
were homemakers and most (88%) had no other job; 5% were engaged in fish farming as a secondary occupation. The majority (66%) of respondents reported fish farming as the third most important source of household income.

Respondents had an average of 6.3 years of experience in fish farming: 14% reported up to 2 years of experience and 43% reported 3–5 years. Fish farming activities were almost entirely male dominated (Table 7), with women significantly involved in feeding the fish only.

### Natural Capital

Access to homestead land and water is critical. The surveyed households were either marginal farmers or small landholders with an average of 0.06 ha of homestead land and 0.11 ha of ponds or ditches. Most (88%) had agricultural land with an average area of 0.31 ha. Almost none (2%) had fallow land, and 12% of the households leased part of their land to others.

The majority of households (88%) had a single pond, and the remainder had 2 or 3 ponds. Most of the households acquired their ponds through inheritance (67%) or land reform (24%); other means were leasing (6%), purchase (2%), and dowry (1%). The average pond water surface area was 0.1 ha. The ponds were generally more than 10 years old (82%). While 68% of the respondents reported single ownership of ponds, 26% were co-owners under a multiple ownership arrangement, and 6% had use rights under lease arrangements. Annual leasing rates averaged about Tk25,700/ha, for periods of 1–5 years.

Respondent fish farmers relied on groundwater and rainfall. Although most of them did not report significant constraints related to water quality or supply, 40% said that seasonality influenced the availability of water for fish farming. The majority of respondents caught wild fish from their own ponds (69%) and elsewhere near their farm (79%).

### Social Capital

The surveyed farmers had not received help from DOF directly and all used local knowledge in their current fish farming practices, usually from other

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**Table 6: Occupations of Respondent Household Heads and Their Spouses, and Household Income Sources in Kishoreganj**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Household Head (n=100)</th>
<th>Spouse (n=99)</th>
<th>Household Income Source (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary (%)</td>
<td>Secondary (%)</td>
<td>Primary (%)</td>
</tr>
<tr>
<td>Fish Farming</td>
<td>6</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Rice Farming</td>
<td>38</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Sharecropper</td>
<td>2</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Livestock</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Wage Labor</td>
<td>7</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Carpenter</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Office Worker</td>
<td>7</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Vendor/Trader</td>
<td>4</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Microenterprise</td>
<td>21</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Rickshaw Driver</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Capture Fishing</td>
<td>8</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>School Teacher</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Boat operator</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other Crops</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Homemaker</td>
<td>0</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

n = number of respondents.

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**Table 7: Gender Roles of Respondents in Kishoreganj in Fish Farming Activities (n=100)**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Only Male (%)</th>
<th>Only Female (%)</th>
<th>Shared (%)</th>
<th>No Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond Preparation</td>
<td>90</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Fingerling Procurement</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feed Procurement</td>
<td>88</td>
<td>0</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Fertilizer Procurement</td>
<td>90</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Fertilization</td>
<td>85</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Feeding Fish</td>
<td>61</td>
<td>2</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>Harvesting Fish</td>
<td>99</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Grading Fish</td>
<td>93</td>
<td>0</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Marketing Fish</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

n = number of respondents.
Table 8: Sources of Information on Aquaculture of Respondents in Kishoreganj (n=100)

<table>
<thead>
<tr>
<th>Source of Information</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Farmers</td>
<td>90</td>
</tr>
<tr>
<td>Friends or Neighbors</td>
<td>40</td>
</tr>
<tr>
<td>Radio</td>
<td>20</td>
</tr>
<tr>
<td>Government Sources</td>
<td>9</td>
</tr>
<tr>
<td>Hatcheries</td>
<td>8</td>
</tr>
<tr>
<td>Printed Materials</td>
<td>7</td>
</tr>
<tr>
<td>Nongovernment Organizations</td>
<td>2</td>
</tr>
<tr>
<td>Seed Traders</td>
<td>2</td>
</tr>
</tbody>
</table>

n = number of respondents.

farmers and also from friends and neighbors (Table 8). However, the technology had been introduced into the area initially through projects, such as the MAEP and the ADB-financed Second Aquaculture Development Project. Diffusion of the information was clearly effective and this was because it was based on feasible, simple, low-cost ways to improve fish farming.

However, some (22%) of the respondent farmers had received training for up to 30 days on aquaculture, integrated farming, or livestock. Only 13% of the respondents were members of a village association, a government-sponsored association, or a nongovernment organization, but few of these associations were directly involved in the dissemination of fish farming technology. Thus, the demand for advice and information on fish farming technology was high. More than half (55%) of the respondents indicated their willingness to pay a modest amount in cash or in kind (a portion of their harvest), for advice that could increase their fish harvest.17

Physical Capital

All respondents reported owning their house or dwelling unit. The houses were basic and most were built with light materials, such as bamboo, rice straw, jute sticks, leaves, or earth, and usually wood and galvanized metal. The major assets owned by respondents were a radio (38%), bicycle (33%), boat (26%), television (14%), and fishing net (10%). Most (85%) had scavenging poultry, 70% had a cow for milk, and 22% had a bullock.

Most respondents reported some difficulties in accessing various facilities (Table 9), although a large number did not; however, none of them claimed that they had easy access to these facilities. For drinking water, virtually all (97%) had access to a tubewell as the main source of drinking water; the others depended on filtered water from ponds or rivers. All respondents had access to a toilet.18

Various sources of fuel were used for cooking, mainly wood (91%), rice straw (72%), and jute sticks (80%); and to a lesser extent, cow manure (35%) and leaf litter (22%). Only 3% used kerosene and 2% had electricity.

Financial Capital

Two thirds of the respondents (69%) relied on their own financial resources for operating fishponds. The others obtained an average of Tk6,000 credit from various sources including moneylenders, relatives, friends, nongovernment organizations, banks, cooperatives, and government-sponsored programs. Respondents quoted several reasons for not accessing financial assistance: some did not need it, while complex procedures was the main reason that others did not avail of credit (Table 10). Farmers frequently used credit obtained for fish farming for other purposes, including farming other crops and personal needs. This reflects the need for credit flexibility and fungibility. Among farmers who have used credit, 90% claimed that they had no problem in repaying their loans.

Less than half (42%) of the respondents reported accumulating savings; of those who did, the average savings were Tk1,750 per year from fish farming and Tk2,500 from other sources. Savings were used for various purposes, with many respondents spending their savings on basic needs (Table 11).

17 Fish farming households clearly appreciated the benefits that aquaculture had brought to their welfare. Privatization of extension services appears to be a feasible strategy to reach a large number of farmers and potential new entrant farmers in aquaculture. The MAEP recruited extension trainers locally with the intention that they would become private extension agents. A number of them operated privately, received payment in cash or in kind for their advisory services, shared crops with pond owners, or facilitated input supply and marketing of fish.

18 Access to toilet facilities comprised 46% to a kucha (made of bamboo with a thatched shelter and inadequate drainage disposal), 52% to a semi-pucca (made of wood/galvanized metal with a squat plate over a pit latrine) and 2% to a pucca (made of brick with a water seal squat plate). In rural Bangladesh, these sanitary features are often used as features in household wealth ranking.

Table 9: Access to Facilities by Respondents in Kishoreganj (n=100)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Very Difficult</th>
<th>Difficult</th>
<th>Neither Difficult nor Easy</th>
<th>Easy</th>
<th>Very Easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>51</td>
<td>41</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Medical</td>
<td>31</td>
<td>50</td>
<td>19</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Transportation</td>
<td>27</td>
<td>48</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electricity</td>
<td>17</td>
<td>59</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reliable Water Supply for Households</td>
<td>5</td>
<td>32</td>
<td>63</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Toilet</td>
<td>1</td>
<td>39</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

n = number of respondents.
Vulnerability and Coping Strategies

Many respondents were exposed to one or more crisis situations to which they were vulnerable (Table 12). The most serious were illnesses of household members, shortage of food, and damage due to floods, erosion, excess rain, and cyclones.

All of the surveyed households reported food shortages for varying periods each year: 1 month (16%), 2 months (54%), 3 months (24%), and 4 months (6%). Months with the greatest food deficit were June–August and November–January (Table 13), coinciding with crop-growing periods as well as social and religious events when households had major expenses.

The main coping strategies (Table 14) for overcoming crisis situations were loans from friends, neighbors, or relatives, adjustment to meals or reduced food intake, and sale of livestock.

Benefits from Fish Farming

Overall, the perceptions among the respondents of the benefits of fish farming were very optimistic.

Table 10: Major Reasons of Respondents in Kishoreganj for Not Acquiring Credit

<table>
<thead>
<tr>
<th>Reason</th>
<th>Respondents (n=69)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex Procedures</td>
<td>33</td>
</tr>
<tr>
<td>Do Not Require Credit</td>
<td>15</td>
</tr>
<tr>
<td>Credit is Unavailable</td>
<td>8</td>
</tr>
<tr>
<td>Unfavorable Interest Rates and Other Conditions</td>
<td>8</td>
</tr>
<tr>
<td>Do Not Know How to Acquire Credit</td>
<td>4</td>
</tr>
<tr>
<td>Fear of Misusing Credit</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>69</td>
</tr>
</tbody>
</table>

n = number of respondents.

Table 11: Utilization of Savings by Respondents in Kishoreganj (n=100)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children’s Education</td>
<td>34</td>
</tr>
<tr>
<td>Health Expenditures</td>
<td>31</td>
</tr>
<tr>
<td>Housing</td>
<td>26</td>
</tr>
<tr>
<td>Clothes</td>
<td>19</td>
</tr>
<tr>
<td>Land Purchase and Rental</td>
<td>19</td>
</tr>
<tr>
<td>Festivals and Social Obligations</td>
<td>5</td>
</tr>
<tr>
<td>Purchase of Livestock</td>
<td>3</td>
</tr>
<tr>
<td>Other Reasons</td>
<td>6</td>
</tr>
</tbody>
</table>

n = number of respondents.

Table 12: Crises of Respondents in Kishoreganj (n=100)

<table>
<thead>
<tr>
<th>Crisis</th>
<th>Households (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illness of Household Members</td>
<td>82</td>
</tr>
<tr>
<td>Shortage of Food</td>
<td>48</td>
</tr>
<tr>
<td>Flood Damage</td>
<td>32</td>
</tr>
<tr>
<td>Poor Production of Rice</td>
<td>29</td>
</tr>
<tr>
<td>River Bank Erosion</td>
<td>24</td>
</tr>
<tr>
<td>Cyclone or Wind Damage</td>
<td>21</td>
</tr>
<tr>
<td>Excess Rain</td>
<td>16</td>
</tr>
<tr>
<td>Loss of Employment</td>
<td>5</td>
</tr>
<tr>
<td>Theft</td>
<td>5</td>
</tr>
<tr>
<td>Loss of Land</td>
<td>5</td>
</tr>
<tr>
<td>Dowry</td>
<td>5</td>
</tr>
</tbody>
</table>

n = number of respondents.

Table 13: Months with Inadequate Food of Respondents in Kishoreganj (n=100)

<table>
<thead>
<tr>
<th>Month</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>18</td>
</tr>
<tr>
<td>February</td>
<td>9</td>
</tr>
<tr>
<td>March</td>
<td>1</td>
</tr>
<tr>
<td>April</td>
<td>1</td>
</tr>
<tr>
<td>May</td>
<td>9</td>
</tr>
<tr>
<td>June</td>
<td>41</td>
</tr>
<tr>
<td>July</td>
<td>34</td>
</tr>
<tr>
<td>August</td>
<td>28</td>
</tr>
<tr>
<td>September</td>
<td>11</td>
</tr>
<tr>
<td>October</td>
<td>6</td>
</tr>
<tr>
<td>November</td>
<td>34</td>
</tr>
<tr>
<td>December</td>
<td>30</td>
</tr>
</tbody>
</table>

n = number of respondents.

Table 14: Crisis Coping Strategies of Respondents in Kishoreganj (n=100)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans from Various Sources</td>
<td>79</td>
</tr>
<tr>
<td>Loans from Friends, Neighbors, and Relatives</td>
<td>64</td>
</tr>
<tr>
<td>Loans from Money Lenders</td>
<td>9</td>
</tr>
<tr>
<td>Loans from Nongovernment Organizations</td>
<td>1</td>
</tr>
<tr>
<td>Loans from Banks</td>
<td>5</td>
</tr>
<tr>
<td>Adjustment to Meals</td>
<td>62</td>
</tr>
<tr>
<td>Sold Poultry, Cows/Bullocks, and Small Livestock</td>
<td>32</td>
</tr>
<tr>
<td>Sold Crops before Harvest</td>
<td>16</td>
</tr>
<tr>
<td>Change of Occupation</td>
<td>13</td>
</tr>
<tr>
<td>Sold Trees</td>
<td>9</td>
</tr>
<tr>
<td>Sold Agricultural Produce at Reduced or Low Prices</td>
<td>7</td>
</tr>
<tr>
<td>Sold or Rented Out Farmland</td>
<td>6</td>
</tr>
<tr>
<td>Sold Household Assets</td>
<td>4</td>
</tr>
<tr>
<td>Seasonal Migration</td>
<td>2</td>
</tr>
<tr>
<td>Pledged Labor</td>
<td>1</td>
</tr>
</tbody>
</table>

n = number of respondents.
of natural resources for fish farming had not declined, (iv) access to aquaculture technology had improved, and (v) the adoption of fish farming technology had increased. The respondents were optimistic about their future in fish farming and anticipated that they would continue to benefit from aquaculture.

The vast majority (90%) of the respondents said they would continue to farm fish; the others were undecided. Primary reasons for continuing to farm fish were profitability, household consumption, and employment generation. Household consumption of fish among farm households was high. All respondents reported consuming fish an average of 5 times per week, far exceeding the frequency of consumption of other animal protein of less than once per week. Those who were undecided about continuing to farm fish were concerned about potential conflict related to multiple pond ownership, inadequate knowledge, low profitability, and insufficient time for fish farming.
CASE STUDY 4
OVERVIEW OF FRESHWATER AQUACULTURE OF TILAPIA IN THE PHILIPPINES

BACKGROUND

This case study was undertaken to provide an overview of freshwater aquaculture of tilapia in the context of production, consumption, markets, prices, marketing channels, access to inputs, support services, and relevant lessons.1 The Philippines is an archipelago of 7,100 islands covering 299,735 square kilometers (km²), with a total coastline of approximately 17,460 km. The inland waters comprise brackish- and freshwater swamps and lakes, fishponds, rivers, and reservoirs (500 km²).2

Valued at P107 billion in 2001, the fisheries sector accounted for 2.3% of the Philippine gross domestic product (GDP) in that year. The sector employs directly or indirectly, at least one million Filipinos.3 Net exports of fish and fishery products in 2001 were valued at $443.5 million. In 2002, artisanal capture fisheries,4 commercial capture fisheries, and aquaculture contributed 29%, 31%, and 40%, respectively, to total fish production of 3.37 million metric tons (t). From 1991 to 2002, total fisheries production grew by 2.4% annually. Artisanal fisheries production declined during this period by 1.3% because of overfishing and environmental degradation, while commercial fisheries production grew by 2.9% from the opening of new fishing areas and new technologies. Over the same period, aquaculture grew by 6.2%, playing an increasingly important role in food security and livelihoods (Figure 1). Tilapia has gained wide acceptance among consumers, and dominates farmed freshwater fish production in the country, particularly in Region III (Central Luzon) and Region IV (Southern Tagalog).

Tilapias are native only to Africa and the Levant. There are no native species with comparable characteristics for aquaculture in the Philippines. The first tilapia introduced to the Philippines was the Mozambique tilapia (Oreochromis mossambicus), imported from Thailand in 1950.5 The Nile tilapia (O. niloticus) was first introduced to the Philippines in 1972 and rapidly gained popularity with farmers and consumers. It is now the main species of tilapia farmed in the Philippines and throughout tropical Asia and the Pacific and has been called an “aquatic chicken,” suitable for farming in diverse systems, from backyard ponds to large commercial ponds and cages.6

Figure 1: Aquaculture, and commercial and artisanal fisheries production in the Philippines, 1991–2002

1 N. Bestari and A. Morales undertook this country case study in collaboration with B. Karon and R. Pullin.
4 Artisanal fisheries in the Philippines are subsistence and small-scale fishing operations including the use of a boat of up to 3 gross tons displacement.
5 In common with all other stocks of this species that were then being tried for aquaculture in Asia and the Pacific, its origin was a population of only two females and three males, discovered in 1938 in an Indonesian coastal pond, probably introduced from East Africa by traders. All of these Asia-Pacific stocks of O. mossambicus subsequently performed poorly in aquaculture, probably in part because of this genetic history.
HISTORY

Substantial and continuous programs of freshwater aquaculture research and extension have been undertaken in the Philippines since 1972. Tilapia farming in fishponds and small-scale reservoirs developed mainly on irrigated and rainfed rice lands. Cage farming has been practiced since the 1970s in large and small lakes. Other fishponds (mostly for tilapia) have long been part of small-scale, mixed enterprise farms in the uplands and other remote areas. However, most freshwater aquaculture in the Philippines has developed as a specialized enterprise: with fish as a cash crop and not as a component of the kinds of integrated agriculture-aquaculture farming systems that have typified its history in much of Asia. Similarly, ricefish integrated farming has not prospered in the Philippines and its future prospects seem limited. Tilapia farming in the Philippines has been and remains a specialized enterprise, regardless of scale, while it retains an artisanal character.

The course of Philippine freshwater aquaculture history has followed that of Philippine agriculture. Developing-country agriculture can be classified into two types: green revolution and resource poor. The former is found in fertile “agricultural heartlands,” which are usually either irrigated or rainfed lowlands near major urban areas; for example, much of Central Luzon in the Philippines. The latter, usually abbreviated to CDR (complex, diverse, risk prone) agriculture, is found where farming systems are much more fragile; for example, much of the Philippine uplands. Philippine freshwater aquaculture and most tilapia pond farming have developed mainly in green revolution areas, not CDR areas. Freshwater aquaculture has demonstrated its importance in the former mainly for urban and rural fish supply, but has considerable underdeveloped potential for rural livelihoods and fish supply.

By the mid-1980s, more than 20 generations of Nile tilapia breeding in the Philippines had gone by with no systematic application of genetics to improve performance. Moreover, some stocks had interbred with the less desirable O. mossambicus. The International Center for Living Aquatic Resources Management (ICLARM), Manila, then incorporated the application of genetics in aquaculture as a major thrust of its strategic research.

7 This work was undertaken principally by the National Freshwater Fisheries Technology Center (NFTTC) of the Philippine Bureau of Fisheries and Aquatic Resources (BFAR), the Freshwater Aquaculture Center (FAC) of Central Luzon State University (CLSU), and the Southeast Asian Fisheries Development Center (SEAFDEC). Their programs laid the foundations of Philippine freshwater aquaculture and continue to support its expansion.

8 More than 20 years ago, small-scale integrated farming was considered to have potential in the Philippines and on-station research was carried out to determine guidelines and economics. None of the technologies developed was adopted to any significant extent, largely because of the high costs of keeping and feeding poultry and livestock in sufficient quantities to manure the ponds. Small-scale farmers also face difficulties in rearing poultry profitably in small numbers due to their inadequate economy of scale, the specialized nature of the business, constraints in accessing financial resources, and the competitiveness of the market. Some integrated farming of chickens, ducks, and pigs with tilapia is practiced in the Philippines (Guerrero 1997; footnote 6 (iii)), but is rare compared to intensive pond and cage farming with pelleted feeds.

9 Rice-fish integrated farming systems research and development have been pursued for decades by FAC/CLSU. Rice-fish farming in the narrow sense (i.e., raising fish and rice concurrently in ricefields to marketable or consumable size) has very limited prospects in green revolution areas, where even the nursing of tilapia fry to advanced fingerlings faces problems. A major thrust in current rice research is to reduce the amount and depth of water needed.


12 Integration of aquaculture has potential for small-scale farmers in resource-poor areas in the Philippines. Upland farmers in Quirino Province have derived ecological as well as economic benefits from using on-farm materials, such as rice bran, straw, and hulls; spoiled fruit and vegetables; and chopped leaves and livestock manure in pond culture. See: Prein, Mark, Roberto Oficial, Mary Anne Bimba, and Teresita Lopez. 2002. Aquaculture for Diversification of Small Farms within Forest Buffer Zone Management: An Example from the Uplands of Quirino Province, Philippines. In Rural Aquaculture, edited by Peter Edwards, David C. Little, and Harvey Demaine. Wallingford, UK: CABI Publishing. p. 97–109.

with national partners in the Philippines and in other tropical developing countries. From the late 1980s, the Asian Development Bank (ADB) and other donors contributed funds for this research on genetic improvement of farmed tilapias and dissemination of improved breeds. Many farmers in the Philippines gained rapid access to improved tilapia strains. Farmed tilapia production increased more than five-fold from 1981 to 2001, largely because of improved breeds, increased access to and availability of input supply and commercial feed, sustained technical support and extension, and cooperation among the government, the private sector, and national and international organizations. The rapid rise in farmed tilapia production has been enabled by an increasing demand for a relatively cheap fish for national food security, partly due to the decline in artisanal capture fisheries production over the last decade.

**PRODUCTION AND CONSUMPTION**

The Philippines Department of Agriculture has prepared a tilapia master plan; proposed directions for tilapia farming up to 2010; and identified strengths, weaknesses, opportunities, and threats. This master plan addresses strategic targets to meet projected long-term growth, identifying strategic actions to encourage stakeholder participation, and identifying and establishing mechanisms that optimize stakeholder cooperation, coordination, communications, and monitoring. By 2010, the Philippines aims to increase production of farmed tilapia to 250,000 t (from 122,000 t in 2002), reduce production costs, export tilapia, increase consumption of tilapia, and expand employment opportunities. While the Government’s program for fisheries and the master plan for tilapia have charted the development of tilapia farming in the Philippines, major challenges lie ahead to fulfilling these targets and increasing the relevance of tilapia farming for small-scale farmers and the poor.

**Production.** Based on production data of 1985–2001, the supply of tilapia in the Philippines is all produced domestically, about 79% from aquaculture and the remainder from inland fisheries. Total tilapia production in this period grew on average by 6% per annum while total tilapia aquaculture and total tilapia freshwater aquaculture production grew by 8.5% and 8.8%, respectively (Figure 2), the difference in total amounts being due to a small component of brackishwater tilapia aquaculture. In 2001, freshwater fishpond
d and cages accounted for 91.2% of the total tilapia aquaculture production of 106,618 t. The total farm gate value of all Philippine tilapia production in 2001 was P5.13 billion ($102 million) and tilapia ranked second among the major fish species farmed. Regions III (Central Luzon) and IV (Southern Tagalog) have been consistently the major production

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14 The development of genetically improved farmed tilapias (GIFT) through selective breeding was partly financed by ADB under TA 5279-REG: Genetic Improvement of Tilapia Species in Asia, for $475,000, approved on 8 March 1988. ADB also supported dissemination of GIFT through TA 5558-REG: Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA), for $600,000, approved on 14 December 1993. The institutional impacts of the GIFT project included the establishment in 1993 of the ICLARM (now the WorldFish Center)–coordinated International Network on Genetics in Aquaculture (INGA: http://www.worldfishcenter.org/inga), now comprising 13 developing country and 12 advanced research institutional members. In 1997, ICLARM, CSLU, and BFAR established the GIFT Foundation International Incorporated, a nonstock, nonprofit corporation that continues breeding research and seed supply with GIFT strains. In 1999, the GIFT Foundation International Incorporated assigned to Genomar ASA (www.genomar.com) the commercial rights and brand name of the GIFT Super Tilapia through a public-private partnership. The DEGITA project distributed GIFT strain tilapias to Bangladesh, People’s Republic of China, Philippines, Thailand, and Viet Nam, with on-station and on-farm evaluation of their performance.


16 The Tilapia Masterplan was prepared by the Philippines Department of Agriculture. January 2002. This master plan is featured in the objectives of a new trade association, Philippine Tilapia, Inc., founded in 2003.


19 Region III (Central Luzon) comprises the provinces of Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac, and Zambales. Region IV (Southern Tagalog) comprises the provinces of Batangas, Cavite, Laguna, Marinduque, Mindoro, Palawan, Quezon, Rizal, and Romblon.
areas, contributing 48.4% (51,595 t) and 31.2% (33,297 t) of total farmed tilapia production, respectively, in 2001.

Tilapia production is characterized by lean and peak production periods. Production is highest during the second quarter of the year because farmers time their harvests to coincide with local fiestas and religious events (especially Lent and Holy Week). During Lent and Holy Week most Filipinos abstain from eating meat and demand for fish is high. Production is lowest in the third quarter when there is greatest risk of typhoons in areas within the typhoon belt. These include the main tilapia farming areas, regions III and IV.

Seasonality of production has an impact on tilapia market price. Generally, prices are higher during lean months and lower during peak months. However, an analysis of the production trends and price variations indicates that tilapia prices in nominal terms have increased in times of increasing total supply, partly because of rising costs of feed, which represents 70–80% of total variable production costs. Tilapia prices also depend on the seasonality of demand for tilapia. For instance, a high demand for tilapia and fish products during the second quarter of the year leads to higher tilapia prices for farmers.20

Consumption. Fish is an important component of the Filipino diet and a valuable source of animal protein and other nutrients. The per capita consumption of fish and fish products amounted to 36 kg/year in 1993, based on data from the Food and Nutrition Research Institute of the Philippines. Most consumption is of marine fish. Among the freshwater fish, tilapia is dominant and its per capita consumption increased from an average of 0.66 kg/year (1979–1988) to an average of 1.61 kg/year (1989–1997), an increase of 144.5%. During the same period, round scad (Decapterus spp.) consumption increased by 24.9% and milkfish (Chanos chanos) consumption declined by 12.5%.21 Consumer acceptance of tilapia has increased its share of total fish consumption.

PRICES, MARGINS, ELASTICITY, AND FARM INCOMES

Prices. The average nominal wholesale price of tilapia during 1985–2001 was P34.16/kg. Prices grew on average by 8.3%/year and more than doubled (2.5 times) over the period. The average retail price for tilapia during 1985-2001 was P45.47/kg, an average annual growth of 6.9%. While tilapia prices have increased in nominal terms, they have declined in real terms.22 Wholesale and retail real prices annually declined by 2.8% and 4.3%, respectively, in constant 2001 prices (Figure 3). This means that wholesale and retail prices of tilapia fell 44% and 69%, respectively, over the 17-year period. Tilapia has become more affordable for the poor. In 1997–2001, the average wholesale price/kg of tilapia (P45.4) was lower than that of milkfish (P63.4) but higher than that of round scad (P38.5). Average retail prices of tilapia, milkfish, and round scad were P60.9, P71.5, and P52.0, respectively, during the same period.

Margins. The average nominal (nominal and real prices) marketing margin between wholesale and retail for tilapia in 1985–2001 was P11.3/kg.23 In terms of 2001 constant prices, the average marketing margin was P13.7/kg. The high margin for the period is attributed to abundant supply that drove down wholesale prices in some years but did not dampen retail prices as much. The high margins obtained from tilapia trading, especially during the late 1980s, attracted the free entry of

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20 For example, average tilapia prices were highest (P41.74/kg) during the 2nd quarter in 1993–1997, relative to the other 3 quarters. During the same period, average tilapia prices were lowest in the 3rd quarter, despite that quarter having the lowest quarterly production (16.45%). The same relationships are reflected using seasonal indexes of production and prices (see Olalo 2001, footnote 17).

21 The milkfish, locally called bangus, has been traditionally the most popular and widely farmed freshwater fish in the Philippines. Round scads (Decapterus spp.), locally called galunggong, have been traditionally the most popular and affordable marine fish for the poor.

22 Real or constant prices are determined after the effects of inflation have been eliminated. Nominal prices refer to the current value of a good or commodity during a particular period or year.

23 The marketing margin is the difference between wholesale and retail prices. The scarcity of ex-farm price data precluded computations on grower-wholesaler margins. Nonetheless, interviews with tilapia wholesalers indicated an average margin of P2.5/kg between wholesale and farm gate prices in 2001.
additional tilapia traders and producers, making the market more competitive. However, during 1997–2001, marketing margins declined annually by 1% and 7% in nominal and real terms, respectively. Market competitiveness led to the exit of inefficient traders as margins fell. The decline in marketing margins in real terms in 1997–2001 was also attributable to improved access to facilities and competitive marketing practices, which reduced marketing costs. Low-income consumers are expected to benefit more as increased market competition leads to lower market prices for tilapia.

**Elasticity.** Demand and supply elasticities of fishery products, including tilapia, indicate the responsiveness of supply or demand to price changes. Tilapia has a supply elasticity of 0.5–0.6, which indicates that a 10% increase in the price of tilapia translates into a 5–6% increase in market supply. For demand elasticities, latest estimates range from 1.24 for the lowest-income group to 0.99 for high-income groups. This implies that lower-income groups tend to respond disproportionately to price changes. For example, a 10% decrease in tilapia prices should increase its consumption by low-income groups by 12.4%. The demand for tilapia also responds to income changes. Income elasticity estimates indicate a shift from elastic for low- to middle-income groups to inelastic for higher-income groups. This implies that increases in incomes of low- to middle-income consumers would trigger higher rates of change in tilapia consumption than would similar increases in income of high-income consumers.

Price changes of other products that can either be complements or substitutes also affect tilapia consumption. Two products are considered as complements if the consumption of one product will not lead to a reduction in the consumption of the other product. In contrast, substitute goods exhibit an inverse relationship. Tilapia prices are generally lower if there is an abundant supply of popular low-priced marine fish in the market, particularly of those species considered as its substitutes. Likewise, if the prices of meat and poultry products change, tilapia prices will adjust depending on their price relationships with meat products. Available data indicate that round scad, milkfish, pork, beef, and poultry are tilapia substitutes. The demand for tilapia responds more to price changes of round scad (2.24) than to price changes of beef (1.13) and poultry (1.07), respectively. For example, a 10% increase in beef prices should result in an increase in demand or consumption of tilapia of 11.3%.

**Farm Yields and Incomes.** The national average annual yields of tilapia in freshwater ponds and cages in 2002 were 4.5 tons per hectare (t/ha) and 15.8 t/ha, respectively. Surveys conducted for the present study indicated that a 1-ha

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25 The study “Analysis of Fish Demand in the Philippines” was conducted by Dr. Yolanda T. Garcia, Dr. Madan Dey, and Ms. Sheryl M. Navarez as part of the Philippine Component of ADB TA 5945: Study on Strategies and Options for Increasing and Sustaining Fisheries and Aquaculture Production to Benefit Poor Households in Asia, for $1.1 million, approved on 17 October 2000. Using results of the Family Income and Expenditure Survey (2000), the study utilized quintiles to classify income groups. The first 2 quintiles refer to low-income households, the next 2 quintiles refer to middle-income households, and the fifth quintile refers to high-income households.

26 Based on regression results, a positive coefficient implies that the two products are substitutes. A negative coefficient means that they are complements.


pond in Central Luzon can generate an average annual net income of ₱235,000 over 2 crops; a fish cage (measuring 10 meters [m] x 10 m x 6–8 m deep) can generate an average annual net income of ₱58,000 (based on 2 crop cycles and yields of 3 t/crop). Average operating expenses per crop cycle were ₱213,000/ha for freshwater ponds and ₱1,021,000/cage.

ACCESSING INPUTS FOR TILAPIA FARMING

Seed Supply. Tilapia seed, i.e., fry and fingerlings, is raised from captive broodstock in hatcheries and nurseries, respectively, often on the same premises. Seed supply is critical for the continuity of the production cycle, normally 2 or 3 crops each year. Tilapia hatcheries and nurseries can be land- or lake-based. The former use ponds, tanks, and hapas (fine mesh net cages) in ponds, and the latter use hapas and cages in open waters. Seed suppliers can be categorized in various ways depending on the criteria used: size (small/backyard, medium, large) based on monthly seed production, and operator type (public, private, and private-public). Seed accounts for 11% and 18% of total operating costs for pond and cage operations, respectively. Based on latest estimates, there are more than 2,000 hatcheries and nurseries in the country. The Government’s program for fisheries for 2002–2004 emphasizes the importance of producing quality tilapia broodstock and fingerlings, including their genetic improvement, for improving and sustaining fish farming productivity.

Small-scale hatcheries and nurseries are usually located near the operator’s homestead. This enables close monitoring and the use of family labor. Broodstock are usually obtained from government or private hatcheries, although some small and medium-scale operators keep their own broodstock. Broodstock are replaced after 1–2 years. On average, hatcheries achieve 9–12 breeding cycles in a year. More advanced commercial operators achieve continuous and higher seed production by collecting eggs from female broodstock and rearing them in artificial incubators before the fry start to feed.

Tilapia seed production is year-round but has seasonal variations. In the typhoon belt, supply and demand for seed are low when there is high risk from typhoons. The productivity of the different sizes and types of hatchery and nursery operations is very variable and there are few reliable comparative data. Tilapia seed production has increased rapidly and continuously from area expansion and improved technology and management. This increased supply has created keen competition among private hatcheries and also between some private and government hatcheries.

Bureau of Fisheries and Aquatic Resources (BFAR) staff estimated total tilapia seed production in 2003 at about 1.02 billion: 900 million from private sources and 120 million from BFAR. Estimated potential demand is 2–3 billion seed, of which BFAR plans to supply about one third through affiliated and accredited private hatcheries. Government hatcheries are expected to remain important sources of seed amid the growing number of private and corporate hatcheries. The Government aims to improve food security through better technologies and increasing the entry of small-scale farmers to tilapia farming. Through BFAR, the Government will likely remain an adjunct supplier and a competitor to private seed producers to some extent. The continued presence of BFAR in the seed market will benefit small

29 The Philippine Bureau of Fisheries and Aquatic Resources (BFAR) uses a nationwide system of size (and, therefore, price) categories for its tilapia seed. Fry and fingerling sizes range from size 38 (up to 1-week old) to size 12 (about 7-weeks old). The code numbers used are actually based on the mesh sizes of the nets used to grade the fish. For example, “size 24” fry (individual weight 0.045–0.096 g) and “size 22” fry (0.129–0.145 g) cost ₱0.15–0.25, respectively, in 2000. “Size 17” fingerlings (0.468–1.200 g) and “size 14” fingerlings (1.30–2.96 g) cost ₱0.35–0.45. The prices apply to all BFAR strains released in 2000.


31 Sizes are either based on (i) the size of land: small, less than 3 ha; medium, 3–5 ha; and large, greater than 5 ha; or (ii) on monthly seed production: small, less than 1 million; medium, 1–5 million; and large, greater than 5 million.

32 Based on the results of the survey for this study.


34 Ginitunang Masaganang Ani for the Fisheries as cited in University of Asia and the Pacific. Food and Agriculture Monitor 18(6), June 2002.

35 Nile tilapias are sexually mature when they are 6-months old and are easy to breed in ponds, tanks, and hapas (fine mesh cages). After spawning, the fertilized eggs are immediately taken inside the female’s mouth and incubated there until they hatch, and thereafter until they become oikocerc larvae and then swim-up fry that eventually feed independently, no longer taking refuge in her mouth. All the tilapia species in genus Oreochromis exhibit this behavior. Artificial incubators enable mass production of fry of similar age and size.

36 See, for example: Bimbao, Gaspar, Ferdinand J. Paraguas, Madan M. Dey, and Ambar Eknath 2000. Socioeconomics and Production Efficiency of Tilapia Hatching Operations in the Philippines. Aquaculture Economics and Management 4(1–2):33–48. These authors considered the average production of fry or fingerlings from land-based operations to be ₱748,000 per ha per breeding cycle in 1996, yielding a net income of ₱119,288.

37 In 2002, the published production for farmed tilapia was 122,316 t. With 40% seed mortality and an average market size of 3–6 fish per kg, the tilapia production required at least 942 million tilapia seeds. This tilapia production does not include fish given away by farmers or used for their home consumption.
farmers by promoting hatchery development in various parts of the country. Although seed supply in remote areas is still problematic, efforts by BFAR have contributed to increased access and choices of seed supply among small-scale farmers. Government seed prices are competitive vis-à-vis other seed suppliers and do not undercut private seed suppliers.

Tilapia genetic improvement has become a highly dynamic and competitive field of research and private enterprise in the Philippines. Consequently, farmers now have access to a wide range of tilapia strains. Increasingly, the breeders of a given strain are entering into agreements with other hatcheries and farmers to become accredited seed suppliers and/or growers. In Central Luzon and Lake Taal, agreements are often accompanied by credit and technical advice as sales pitches to attract customer loyalty. During interviews, BFAR staff indicated that most Nile tilapia farmed in the Philippines now have genes that originated from the genetically improved farmed tilapia (GIFT), either as GIFT strains or as hybrids developed with some GIFT material (footnote 14). There is no standard strain nomenclature and no independent strain certification. The result is a confusing mixture of marketing claims. Small-scale farmers, however, are risk averse and hesitate to try new strains based solely on suppliers’ claims about performance.

Tilapia seed prices vary according to size, strain, and whether they are mixed sex (males and females) or sex-reversed tilapia (SRT) comprising 95–100% males. BFAR applies mandated prices for its accredited hatcheries and private hatcheries have their own set of prices. Higher prices are charged for SRT seed. The case studies of Central Luzon and Lake Taal (Philippines) suggest that the market share of SRT seed is significant: 45% of cage farmers and 62% of pond farmers interviewed have been using SRT. The BFAR GET strain and GST are the most popular strains. Aside from their performance, the popularity of these strains is attributed to the proximity of the suppliers of these strains to farms, the number of accredited suppliers of these strains, and the aggressive marketing and technical assistance provided by their respective accredited hatcheries.

Seed prices depend on supply and demand conditions. When seed production is high or demand is low, prices are lower and mortality allowances higher. This occurs mainly in private hatcheries attempting to dispose of their produce quickly because of space constraints and maintenance costs. Seed prices from government hatcheries have remained relatively stable. The Philippines Commission on Audit reviews proposed price increases, ensuring that any price change is based on cost recovery. Prices of mixed-sex seed from BFAR-accredited and other private hatcheries are usually P0.05–0.10 higher than government prices. Prices of SRT seed are higher due to added costs arising from the sex-reversal treatment. Some private hatcheries impose additional mark-up to cover the costs of delivery or transport, particularly for distant clients. Market competition and the increasing choice of strains are beneficial for small-scale operators in the long run because they receive competitive prices and technical services. However, small-scale farmers put a premium on the growth characteristics of strains, and seasonal price influences are secondary in the choice of tilapia strain.

Licensing and accreditation arrangements vary. BFAR distributes its GET EXCEL strain seed and broodstock to BFAR multiplier stations and to private hatcheries that are encouraged to breed their own fish and to feedback information and superior breeding material. Genomar Supreme Philippines, however, holds the eight current members of its Preferred Partner Hatchery Network to contracts that preclude the unauthorized breeding of strains other than its Genomar Supreme tilapia (GST) strain. In practice, restrictions on what recipient farmers or hatcheries do with any strain are almost impossible to enforce because most Nile tilapia strains are not distinguishable except by DNA or other biochemical markers.

The Genomar Supreme tilapia (GST) was developed from the GIFT Foundation’s strain G9. The BFAR strain (GET 2002 EXCEL) was developed by crossbreeding other farm stocks with BFAR GET 2000 (i.e., GIFT renamed by BFAR). FAC sells its own strain known variously as FAC-selected, FAST, and IDRC strain (acknowledging support from the International Development Research Centre of Canada).

Tilapias breed prolifically and males grow faster than females. These factors encourage use of monosex, all-male tilapia seed. Feeding sexually undifferentiated fry with feed containing methyltestosterone is the main method to produce “sex reversed” tilapia (SRT) seed. This is safe because there are no detectable hormone residues in the fish long before they reach harvestable size. An alternative approach, pioneered at the University of Wales Swansea, United Kingdom, with FAC/CLSU collaboration in 1991–1994, is called the “YY technology,” yielding “genetically male tilapia” (GMT) from broodstock that have YY sex chromosomes. Hormonal sex reversal is needed to develop the YY broodstock, but no hormone treatment is involved in the seed production phase. GMT have given mixed results on-farm, sometimes containing unacceptable numbers of females. GMT research and development are continuing. SRT and GMT describe seed production methods and are not strain names.

Based on interviews with government and private hatchery operators in the Central Luzon study area, sex reversal increases cost by at least P0.10–0.15 per fingerling. A size 22 fingerling that sells for P0.25 sells at P0.35–0.45 if it is sex reversed.

Based on the case studies of Central Luzon and Lake Taal (Philippines), BFAR GET (64%) and GST (28%) are the most popular strains used in Central Luzon. GST (42%) and “Niloticus” (a term for a local breed of unknown provenance) (19%) are the most popular in Lake Taal, Batangas.

Mortality allowances refer to the 10–15% additional fingerlings provided by seed suppliers to their buyers on top of the total volume purchased. The allowance is to cover seed mortality losses resulting from various factors, especially transport and handling.

The latest increase in government tilapia seed prices was in 2000, mandating a P0.05 increase across all sizes. In the 1980s, a size 22 fingerling cost P0.10. Its current price is P0.25.

The price of methyltestosterone, the hormone used for SRT, is P2,100–2,700 per 10 g, and 1 g treats about 66,000 fry. Sex reversal also incurs additional labor costs.
Marketing of fry and fingerlings is lucrative because there is high demand for seed. The major sources of seed are the hatcheries and nurseries in Nueva Ecija, Bulacan, Pampanga, and Laguna. These areas are also the final market destinations of seed, in addition to Batangas, Isabela, Bataan, and Camarines Sur. However, the archipelagic nature of the country poses a challenge for the seed market to expand nationwide, unless more hatcheries are established in remote islands and coastal provinces. The availability of and preference for marine fish over farmed fish among the population in coastal communities are also major factors constraining the expansion of freshwater tilapia farming.

The market channels for tilapia seed, although unorganized, are relatively short and simple, due to the high risks involved in selling the product. Normally, a hatchery operator sells directly to growout farmers, either through delivery or pick-up. Product delivery facilitates and strengthens seed supplier-farmer relationships. Seed quality is judged by growth rate, survival, uniformity of size at harvest and, for SRT seed, whether there is any breeding in the production stock from unwanted females. These factors largely determine seed suppliers' reputations and business positions. The main problems affecting the tilapia seed business are high seed and broodstock mortality, seasonality of markets, low seed prices, unfavorable weather conditions, collection of arrears, and non-payment among seed buyers.

A few hatchery and nursery operators use agents to increase sales, especially in remote areas. Others sell directly and employ agents at the same time. This practice is quite common among nursery operators in Batangas, who resort to intermediaries to buy fry from Laguna, which they nurse to fingerlings for sale to cage growout farmers in Lake Taal. Generally, agents obtain their incomes by a mark-up of P0.01–0.02 per fingerling or through pre-agreed commissions. Promotion of seed sales is usually by word of mouth and small business signs, particularly for small- and medium-scale operators. Among large-scale seed suppliers, printed materials, such as brochures and leaflets, signboards, and the maintenance of Internet sites are utilized for market promotion.

**Feeds for Tilapia Farms.** The case studies of Central Luzon and Lake Taal indicate that feeds accounted for 72% and 79% of total operating costs for pond and cage operations, respectively. The increasing share of feeds to total operating costs is attributed to feed price changes resulting from the escalating costs of feed ingredients. Feed prices are highly dependent on the costs of imported ingredients (especially fishmeal) and the availability of local ingredients (e.g., rice bran, copra). Reducing feed costs through better feed conversion ratios (FCR) is the key to increasing returns and staying competitive in tilapia farming. Better FCRRs may be achieved by increasing reliance on pond fertilization to generate natural feed for fish. As the amount of nutrition derived from natural food organisms in the pond increases, there is a corresponding reduction in the amount of artificial feed required.

Recognizing the high costs of feed inputs, farmers look for alternative ways of reducing feed costs. An alternative is the use of home-made feeds. Homemade feeds are rarely a feature of Philippine tilapia farming, except in resource-poor areas. On-farm feed manufacturing has not developed significantly because of the high cost and erratic supplies of raw materials, high capital requirements, and lack of equipment specifically designed for small-scale farmers. Moreover, feed

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46 Delivery is sometimes priced higher than pick-up, but in Central Luzon prices for delivery and pick-up sales are similar because suppliers usually pay for delivery costs. Most seed suppliers monitor their performance by ensuring that their clients’ farms and husbandry are suitable. This lessens the risk of claims for mortality replacements. Moreover, after-sales support is a good marketing strategy to enhance or maintain hatchery-farmer relationships and hatchery reputations. This is a common practice among medium- to large-scale hatcheries in Central Luzon.

47 For example, Central Luzon hatcheries use agents for seed sales to more distant areas in Luzon (e.g., Isabela and Zambales) that have good potential for tilapia farming because of increasing demand and suitability of the areas for tilapia production.


49 For pond and cage farming systems where tilapia growth is almost totally dependent on pelleted feeds, a typical FCR for current feeds, strains, and husbandry methods is about 1.5 (weight of feed given to unit weight of fish harvested). For well-fertilized ponds and for less intensive systems that use home-made feeds, FCRs vary and are about 1.2 or less.

mills receive 20–30% discounts for bulk purchase of ingredients. Because they pay cash, they get preferential treatment from traders when raw materials are in short supply.\textsuperscript{53}

The average costs of producing tilapia feed in 2003 were P13,000–17,000/t, of which 70–90% of costs were for imported feed ingredients, such as fishmeal, wheat, soya, vitamins, and minerals.\textsuperscript{52}

Theoretically, the large share of imported components is the primary reason why feed prices fluctuate—the depreciating value of the Philippine peso against foreign currencies\textsuperscript{53} has increased the domestic costs of imported ingredients of feeds. The distance and isolation of many small-scale farms also contributes to higher feed prices. Access to inputs is one of the major problems confronting small-scale farms.

Major feed mills produce feeds for livestock, poultry, fish, and shrimp. The growth of Philippine aquaculture has contributed to the expansion of the feed industry. By 1995, tilapia feeds comprised 47.3% (70,000 t) of the total national production of aquaculture feeds for aquaculture (148,000 t).\textsuperscript{54}

These tilapia feeds were mainly used in Luzon (87%), with Mindanao and Visayas accounting for 10% and 3%, respectively.

Tilapia feeds are usually sold in standard 25-kg polypropylene bags and have various forms and composition appropriate to the production cycle: starter mash and crumble for fry, and pellets (starter, grower, and finisher) for growout. Tilapia feed prices in 2003 were P15–23/kg.\textsuperscript{55} Feed prices depend on the type of feed and the manufacturer. Distributors and dealers generally impose a price margin of 4–6% for fish feeds. In general, because of differences in protein content, the prices of feeds used during the early stages of tilapia rearing (30–48% crude protein) are higher than those for subsequent stages of the crop cycle (25–44%). These crude protein levels may be higher than necessary and lowering them may lead to reduced feed prices.\textsuperscript{56}

Tilapia feeds are distributed and sold together with feeds for livestock and poultry by agricultural supply stores. Some large feed manufacturers have agreements with farmers and with those who finance tilapia farming for exclusive use of feeds, with favorable purchase and credit terms. Some feed companies are also involved in seed supply and growout in vertically integrated arrangements.

The marketing chain of aquaculture feeds is well organized. It starts with the feed manufacturer who distributes products either to a wholesaler or to an authorized area distributor. Wholesalers pass the products to dealers who have their own set of retailers for final distribution to end-users. Authorized dealers deal directly with farmers. Some major feed companies have their own distribution warehouses in key areas. In such cases, the company deals directly with large customers. Feed manufacturers provide sales incentives to wholesalers or dealers depending on the volume of their total sales. Promotional activities to boost feed sales are usually undertaken by the technical and sales agents of feed manufacturers, through sponsorship of community and industry activities, feed trials, and the distribution of promotional items like shirts, bags, pens, caps, and calendars.

**Fertilizers for Fishponds.** Organic and inorganic fertilizers are used as inputs for freshwater fishponds and play a critical role in enhancing production of natural food. The case study of Central Luzon indicated that fertilizers were frequently used only as a basal fertilizer during pond preparation, and were not routinely used during growout to continue production of natural food. This practice has not fully captured the potential of reducing feed costs through routine pond fertilization; fertilizers accounted for only about 4% of total variable costs. The most widely used organic fertilizer for ponds was chicken manure at P30–40 for a 50-kg bag. Livestock manure, mudpress (agricultural waste from sugar mills), and rice bran are also used but to a much lesser extent. Collection of manure from poultry and livestock on small-scale farms is seldom feasible because the animals scavenge to feed or they are not held in sufficient numbers to provide adequate manure. However, chicken manure is collected by large-scale, feedlot broiler and layer farms and is sold as a commercial product. The demand for chicken manure as an organic fertilizer for tilapia fishponds is relatively low.


\textsuperscript{52} Information provided by 5 major feed companies engaged in aquaculture feed production in the Philippines.

\textsuperscript{54} Two major feed companies reported a 25–29% increase in feed prices during 2001–2003 because of increasing costs of imported feed ingredients.

\textsuperscript{55} As of 2002, there were 55 feed mills producing feeds for aquaculture with a rated capacity of 8,114 t over an 8-hour operation. Aquaculture feedmills are concentrated in Region III (22), Region IV (7) and the National Capital Region (7). Collectively, these mills have a rated capacity of 7,140 t over an 8-hour operation.


high in Central Luzon because of the proximity of ponds to large poultry farms. There are only a few firms that process organic fertilizers and most farmers in Central Luzon prefer low-cost unprocessed organic fertilizers.57

The supply of inorganic fertilizers, including those used for tilapia farming, is usually adequate, and government support for the fertilizer industry is historically strong.58 Data from 2000–2001 reveal that at least half (51%) of the total annual inorganic fertilizer supply (2.32 million t) then used in the Philippines was imported. The most widely used inorganic fertilizers in tilapia production are urea (45–0–0), ammonium phosphate (16–20–0), and to some extent ammonium sulfate (21–0–0) and complete fertilizer/NPK (nitrogen-phosphorus-potassium; 14–14–14). In 1997–2001, the average shares59 of imported chemicals for the supply60 of fertilizers were 100% of urea, 7% of ammonium phosphate, 57% of ammonium sulfate, and 0.9% of NPK.

Inorganic fertilizer retail prices increased annually by 4.0–5.5% in 1985–2001. However, in real terms at 2001 constant prices, their retail prices declined by 6.7–7.6%, indicating that these fertilizers have become more affordable and accessible to small-scale and poor farmers (Figure 4). Progressive farmers have used a combination of organic and inorganic fertilizer in tilapia pond farming to reduce feed costs. Pond fertilization with reduced use of commercial pelleted feed could reduce feed costs, but lengthen the time taken for the fish to reach marketable size. Domestic prices of inorganic fertilizers are influenced by world prices and currency exchange rates; prices of organic fertilizers are more stable because they are locally produced. In 2003, prices for a 50-kg bag of inorganic fertilizer used for aquaculture were as follows: P551 for urea, P316 for ammonium sulfate, P466 for ammonium phosphate, and P477 for NPK. The deregulation of the fertilizer industry in 1986 encouraged the entry of more traders, allowing increased competition that reduced marketing margins and dampened retail prices.

While organic fertilizers are usually sold in the area where they are produced, the market channel for inorganic fertilizers originates with producers or importers who distribute them to their area distributors (wholesalers) through their regional or provincial sales offices. The distributors transfer the products to local dealers and retailers who sell directly to farmers. Hence, the presence of local dealers is important, particularly in isolated areas, to increase the access of farmers to fertilizer inputs. Akin to the feed industry, fertilizer companies advertise their products through sponsorship of related activities and the distribution of promotional items. However, there are intricacies in fertilizer marketing. A few importers are also distributors, giving them an added advantage in terms of direct access to retailers. At the wholesale level, some distributors are authorized dealers themselves and sell directly to plantations and/or farmers in areas where local dealers are absent, few, or relatively weak. In some cases, traders access cooperatives to distribute fertilizers to their farmer-members. However, the geographical isolation of most Philippine islands adds to marketing and distribution costs, although transportation through the use of inter-island vessels is widely available.

**Access to Land and Water.** Access to land is a prerequisite for hatcheries and pond farming. Small-scale fish farms have gained access to land either through private ownership or lease arrangements. Private lands are acquired either through direct purchase or inheritance. However, issues related to land-use rights and landownership are very complex and access to land is frequently made possible through lease arrangements or other schemes involving transfers of land-use rights under various terms and conditions. Under lease arrangements, farmers may either pay an annual rent or share net profits with landowners. In some cases, land-use rights are acquired in exchange for

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57 Processed organic fertilizers are products of composting mixtures of animal manures, agricultural wastes, and limestone and other nutrients. The selling price is usually 2–3 times that of chicken manure.

58 Government support was manifested through price controls and other cash and noncash incentives. This also explains why nominal price increases were limited.

59 Percentage shares were derived from production and import data from http://www.faidnap.org/philippines/.

60 The average annual quantities of fertilizer supplies in 1997–2001 were 610,073 t (urea), 405,941 t (21–0–0), 96,089 t (16–20–0), and 337,168 t (NPK).
an interest-free loan for a specific or indefinite period. In Central Luzon, annual land rental rates are P10,000–25,000/ha. The period of leased rights may be several years, depending on the agreement between the two parties. Land rentals are influenced by prevailing land prices and the opportunity costs of land. Access to land by small-scale landless farmers may severely decline as land prices and rental rates continue to rise. Rising land prices can also affect tilapia production if landowners sell their farms when faced with more lucrative options, instead of making their land available for rent.

In terms of water access, fishpond operators rely on deep wells, irrigation, rain, rivers and streams, and small water impoundments. For tilapia cage farming in lakes and reservoirs, the only requirements for access to land are the lakeshore and marginal lands from which services for the fish farms can be provided. There is also limited use of land for nursery ponds. In the Philippines, lake waters are state property, and cage operators gain access to these waters by leasing or obtaining a permit. However, certain conditions and restrictions may apply in accessing public or open water bodies, including preferences for people residing in certain locations in the vicinity of the designated water bodies. Such restrictions can exclude people who do not reside in the immediate vicinity of the water bodies, unless partnership arrangements are made between outsiders and local inhabitants.

**Labor and Employment.** Freshwater tilapia farming, including hatchery and nursery operations, provides opportunities for self-employment for operators and cage caretakers and their families. Backyard/small-scale pond and cage farms rely mainly on family labor. Larger farms employ regular full-time workers and seasonal or casual workers for pond preparation, stocking, and harvesting. Exchange labor from members of the local community is also used. Neighbors and other members of the community provide labor exchange (e.g., for pond preparation or harvesting) without financial payment. The pond or cage owner is expected to reciprocate the initiative by helping fellow farmers when needed. If the activity is harvesting, fish are normally given to reward those who participate. In rural areas, with limited employment opportunities and high unemployment, labor supply is abundant. Men, women, and even children assist in hatchery/nursery, pond, and cage operations. However, heavy physical tasks, such as pond construction, preparation, and harvesting remain male-dominated.

The total number of Filipinos directly or indirectly involved in freshwater aquaculture and specifically in tilapia farming is debatable because
there are no disaggregated statistics. Field observations indicate that much of the hired labor requirements are seasonal. The abundance of labor supply in rural areas means that workers often receive less than the legislated minimum wages. Work opportunities in aquaculture include full- and part-time employment in pond excavation, cage and net making, boat operation, services for cage farms, fish sorting and grading, marketing, transport, and miscellaneous activities. The employment impact is clearly seen in the local economies where tilapia is farmed. At least 280,000 people, including their families, directly and indirectly benefit from employment generated by the freshwater tilapia industry alone. This does not include additional full-time, part-time, and seasonal labor required by associated industries, such as tilapia feed processing and fertilizer and other supplies and their respective processing and distribution.

ACCESSING SUPPORT SERVICES

Credit, Financial Services, and Incentives. Small-scale operators usually rely on their limited household savings to finance tilapia operations. However, the long growing period before harvest and sales can strain household finance. Access to financial capital is generally a major constraint. Farmers usually avoid formal credit from commercial banks and private lending institutions because of high interest rates, paper work, and requirements for collateral. In addition, the risks of tilapia farming have often deterred small-scale farmers from attempting to obtain formal credit, fearing loss of property or collateral in the event of harvest failure. Many farmers resort to informal credit, which incurs high interest but is usually collateral free, readily available, and has flexible repayment terms. Informal loans may carry interest rates of 2.5–20.0% per month.

The dominance of informal credit over formal credit in tilapia farming is further emphasized by the emergence of informal credit schemes and other financial arrangements to overcome financial barriers facing tilapia production. These include financier-caretaker arrangements, trader-operator agreements (usually forward sales), contract farming, and various suppliers’ credit schemes. Financier-caretaker arrangements are prevalent in cage culture in Batangas, where the financier pays all operating expenses of the fish farms regardless of whether the financier owns or rents the cage. Under these arrangements, net profits are shared between both parties on agreed terms; caretakers absorb some of the operating risks because they receive no wages. In contrast, trader-operator arrangements are usually based on forward sales, characterized by loans extended by the trader to the operator on condition that the final produce will be sold to the trader exclusively. In the case of contract farming, farmers receive all inputs in advance except land and the final produce is sold to the contractor. Under suppliers’ credit schemes, input suppliers (usually feed suppliers) provide credit lines to farmers who pay for the inputs at harvest. Depending on pre-agreed conditions, input prices are usually higher than prevailing prices of the specific inputs to cover the cost of capital and the risks involved. Overall, these nonbank financial arrangements have benefited and enabled small-scale farmers to take advantage of the economic opportunities of tilapia farming.

The Philippine Government operates low-interest credit and financing programs for the fisheries sector, particularly aquaculture, to meet national food requirements and to improve farmers’ welfare. These credit programs have been channeled through commercial private and government-controlled financial institutions as well as nongovernment organizations. However, credit delivery along these channels mostly fails to reach the intended beneficiaries. Municipal agricultural officers and agricultural technicians find that many farmers are hesitant to apply for these credit schemes because of the paperwork required. The difficulties of forming groups to seek group credit and unawareness of available credit schemes, particularly among small-scale farmers, have also contributed to their low use of government credit schemes. Where farmers have enjoyed free or heavily subsidized farm inputs through government programs, they tend to develop dependency and expect to continue to receive government aid.

The Quedan Rural Credit and Guarantee Corporation (QUEDANCOR) is currently the executing agency for a government credit program for aquaculture that provides loans to farmers’ groups at an annual interest of 12%, including a 3% service fee. The system involves the creation of self-reliant teams, whose members are collectively responsible for loan repayment. Government fishery

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61 Past credit programs for fisheries and aquaculture were comprehensively discussed by Yap 1999. See footnote 10.

62 Under the Local Government Code of 1991, the responsibilities of facilitating national and local government programs were devolved to local/municipal agriculture staff, which include local agricultural officers and technicians.
loan programs implemented by QUEDANCOR have helped tilapia farming teams by providing loans in the form of farm inputs in kind. Reportedly, the repayment rate is higher than 98%. QUEDANCOR has also formulated special loan arrangements for tilapia contract growers targeting future exports. The Philippines' investment policy embodied in Executive Order 226, the Omnibus Investment Code of 1996, provides incentives for investments in the form of tax holidays, tax and duty exemptions on imported inputs and equipment, and tax credits for domestic inputs. The Code applies to tilapia production in the form of tax exemption, an incentive that has already been granted to a potential tilapia exporter in Region III.

**Extension Services.** Advisory services are critical to the success of tilapia operations, particularly for small-scale tilapia farmers who lack the necessary training and education. Fortunately, extension services for tilapia operations are virtually free. Most input suppliers, particularly seed and feed suppliers, provide such services as part of their marketing schemes. Furthermore, strong social networks facilitate technical information exchange and dissemination of knowledge among farmers. Government agencies also remain important sources of technical advice to small-scale farmers. BFAR, fishery-related agencies, and the agricultural officers and technicians of local government units provide free extension and advisory technical services to tilapia farmers—including small-scale farmers—complementing the advisory services provided by input suppliers. However, government budgetary constraints have limited the number of agricultural extension workers in rural areas.

**Fish Health Services.** BFAR provides fish health services and maintains a fish health division that addresses drug use in aquaculture and related concerns under existing national legislation. An ongoing but under-resourced national program on the use of drugs in aquaculture comprises the following: (i) monitoring the efficacy of drugs in treatment and prevention of diseases of farmed fish; (ii) testing fish feeds and produce for the presence and concentrations of prohibited and regulated drugs in the fish and human food chains; and (iii) monitoring the impacts of drugs on the environment. Irresponsible use of drugs in fish farming can lead to environmental contamination and the evolution of drug-resistant strains, not only of fish pathogens but also of human pathogens, because the same drugs are used in medicine and drug resistance may be transferred. Technically, the presence of prohibited drug residues in farmed fish disqualifies the fish from being exported.

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**MARKETING TILAPIA**

**Market Structure and Conduct.** Farmed tilapia is sold live, fresh, and, to a lesser extent, chilled or frozen. In practice, the nature of the product has shielded the domestic market from imports because of transportation and other transaction cost barriers. Tilapia harvesting is normally timed according to the preferred mode of sale and its marketing channel. For example, in Batangas, harvesting of tilapia from cages in Lake Taal for the Manila markets is done late in the morning or early afternoon, for fish delivery to coincide with the opening of urban wholesale markets in the early evening. Elsewhere, for fish intended for the markets of neighboring towns, pond and cage harvests start as early as midnight to reach final market destinations before dawn. Harvest time is crucial to pricing for two reasons. First, early arrival in the market provides better opportunities of ready sales and better prices, given a large number of customers and intermediaries who want to be assured of an early supply of fish. Second, the entry of more suppliers in the course of the day will tend to saturate supply, leading to lower prices. Some traders, particularly wholesalers, finance small-scale farmers in order to be assured of a steady supply of fish. Under this arrangement, the farmer is mandated

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63 Based on the presentation of QUEDANCOR officers during the 2nd Philippine Tilapia Congress, 13–14 November 2003. San Fernando, Pampanga, Philippines.

64 Republic Act 8550 (The Fisheries Code of 1998) is the main legal framework. More recent instruments include fisheries administrative orders 213 and 214, Series of 2001: Operation of the Fish Health laboratories and the Code of Practice for Aquaculture, respectively.

65 Examples are nitrofurans and chloramphenicol prohibited by the Department of Health and Department of Agriculture Joint Administrative Orders Nos. 2 and 60, respectively, series of 2001.

66 Tilapia is also sold in value-added forms, such as filleted and smoked. Tilapia fillets have potential for export, with one large commercial farm targeting an initial shipment of 5,000 t in 2003.
to sell exclusively to the trader at a pre-agreed price. Major marketing issues for tilapia include fluctuating prices, irregular supply, nonpayment of debts by traders, informal levies (particularly when transporting the product), and seasonal off-flavors that render the fish less marketable.

Buyer and seller concentration is high, particularly in Luzon. With the increasing popularity of tilapia, the number of tilapia traders has increased substantially. This is beneficial for small-scale farmers because it provides more market outlets for their produce. Entry and exit of traders to the tilapia market have been relatively easy, especially at the retail level. However, traders’ knowledge of the market is often poor. Some new entrants leave quickly after incurring losses, indicative of an unorganized and highly competitive market. For example, traders may trigger tilapia harvesting from many farms at the same time, causing seasonal excess supply and driving market prices down.

Figure 5 illustrates different marketing channels for tilapia in the Philippines. The most direct channel (1)—producer to consumer—is prevalent among small-scale or backyard farms where buyers, usually neighbors and community members, consume most farm produce at home. Here, marketing cost is almost nil when the buyer collects the fish at the farm, and minimal if the farmer is the ambulant vendor. Sales are for cash or on credit. Channels 2 and 3 are typical for small pond farms and for some small cage farms, selling by delivery to or pick-up by ambulant vendors, who sell fish around the locality or deliver to various market sites within the community or in neighboring towns and municipalities. In Central Luzon, ambulant vendors (wholesaler-retailers or retailers) with tricycles or jeeps buy tilapia from ponds. They usually pick up tilapia from early morning harvests and transport them as live fish to prolong product freshness, selling around town from aerated plastic or metal barrels and tanks that hold 30–150 kg of fish. Iced tilapia are delivered to wet markets in the community or in neighboring municipalities of Lake Taal from some of the cages there. Channel 4 involves brokers who initiate sales between the producers and clients. Brokers do not own the products that they handle. With many active traders and abundant tilapia supply, brokers make P0.5–1.0 per kg of fish sold, representing “viajeros,” i.e., wholesalers who transport tilapia in bulk to major market destinations. Brokering is typical in Central Luzon, particularly with traders who want an assured daily supply of fish.

Large fish markets (channel 5) facilitate trade among various entrepreneurs by offering physical facilities for product handling and negotiations. For tilapia, the large fish market serves as the venue where wholesaler-retailers and retailers

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**Figure 5:** Marketing channels for Philippine tilapia
procure their fish for resale. Large markets usually operate on a consignment basis because they earn a fixed commission of 5% of gross sales in exchange for the use of their facilities. Wholesalers or producers who use these market facilities are directly paid in cash. Small-scale farmers usually receive cash payments from wholesalers. Channel 6 is the most popular among tilapia farmers in the main production areas of Central Luzon and Batangas. Selling to wholesalers reduces farmers’ transaction costs and minimizes the risks of selling a perishable commodity. Wholesalers buy in bulk and usually pay in cash. A wholesaler’s choice of its own marketing channel greatly depends on marketing costs, distance, prevailing supply, and prices. Generally, for channels 4, 5 and 6, the wholesalers pay for harvesting costs, with pick-up at the farm gate as the preferred mode of sale.

An emerging channel (7) centers on the imminent entry of Philippine tilapia in the world market in fillet form. The channel is relatively simple: farm production goes directly to the exporter/processor who maintains contract schemes with a number of small-scale farmers to ensure a sufficient volume of tilapia for processing and export. The addition of this marketing channel can benefit small-scale farmers in two respects. First, they can group themselves and make contract agreements with a processor who is able to provide financing arrangements, including from government sources. Second, the prospect of entry to the export markets for tilapia can improve marketing opportunities for small-scale farmers.

**Pricing Strategies.** In tilapia marketing, the point of first sale is the farm gate where the producer and buyer agree on a certain price. The usual practice for tilapia marketing at the farm gate is to provide a price discount to bulk buyers. Wholesalers in Central Luzon and Batangas usually impose margins of P2–5/kg before the fish reach the next intermediary. Product differentiation and pricing are based on fish size. For example, in Batangas, there is an 8-level pricing scheme. The highest price (1st tier) is for tilapia of 0.5–1.0 kg each, and the lowest (8th tier) is for fish of about 100 grams each. After harvest, Batangas tilapia are sorted and loaded into 40-kg containers. In Central Luzon, there are 4–5 pricing levels at retail markets. However, farm gate sales in Central Luzon usually have a uniform price for a single harvest given the difficulty of sorting fish into aerated tanks. Further price differentiation occurs when the fish reach retail outlets. At retail markets, retailers resort to price reduction before the end of the day if tilapia remain unsold. In Central Luzon, a price premium of about P5/kg is applied to live tilapia over iced or chilled fish. Retailers generally apply a mark-up of P10–15/kg. A recent shift in consumer preference for live tilapia has led to the development of sales from aerated containers in markets and at the roadside.

**Marketing Investments.** Based on interviews with wholesalers and retailers in the provinces of Batangas, Pampanga, and Nueva Ecija, investments among wholesalers total P650,000 to P1.5 million. Tilapia traders’ investments include vehicles (tricycles, jeeps, or trucks) and equipment (containers, weighing scales, and sorting trays). Wholesalers’ operating expenses are mainly labor for harvests and delivery, fuel, ice, toll and parking fees, commissions, maintenance and repairs, and vehicle rental. Daily operating expenses, specifically for marketing tilapia intended for large fish markets in Metro Manila, are usually P4,000–

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67 Usually, a wholesaler has an established contact person at a specific market destination. Wholesalers prefer to deal with just a few individuals. For large wholesalers, the wholesaler-retailers are usually the next channels in bigger markets. Small wholesalers deal directly with retailers, especially if the destination market is small.

68 The QURDANCOR program has agreed to provide a higher loan limit (P170,000/ha/crop cycle) for farmers who are engaged in contract programs with the fillet exporter.

69 This practice, prevalent in Batangas and Central Luzon, involves the reduction of total purchase price by 5–10%, depending on market conditions.

70 Wholesalers are sometimes forced to sell tilapia at low prices because of excess supply and/or competitively priced marine fish. The main destination markets of tilapia from Central Luzon and Batangas include Metropolitan Manila, Laguna, Rizal, Cavite, Pangasinan, and other provinces in Central Luzon. On average, wholesalers in Batangas alone handle 3–6 t of tilapia daily during peak seasons, and 1–2 t daily during low seasons.
5,000 per trip. Retailers invest in vehicles and equipment and their operating costs include fuel, stall fees, packaging materials (plastics), and ice. Daily operating expenses of ambulant fish vendors may be PhP80–250, depending on the area covered.

LESSONS LEARNED

Rising Costs of Feeds. Concerted efforts are needed to reduce the dependence of tilapia farmers on commercially formulated feeds by finding viable alternatives. A shift from intensive to semi-intensive fish culture can reduce feed costs by increasing reliance on natural food produced in fishponds through fertilization, with supplementation of rather than total reliance on commercial feed. The Philippines is a net importer of fishmeal for making fish feeds. Developing and testing technologies to reduce the fishmeal component of commercial feeds is a key challenge. There is also scope for reducing the protein content of commercial feed as a way of reducing feed costs. Without viable alternatives, small-scale farmers will be vulnerable to rising production costs and narrowing profit margins. Feed costs account for more than 70% of total operating costs for producing tilapia in ponds and in cages. Domestic fishmeal prices have increased largely because of the continuing depreciation of the peso. The reduction of tariffs on imported fishmeal from 50% in 1997 to 20% by 2004 is expected to dampen this trend.71

The Importance of Seed Supply. In Philippine tilapia seed production and distribution, there are strategic linkages between breeders and private hatcheries/nurseries, enabling farmers in major production areas to gain access to a range of tilapia strains. Farmed tilapia production in the country increased more than five-fold in 1981–2001, largely because of improved seed quality through selective breeding, increased access to and availability of input supply, sustained advisory services, declining catches of marine fish, expanding consumer markets, and development of marketing channels in response to the market-driven demand for tilapia. Also, tilapia genetic improvement has become a highly dynamic and competitive field of research and development. Access to a reliable seed supply has become the backbone of tilapia farming, which is characterized by vibrant competition and promotional initiatives. This highlights the importance of continued efforts to ensure a reliable seed supply to support an expanding industry that has benefited small, medium, and large fish farm operators, and consequently generated rural employment and incomes for a large number of people.

Accessing Credit. One of the enabling conditions for small-scale farmers to enter tilapia farming is the provision of appropriate credit schemes. Small-scale farmers are often ineligible or reluctant to apply for bank loans because of stringent requirements for loan application. Some bank loans require insurance and invariably require collateral. Aquaculture insurance has almost no history or current market in the Philippines. The emergence and increasing dominance of informal credit schemes from nonbank sources has benefited small-scale tilapia farmers directly and indirectly, although some of these schemes carry higher costs than bank commercial loans. These nonbank financing arrangements include financier-caretaker arrangements, trader-operator agreements (usually forward sales), contract farming, and suppliers’ credit schemes.

Accessing Technology and Related Services. Small-scale tilapia farmers need access to technology and support services from a network of providers, both public and private. Public institutions and agencies in the Philippines provide substantial support to freshwater aquaculture, particularly tilapia farming, through collaborative research, technology development, and extension. The private sector continues to invest in aquaculture education, extension, facilities, and equipment.72 Nongovernment organizations and cooperatives also contribute as conduits of support services. The result is a broad network, including public-private partnerships that have benefited the tilapia industry to date. However, numerous local government agricultural officers have noted that one immediate impact of the devolution of responsibilities to local government units has been the deterioration of extension services in terms of quality and frequency, particularly during the transition period. Local governments are confronted with financial constraints and inadequate technical skills on aquaculture among their agricultural extension workers. Favorable market conditions have expanded opportunities for accessing farm inputs and services, and small-scale tilapia producers have benefited from demand-led and market-based extension services provided by farm input suppliers, particularly seed and feed suppliers.


Social networks among small-scale farmers have helped information exchange and farmer-to-farmer dissemination of knowledge.

**Legal Framework.** Various laws that affect freshwater aquaculture and can benefit small-scale farmers, have been enacted in the Philippines. If properly implemented, appropriate legal provisions may enable these farmers to overcome binding constraints confronting them. However, inadequate funding and institutional capacities have restricted their effective implementation. The Local Government Code of 1991 (Republic Act 7160) devolved many of the functions of central government offices to local government units, including extension services, regulation and licensing, and law enforcement in municipal waters. Increased capacity-building efforts at the local level are required if local governments are to fulfill their new mandates. The Agriculture and Fisheries Modernization Act of 1997 (Republic Act 8435) provides a blueprint for modernizing the agriculture sector in the context of global competitiveness and is concerned with the allocation of appropriate budgetary and technical resources, but actual funding has generally fallen short of planned levels.

The Fisheries Code of 1998 (Republic Act 8550)\(^\text{73}\) aims to ensure sustainable resource management, food security, and development, including the reconstitution of BFAR for improved service delivery. It also recognizes the active participation of local fishers and coastal communities in policy formulation, planning, and program implementation. However, the overall management of fisheries and aquatic resources has been partly dependent on the priority accorded by local government units to this sector and on the presence of strong fisheries and aquatic resource management councils (FARMCs). Not all FARMCs are functional. Thus, improving resource management capacity and consensus building are required for addressing the needs of stakeholders, together with monitoring impacts on poor and small-scale farmers. In some areas, fishers have organized themselves to create FARMCs and have been able to influence policymaking and benefit from aquaculture operations.

\(^{73}\) The Fisheries Code of 1998 has many provisions for small-scale fish farmers, leading to the formulation of various fisheries administrative orders (FAOs) pursuant to the Fisheries Code. FAOs of significance to tilapia production include the recognition and empowerment of small fishers in resource management (FAO 196), provision of incentives for aquaculture workers (FAO 197), stabilization of input prices, particularly seed (FAO 205), proper conduct of aquaculture operations (FAO 214), insurance for aquaculture stocks (FAO 215), ensuring the absence of obstructions to navigation (FAO 217), and defined fish migration paths (FAO 218). Although there are no recorded reports regarding the implementation of FAO 215, its purpose is to increase the participation of formal financing institutions to lend and allocate funds for small tilapia farmers. Lending risks are minimized through insurance guarantees for loans.
CASE STUDY 5

FARMING TILAPIA IN PONDS IN CENTRAL LUZON, PHILIPPINES

BACKGROUND

Scope and Purpose

This case study provides details of pond farming of tilapia in a major production area of the Philippines. The study used primary and secondary data and published information to document the human, social, natural, physical, and financial capital available to households involved in the production and consumption of freshwater farmed fish and to identify ways in which the poor can benefit.1 The history, biophysical, socioeconomic, and institutional characteristics of Central Luzon are described, followed by accounts of the technology and management of tilapia farming, with detailed profiles of fish farmers and other beneficiaries. Transforming processes are then discussed with respect to markets, institutions, support services, policy and legal instruments, natural resources management, and environmental issues.

Methods and Sources

The following methods were used: (i) review of secondary documents; (ii) semi-structured interviews with key informants from government agencies, nongovernment organizations, academic personnel, small- and large-scale tilapia farmers, input suppliers, and traders; (iii) a survey of 248 households—124 adopters (tilapia farmers) and an equal number of nonadopters, i.e., small-scale rice farmers; and (iv) triangulation. Survey sites were selected using the following criteria: (i) existence of tilapia farming in ponds; (ii) being representative of small-scale operations;2 (iii) stable peace and order conditions that allow unhindered and authorized access; and (iv) inclusion of agroecological zones that typify irrigated and nonirrigated areas, to account for resource variations.3

Presurvey activities covered site reconnaissance and rapid appraisal, pretesting and revision of the household survey instrument, preparation of the sampling frame, training of field enumerators, and a survey dry run and its feedback. The survey took place in Nueva Ecija and Pampanga provinces on 13 July–23 August 2003. The tilapia farmers were selected randomly from a list of tilapia farms in Central Luzon from the Bureau of Fisheries and Aquatic Resources (BFAR).4 The nonadopters were drawn randomly from the most recent lists of rice farmers provided by the Municipal Agriculturist Office in various municipalities.5 Differences between the two

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2 Tilapia farming has hatchery/nursery operations for supplying seed (fry and fingerlings) and growout operations in which fish are raised to market size. For this study, small-scale operations were defined as those using ponds of 1 ha or less for tilapia growout; and for nonadopters, rice farms of 3 ha or less.
3 The study provinces were Pampanga and Nueva Ecija, major producers of freshwater tilapia in Central Luzon. The survey sites included 10 municipalities with small-scale operations. In Nueva Ecija, these included (i) Aliaga, (ii) Guimba, (iii) Muñoz, (iv) Quezon, (v) Talavera, and (vi) Cabiao. In Pampanga, the sites were (i) Porac, (ii) Sta. Rita, (iii) Guagua, and (iv) Floridablanca. Half of all these sites were predominantly rainfed and half were largely irrigated. The sample size of 124 tilapia farmers was based on a reliability/confidence level of 95% and a sampling error of 10%. Likewise, 124 nonadopters from Nueva Ecija and Pampanga were interviewed to facilitate a comparative analysis of tilapia farmers and nonadopters, making a total of 248 respondents from both groups. The sampling method used was proportional stratified random sampling.
4 Source: BFAR, Region 3 Office.
5 The choice of rice farmers as nonadopters was based on the finding, during the reconnaissance, that many tilapia farmers were formerly rice farmers who had converted their rice lands into tilapia ponds. Thus, those rice farmers who had continued to plant rice, but had not grown tilapia, were considered nonadopters for survey purposes and were selected randomly from the same villages from which the tilapia farmers were drawn.
groups and between time periods were tested for statistical significance.\textsuperscript{6}

**History**

Central Luzon, known as Region III, comprises the seven provinces of Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac, and Zambales. Pond farming of tilapia began here in the 1950s, following introduction of the Mozambique tilapia (*Oreochromis mossambicus*), which did not perform well. Nile tilapia (*O. niloticus*) was first introduced in the early 1970s and hailed by farmers and consumers as a much better fish for farming. Supported by national and international research and technology development, tilapia farming in the Philippines expanded rapidly, with Central Luzon ponds (especially those in Pampanga, Bulacan, and Nueva Ecija) the main source of production since the 1980s. National tilapia production from freshwater ponds increased from 13,874 metric tons (t) in 1985 to 65,968 t in 2002, with Central Luzon expanding its share from 75% to 87% over this period.\textsuperscript{7}

**BIOPHYSICAL CHARACTERISTICS**

**General Characteristics of Central Luzon**

Central Luzon is an agricultural region of 21,366 square kilometers (km\textsuperscript{2}). In 2002, it contributed about 17% of the Philippines’ total production of rice. Its rice lands comprise 13.7% of the country’s total of 4.05 million hectares (ha).\textsuperscript{8} It contributes significantly to maize, fish, and vegetable production. Central Luzon contains the Philippines’ largest areas of contiguous lowlands, bordered by the Sierra Madre to the east and the Zambales mountains (including Mount Pinatubo) to the west. Forest cover is low (<16%). Conversion of agricultural land for human settlements, recreational, and industrial purposes is increasing. In the south of the region (Bataan and Bulacan), industrialization has increased, with expansion of Metropolitan Manila into these provinces.

**Waters**

Central Luzon contains one major river basin, that of the Pampanga River (9,579 km\textsuperscript{2}; annual run-off, more than 10,000 million cubic meters [m\textsuperscript{3}]). There are about 40 other significant rivers. Surface waters in the Philippines are broadly classified as (i) public water supply; (ii) recreational; (iii) fishery water (including aquaculture); and (iv) agriculture, irrigation, livestock watering, etc. Note the overlap (iii and iv) here with respect to pond farming, if irrigation water is used. Many of the rivers and streams of Central Luzon dry up or have low flow rates in the dry season. They are not well monitored for water quality and their classification depends largely upon sporadic and out-of-date measurements. The limited data available\textsuperscript{9} suggest that most rivers (25) are “nonpolluted,” others (12) “slightly polluted,” and 5 “dead,” but these data are out of date and probably optimistic.

Central Luzon has no large lakes and only two large reservoirs: the Angat dam in Bulacan and the Pantabangan dam in Nueva Ecija. The latter irrigates about 94,300 ha of farmlands and the Angat dam, 31,485 ha. The Candaba swamp, Pampanga (5,040 ha), is an important wetland for fisheries and aquaculture in Central Luzon. Its annual flooding restricts some of fishpond operations there to one crop per year. The Candaba swamp is also largely used for rice farming in the dry season.

Annual rainfall in Central Luzon is close to 2 meters (m) and run-off exceeds 1 m. Central Luzon is classed as a “favorable” groundwater area.\textsuperscript{10} It has large “lowland” groundwater resources and

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\textsuperscript{6} The Statistical Package for Social Sciences was used to generate descriptive statistics (frequency counts, percentages, and means) as well as inferential statistics (t-test and chi-square for analyzing survey data. The paired t-test was used for testing the significance of differences between two time periods (e.g., 5 years ago versus present); the independent sample t-test was used for testing the significance of differences between two independent samples (e.g., adopters versus nonadopters). For qualitative variables, chi-square was used for testing the hypothesis of independence between samples of respondents. Statistically significant differences existed if the level of significance was less than 5% or 1% (p<0.05 and p<0.01).

\textsuperscript{7} In 2002, freshwater tilapia ponds in Pampanga produced 43,411 t. This was a 48% increase over 2001 and comprised 66% of total national tilapia production from freshwater ponds (65,968 t) and 36% of all national tilapia production from aquaculture (122,316 t). The corresponding 2002 harvests from ponds in the other Central Luzon provinces were: Bulacan, 5,900 t; Nueva Ecija, 5,241 t; Tarlac, 2,217 t; Aurora, 465 t; Bataan, 315 t, and Zambales, 77 t. This gives a total of 57,626 t for Central Luzon. Bureau of Agricultural Statistics, Department of Agriculture. 2003. Fisheries Situation. Vol. 7, No. 10. January–December 2002. Quezon City.

\textsuperscript{8} In 2002, Nueva Ecija was the province with the largest rice area harvested (239,127 ha) and the largest production in Central Luzon and in the country (968,754 t). Philippine Rice Research Institute. 2003. Rice Statistics. http://www.prrri.gov.ph.


volcanic groundwater basins in Bataan and Zambales. Alluvial deposits cover about 35,000 km² and the river valleys are covered with dense, irregular deposits up to 200 m deep. Annual recharge to unconsolidated lowland aquifers is from 0.3 to more than 1 m. They provide seasonally abundant, high-quality groundwater at a rate of 10–260 m³/hour. There are more than 2,000 small farm reservoirs in Central Luzon, with average size of about 1,000 m². They have potential for tilapia farming,¹¹ but their main function is supplementary irrigation of ricefields in the dry season.

Published regional and provincial data on the distribution of fishponds by size are not available. An indicative estimate derived from BFAR’s list of tilapia farms in 2002 revealed that freshwater ponds of 1 ha and less accounted for about 34% of the total water surface area of 4,745 ha at the present study sites in Pampanga and Nueva Ecija.¹² Small-scale pond farmers outnumbered large-scale pond farmers (79% versus 21%). Larger ponds are found in parts of Pampanga, particularly in Candaba, Macabebe, San Luis, Bacolor, and Sta. Ana, among other municipalities.

The surface water and groundwater of Central Luzon are of generally good quality for tilapia farming. Most are moderately hard (average total hardness, 81.41 milligrams per liter [mg/L]). Heavy metal contamination is well within safe limits for fish and consumers. During the last decade, the promotion of integrated pest management has lessened some of the profligate use of pesticides and herbicides. The extent to which these pollute surface waters will vary according to future pest and disease challenges and chosen control measures. The water quality in fishponds, small farm reservoirs, and other waters used for tilapia farming varies greatly with the intensity of operations (fish stocking density, feed, and fertilizer inputs) and local sources of pollution.

**SOCIOECONOMIC AND INSTITUTIONAL PERSPECTIVES**

**Poverty**

The annual per capita poverty line in Central Luzon in 2000 was P13,843 ($314 at $1=P44.10 in 2000), requiring a family of 6 to have a minimum annual income of P83,058 to meet food and nonfood needs. The proportion of families living below the poverty line in Central Luzon increased from 14% to 17% in 1997–2000.¹³ These income-based poverty measures do not reveal the circumstances faced by poor farmers or the operating environment of their livelihood. In general, the rural poor are dependent on agriculture, have low educational levels, and have poor access to credit. Smallholders, leaseholders, and tenants are included among the rural poor. Those whose incomes are precariously above the poverty line are vulnerable to economic shocks.

The samples of small-scale farmers in the present survey contained higher proportions of poor households than the regional average. Roughly 43% of the tilapia farmers and 71% of nonadopters were below the provincial poverty line (Table 1).

**Demographic and Social Attributes**

The 2000 Philippine Census of Population and Housing indicated that Central Luzon was the third most populated region in the Philippines in 2000, with 8.0 million people. Its population grew at

¹¹ Current literature includes

¹² The Bureau of Agricultural Statistics estimated the total tilapia farm area in Central Luzon in 2002 at 6,500 ha.

2.6% annually (1995–2000), surpassing the national rate of 2.1%. Population density was 422 people per km², up from 340 people per km² a decade earlier. Males (50.4%) slightly outnumbered females (49.6%) in 2000. The 15–59 years age bracket comprised 59% of the population, the 0–14 age bracket 35%, and the 60 years and older group only 6%. Literacy was generally high at 95%. Most households (87%) depended on electricity for lighting and had access to piped water (96%) for drinking and cooking. About 76% of households owned their housing units.

### Human Health and Nutrition

Fish are not only an important source of animal protein in human diets, but also of micronutrients (vitamins and minerals) and healthy lipids. In Central Luzon, the average annual intake of fish in 1993 (latest statistics available) was about 28 kg per person, but regional data did not reflect the types of fish consumed. Cereals (124 kg) and vegetables/fruit (78 kg) dominated food intake. Milk products and meat accounted for 27 kg and 16 kg per person per year, respectively. On average, the daily energy intake (1,758 calories) and the daily protein intake (51 g) per person were close to the national averages.

#### Consumption of Tilapia: Tilapia Farming Households versus Nonadopters

The survey of 124 tilapia farming households and 124 nonadopter households for this study indicated that tilapia is an important fish in the diets of tilapia farming households and nonadopters alike. The main reasons given for eating tilapia were taste, freshness, availability, and low price. Other reasons included the presence of few fish bones, familiarity with the fish, and perception of a healthy alternative to meat. Given the proportion of poor, small-scale farm households (Table 1), the survey shows that tilapia farming provided nutritional benefits to poor households. Food accounts for roughly 52% of the total household expenditures of the poor; thus, these poor people have gained from the availability of tilapia as an affordable food fish.

### Consumption of Tilapia and Nonfish Items

In 2002, the most frequent average consumption of tilapia by respondent households was 3 days a week, and the least frequent consumption was 2 days a week. Given these frequencies and the mean size of 5 fish per kg (200 grams per fish), annual tilapia consumption would be 21–31 kg per person at tilapia producing sites, if tilapia were eaten every week. In 2003, about 85% of all respondent households ate tilapia 1–4 days a week (the reference period was the 7 days before interview). The mean consumption frequency was 3 days a week. Almost half of the households preferred a size of 5–6 fish per kg largely due to equity considerations (one fish per household member). Others chose larger sizes because these had more flesh and were easier to clean. Only 10% of the households preferred smaller tilapia (7–8 fish per kg). The correlation between fish size and poor

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15 Tilapias belong to the fish family Cichlidae, the species of which (unlike carps, milkfish, and other widely farmed freshwater species) have no intramuscular bones in the somatic muscles used for fillets, which are, therefore, completely bone free.

16 In the absence of official data, the indicative share of food in the household expenditures of the poor can be inferred from the percentage spent on food by households in poor Philippine provinces. See [http://www.nscb.gov.ph/poverty](http://www.nscb.gov.ph/poverty)
households was weak (p > 0.05), implying that poor households did not necessarily opt for smaller fish. Tilapia farmers and nonadopters shared similar preferences. The survey indicated that in 2003, households consumed vegetables more frequently (5 days a week) than milk, eggs, and meat. On average, they consumed milk and eggs on 3.0 days a week, and meat on 2.6 days a week. The frequent consumption of vegetables is not surprising; farmers at the study sites also grow vegetables.

**Months with Inadequate Food.** Two thirds (67%) of the respondents experienced food deficits in 2002. The most difficult months were August (43%) and September (38%). These months coincided with the completion of major farming activities (pond preparation, rice planting, etc.), marked by an absence of income and a slackening of on-farm employment. They also coincided with the occurrence of typhoons in this area. Food deficits were significantly longer for nonadopters than for tilapia farmers (2 months versus 1 month).

**TECHNOLOGY AND MANAGEMENT**

**Genetic Improvement of Tilapia**

Since the late 1980s, substantial research and technology development for genetic improvement of farmed tilapia have been undertaken on the campus of Central Luzon State University (CLSU) at its Freshwater Aquaculture Center (FAC) and at the adjacent National Freshwater Fisheries Technology Center (NFFTC) of BFAR. Tilapia genetic improvement has become a highly dynamic and competitive field of research and private enterprise. Central Luzon tilapia farmers now have access to a wide range of tilapia strains, produced by public agencies, public-private partnerships, private corporations, and small-scale hatcheries. Increasingly, the developers of tilapia strains are entering into agreements with other hatcheries to become accredited suppliers. These agreements are often accompanied by technical support services to encourage customer loyalty.

**Seed Supply**

Tilapia seed (fry and fingerlings) is raised from captive broodstock in hatcheries and nurseries, which may be on the same premises. In Central Luzon, hatcheries nurse fry to fingerlings and there is no significant nursery subsector. Nile tilapia are sexually mature within 6 months and are easy to breed. Their courtship behavior and spawning require a surface upon which the female deposits eggs. The eggs are fertilized externally by release of sperm from the male and immediately taken into the female’s mouth and incubated there until they hatch, and thereafter until they become yolk sac larvae and then swim-up fry that eventually feed independently, no longer taking refuge in her mouth. All the tilapia species in genus *Oreochromis* show this behavior.

There are two other basic characteristics of tilapias that are of great importance for seed supply and growout. First, their prolific breeding in ponds can lead to unpredictable harvests, including significant quantities of undersized fish. Second, the males grow faster than females. These two factors led to decades of research on how best to produce all-male tilapia seed. From a wide range of possible methods, so-called “sex reversal” is by far the most widely practiced. It requires that the

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17 Through selective breeding, the development of genetically improved farmed tilapias (GIFT) was partly financed by ADB under TA 5279-REG: Genetic Improvement of Tilapia Species in Asia, for $475,000, approved on 8 March 1988. ADB also supported dissemination of GIFT through TA 5558-REG: Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA), for $600,000, approved on 14 December 1993. The initiatives on research, development, and dissemination of GIFT (1988–1997) were supported by ADB and UNDP and implemented by the International Center for Living Aquatic Resources Management (ICLARM, Manila) in partnership with Philippine agencies and institutes (BFAR, CLSU, and the University of the Philippines Marine Science Institute) and with other partners, principally AKVAFORSK of Norway (http://www.akvaforsk.no). Development of new strains of tilapia continues, with extensive use of genetic material derived from these projects; for example, the Genomar Supreme Tilapia (GST) and the BFAR strain (GET 2002 EXCEL). FAC sells its own strain, known variously as FAC-selected, FAST, and IDRC strain (acknowledging support from the International Development Research Centre of Canada). To date, there is no standard strain nomenclature and no independent strain certification. The result is a confusing mixture of marketing claims. BFAR distributes its seed and broodstock to BFAR multiplier stations and to affiliated private hatcheries that are encouraged to breed their own fish and to feedback information and superior breeding material. Genomar Supreme Philippines (http://www.genomar.com/supreme.asp) holds eight current members of its preferred partner hatchery network (six hatcheries in Central Luzon) to contracts that preclude the unauthorized breeding of strains other than its GST strain. These Genomar partner hatcheries distribute only all-male, sex-reversed tilapia seed to farmers.

18 Technical services include training, performance monitoring, on-site consultation, and sharing of good practices.

19 BFAR uses a nationwide system of size (and price) categories for its tilapia seed. The code numbers used are based upon the mesh sizes of the nets used to grade the fish. For example, “size 24” fry (individual weight 0.045–0.096 grams [g]) and “size 22” fry (0.129–0.145 g) cost P0.15–0.25, respectively, in 2000. “Size 17” fingerlings (0.468–1.200 g) and “size 14” fingerlings (1.30–2.96 g) cost P0.35–0.45. These prices pertain to the GET 2000 fingerlings of BFAR, effective 14 August 2000.

20 The possible methods include hand sexing and discarding females (laborious and wasteful), stocking predatory fish species to eat the unwanted fry produced during growout (difficult to manage and forfeits the male growth advantage); and interspecific hybrid crosses that produce skewed sex ratios, sometimes 99–100% male (difficult to manage). These methods were compared by the Filipino developer of SRT—Guerrero, Rafael D. III, 1982. Control of Tilapia Reproduction. In The Biology and Culture of Tilapias, edited by Roger S. V. Pullin and Rosemary H. Lowe-McConnell. ICLARM Conference Proceedings 7. Manila. p. 309–316.
feed given to swim-up fry in the first 25–30 days contain an androgenic hormone (usually methyltestosterone) and results in 95–100% male seed, called sex-reversed tilapia (SRT). Buyers expect SRT seed to be at least 98% male, in order to avoid significant and unwanted breeding during growout. Hatchery reputations depend upon achieving the highest possible percentage of male seed. The SRT technique works with all tilapia strains and is safe for the fish and for consumers.21 Another approach to mass production of all-male tilapia seed was pioneered at the University of Wales Swansea, United Kingdom, and further developed in collaboration with FAC/LSU in 1991–199422 and subsequently with the commercial company FishGen.23

There are at least 142 tilapia hatcheries in Central Luzon, of which 53 are in Pampanga and 45 in Nueva Ecija. Official statistics are not available on the seed production of these hatcheries but, based on key informant interviews, monthly production per hatchery ranges from 100,000 fingerlings for smaller hatcheries to more than 5 million fingerlings for larger hatcheries.24 In 2003, the eight Genomar-accredited hatcheries jointly produced 20–40 million fingerlings per month. The NFFTC hatchery in Central Luzon produces about 96 million fingerlings per year.25

Growout

Reasons for Engaging in Tilapia Farming. For the majority (71%) of tilapia farmers surveyed, profitability was the main driving force, highlighting the role of tilapia in generating cash income for the household rather than food for home consumption. Other motivating factors cited were the influence of other farmers (31%) and extension workers (20%). To some extent, advice from family members and observation of other tilapia farms also influenced decision making.

Barriers to Starting Tilapia Farming. Both tilapia farmers and nonadaptors considered that the most formidable barrier to starting tilapia farming was the lack of capital (57%) for financing pond construction and operating expenses. Seen as further deterrents were high input prices, particularly of feeds (16%); unsuitable farm location, i.e., flood prone and no access road (9%); fear of bankruptcy (6%); lack of technical expertise (4%); unreliable water supply (4%); limited land (2%); and low farm gate price of tilapia (2%).

Tilapia Farming Practices. Nearly all respondent small-scale tilapia farmers (96%) raised at least one crop of tilapia in 2002. Fewer farmers (72%) had a second cycle of tilapia, due largely to inadequate water supply during the dry season. (Even if tilapia farmers had water pumps, the

21 According to a Joint FAO/NACA/WHO Study Group: “Hormones are employed principally in hatcheries to induce spawning (e.g., carps) and to control sex of offspring, especially for tilapias. In view of the stages in the production cycle in which the hormones are used and the rates at which they are excreted by fish, there is no risk to consumers of the products of aquaculture.” Source: World Health Organization (WHO). 1999. Food Safety Issues Associated with Products from Aquaculture. WHO Technical Report Series 883. Geneva. 55 p.

22 Mair, Graham C., and David O. F. Skibinski. 1994. Genetic Means for the Production of Monosex Tilapia. Final Report. Muñoz, Nueva Ecija; Philippines; Freshwater Aquaculture Center, Central Luzon State University and Swansea, U.K., School of Biological Sciences, University of Wales Swansea. Using an Egyptian strain of Nile Tilapia developed at the University of Wales Swansea, this project successfully produced YY males and females.

23 Available: http://www.fishgen.com

24 The estimated demand for tilapia fingerlings in Central Luzon is 227–455 million fingerlings per cycle, derived by multiplying a mean stocking density of 70,000 fingerlings per hectare (based on survey results) by the total fishpond area (low assumption of 50% and high assumption of 100% utilization of 6,500 ha). The annual demand for fingerlings in Central Luzon could be 454–910 million.

25 Source: National Freshwater Fisheries Technology Center, BFAR.
amount of water that could be drawn was less during the dry season than during the rainy season). The most common fingerling size used for stocking was size 22 (footnote 19). These cycles typically last about 4 months. A third cycle was possible in Pampanga as reported by 6% of the respondents, but the growing period was relatively short (3.0–3.5 months). Some farmers used relatively large fingerlings (sizes 17 and 14) during the third cycle to reduce mortality and shorten the growing period. In Pampanga, farmers procured their fingerlings from local hatcheries (70%) as well as from Nueva Ecija and Bulacan. In Nueva Ecija, almost all farmers purchased their fingerlings locally. The months for raising tilapia varied, but most farmers stocked their ponds in January/February as well as in August/September so their harvest would coincide with religious events (particularly Holy Week in March or April), town fiestas, and other festivities.

Freshwater tilapia ponds can be conveniently divided into three size groups: ponds of less than 1,000 m², 23% of all ponds surveyed; ponds of 1,000–5,000 m², 43%; and those of 5,001–10,000 m², 34%. Ponds had a mean water surface area of 0.50 ha and a depth of 1.5–2.0 m. The stocking density was 6–7 fingerlings per m², close to the BFAR-recommended stocking densities of 9–15 fingerlings per m² for intensive aquaculture (total reliance on commercial feeds) and 4–8 fingerlings per m² for semi-intensive aquaculture (fertilization plus supplemental feeding). The survival rates were 71–82%. Most farmers (62%) used SRT, which generally had better growth and feed conversion, and often came with advisory services from better-organized hatcheries. BFAR does not sell SRT, but BFAR-registered hatcheries may produce SRT as an option. For the BFAR GET strain, sex reversal increases the retail cost by at least P0.10 per fingerling, according to some hatchery operators.

The most popular tilapia strains at the sites surveyed were the BFAR GET strain (64% of responses) and Genomar Supreme Tilapia (28%). Genetically male tilapia and other strains accounted for the balance (8%). On the choice of strain, most tilapia farmers (91%) placed a premium on fast growth. The price of fingerlings was secondary. Other factors that influenced the choice of strain were proximity of the hatchery, advice from the supplier of fingerlings, and advice from other farmers. Having a choice of strain was seen as important (50%) to very important (45%). About half indicated that they would purchase tilapia seed based only on claims about its performance whereas about half would not, suggesting differences in level of risk aversion among farmers.

The majority of tilapia farmers (68%) preferred to feed their fish with commercial feeds (intensive tilapia farming). The extent of dependence on commercial feeds was more pronounced in Pampanga than in Nueva Ecija (79% versus 58%) due, in part, to existing credit lines with feed suppliers. Only a quarter of the farmers (27%) combined the use of commercial feeds, pond fertilization, and feeding with rice bran, and very few (2%) relied solely on natural production of pond plankton to feed their fish. Overall, the mean feed conversion ratio for semi-intensive ponds was 1.1, and for intensive ponds, 1.3. Farmers fed their tilapia twice (31%) or three times a day (62%). Feeds comprised the main cost component—about 72% of the total variable cost of production for intensive tilapia farming—and comprised mainly imported ingredients, especially fishmeal. Lowering tilapia feed costs and improving feeds are major issues, together with the search for suitable substitutes for fishmeal.

Most tilapia farmers (92%) reported that they used fertilizers largely for basal application to their ponds, and 76% used inorganic fertilizers, such as urea and ammonium phosphate, which could be purchased at the town centers more readily than the organic fertilizers (mainly chicken manure) used by some (22%). A few tilapia farmers (2%)

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26 These backyard ponds were more common in Nueva Ecija than in Pampanga (37% versus 8%) and usually provided secondary income to rice farmers.

27 This survey finding applies to small-scale tilapia farms. Key informants from large-scale farms outside the study sites reported the use of FAST, Genomar Supreme Tilapia, and other tilapia strains.

28 FCR = weight of feed given: weight of fish harvested.
did not use any fertilizers at all, believing that their pond soil was fertile enough and relying on commercial feeds. They also perceived that fertilization could lead to off-flavors in harvested fish.

Complete harvesting of a pond was the most common practice (72%) for tilapia destined for sale. Partial harvesting, where harvesting is done more than once regardless of fish size, accounted for the remainder of tilapia farmers. Selective harvesting, where size selection matters and where harvesting takes place more than once, was the least common practice (10%) among farmers.

Unwanted Tilapia Breeding in Growout Ponds. About half (52%) of the surveyed tilapia farmers had not experienced tilapia breeding in their growout fishponds, but for the remainder (48%) the extent of unwanted breeding was substantial. This resulted in slower fish growth and smaller fish, attributed largely to overcrowding in the pond and the presence of slower-growing female tilapia.

Yields, Sales, Production Cost, and Net Income. The average tilapia yields recorded were 7.8 t and 8.8 t per hectare (ha) for the first and second crop cycle, respectively. For a two-crop cycle in 2002, the average gross income per ha was approximately P56,734 (Table 2), at a mean farm gate price of P42.45 per kg. Expenses per ha for a two-crop cycle were P421,346; 72% on feeds; 11% for fingerlings; 7% labor; diesel, water, and other expenses, 6%; and fertilizer and chemicals, 4%. Total net income was about P235,388 per ha, much higher than the average P57,869 per ha from two-crop rice farming.

The annual net income (P56,619—108,505) from tilapia farming, however, was lower than that on a per-ha basis because farmers’ ponds had an average water area of 0.5 ha per crop and only about 70% had a second crop. The others had inadequate water supply in the dry season due to weak water pressure. Inadequate water for a second crop was also an issue for small-scale rice farmers. The annual net income of rice farmers in 2002 was P29,499—77,524. The farm gate price of paddy rice per kg was P8.50–8.92. On average, rice yields were 4.0 t and 4.7 t per ha for the first and second crop, respectively.

Tilapia farming contributed an average of 39% of the total income of farmers’ households. Small-scale tilapia farmers sold about 91% of their harvests, confirming tilapia as a cash crop. The rest was given away (5%) or consumed (4%). Respondents felt that sharing part of the tilapia harvest and fostering good community relations were important. Rice contributed 66% of total household income of nonadopters. These farmers sold on average 60% of their rice, with 21% consumed in their households, 6% given away, and 13% saved as seed for the next crop.

Table 2: Comparative Net Incomes per Hectare in 2002 from Tilapia Ponds and Rice Farms in Central Luzon (P)

<table>
<thead>
<tr>
<th>Cycle/Crop</th>
<th>Mean Gross Incomea</th>
<th>Mean Production Cost</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tilapia Pond</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>336,582</td>
<td>212,729</td>
<td>123,853</td>
</tr>
<tr>
<td>Second</td>
<td>320,152</td>
<td>208,617</td>
<td>111,535</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>656,734</strong></td>
<td><strong>421,346</strong></td>
<td><strong>235,388</strong></td>
</tr>
<tr>
<td><strong>Rice Farm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>39,205</td>
<td>17,107</td>
<td>22,098</td>
</tr>
<tr>
<td>Second</td>
<td>47,875</td>
<td>12,104</td>
<td>35,771</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>87,080</strong></td>
<td><strong>29,211</strong></td>
<td><strong>57,869</strong></td>
</tr>
</tbody>
</table>

P = Philippine peso.

*aIncludes both cash and noncash income. Noncash income, or the monetary equivalent of fish that were either consumed or given away, accounted for 9%. In the case of rice farmers, the mean cash income from the sale of paddy accounted for 60%, and noncash income or monetary equivalent of rice consumed, given away, and saved as seed, 40%. Source: Special evaluation study survey of 248 farms.

Farmers’ Problems and Future Plans. The most common problems of tilapia farmers were: (i) high feed prices (88%); (ii) high fertilizer prices (73%); (iii) declining net profits (72%); (iv) high cost of pond construction (65%); and (v) presence of tilapia predators, such as Channa striata (snakehead), Clarias spp. (catfish), and bullfrogs (54%). Nonadopters cited high fertilizer prices, insufficient water supply, pests and diseases, dwindling profits, destructive typhoons, and floods as constraining their rice farming operations. Most tilapia farmers were optimistic about their future operations: 59% planned to continue and 15% to expand operations due to attractive financial returns; however, 16% were uncertain about the future and 10% planned either to discontinue or to reduce their operations because of fish kills and financial losses. Most nonadopters (52%) did not see themselves engaging in tilapia aquaculture in view of perceived risks and their limited financial resources. About 20% of them were undecided but the remainder were open to venturing into tilapia farming.

Tilapia farmers perceived the following as being the principal threats to tilapia farming: (i) declining farm gate prices of tilapia29 amid rising feed costs (43%); (ii) increasing number of tilapia growers (9%); (iii) water pollution (4%);

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29The farm gate price per kg of tilapia at the special evaluation study sites declined from P51 to P42 in 1998–2002. Feed prices increased from P15 to P17.2 per kg over the same period, i.e., from P375 to P430 per 25-kg bag.
(iv) lack of unity among small operators (4%); and (v) climatic change (2%). Financial losses and price monopoly by traders were mentioned by 1% each. In Nueva Ecija, poisoning of tilapia by unfriendly people was an issue. The rest did not perceive any threats. Nonadopters shared broadly the same views on threats.

**Fish Health**

Tilapia farming in the tropics is relatively free from serious disease problems and the hatchery and pond growout operations of Central Luzon fit this general pattern. Most fish mortalities are caused by adverse environmental conditions and poor husbandry and not by parasites or pathogens. Among the tilapia farmers, 32% reported fish kills, which occurred more frequently in the hot months of March, April, and May. Fish kills were higher in Pampanga than in Nueva Ecija (50% versus 13%). The Pampanga farmers attributed fish kills to the lack of dissolved oxygen (33%), water pollution (30%), and high water temperature (20%). The only notable fish disease reported was fungal infection (20%).

**PROFILE OF TILAPIA FARMERS**

The study illustrates that access to water and land, along with linkages with input suppliers and service providers, opens up opportunities for farming tilapia. Nonownership of land does not always deter entry to tilapia farming. Owner-operators have secure tenure to their land but others, such as caretakers and lessees, can nonetheless farm tilapia as a source of livelihood if adequate tenure rights can be obtained and if constraints on access to input and output markets do not discourage investment. The ability to purchase the required inputs depends on access to funds, whether from one’s own savings or from external sources. Most small-scale tilapia farmers (66%) use their own resources to finance their operations. For those who have inadequate family resources, the financial barrier can be overcome by credit lines with feed suppliers, friends, relatives, or financiers.

**Human Capital**

**Type of Operators.** Most respondent small-scale tilapia farmers in Nueva Ecija and Pampanga were owner-operators (86%). Lessees and caretakers accounted for 8% and 4%, respectively, and laborers with a fixed salary made up 2%. Pampanga had a higher proportion of lessees than did Nueva Ecija (15% versus 2%). Nonadopters were also predominantly owner-operators (79%). The rest were lessees (16%), caretakers (3%), and sharecroppers (2%). Tilapia farmers and nonadopters differed significantly in many attributes, except household size, for which both groups had an average slightly more than 5 members (Table 3). Tilapia farmers were younger, had completed more years of high school education, and had shorter years of residence in the village than nonadopters. Their average length of experience in tilapia farming was relatively short (4.7 years). Nonadopters, by contrast, had almost 30 years of rice farming experience. Among farmers who own land, tilapia farmers had on average larger landholdings than nonadopters (2.5 ha versus 1.3 ha). About 39% of tilapia farmers were previously rice farmers. In general, most respondents (74%) were born in their villages.

**Occupations and Related Risks.** Most (89%) of the heads of tilapia farming households reported more than one occupation, indicating occupational diversification as a survival strategy among small-scale farmers as well as a means of spreading risk in case of crop failure. Overall, tilapia farming was the primary occupation of nearly half (46%), with secondary and other occupations as follows: rice farming (21%), vegetable farming (12%), and livestock raising (12%). Other occupations included driving, vending/trading, office employment, and carpentry. Some tilapia farmers (36%) have continued to plant

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**Table 3: Characteristics of Tilapia Farmers and Nonadopters in Central Luzon**

<table>
<thead>
<tr>
<th>Variable (Mean Values)</th>
<th>Tilapia Farmer</th>
<th>Nonadopter</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>51.0</td>
<td>56.9</td>
<td>0.001*</td>
</tr>
<tr>
<td>Education (years)</td>
<td>9.6</td>
<td>7.3</td>
<td>0.009*</td>
</tr>
<tr>
<td>Length of Residence (years)</td>
<td>40.4</td>
<td>50.8</td>
<td>0.004*</td>
</tr>
<tr>
<td>Household Size (number)</td>
<td>5.3</td>
<td>5.5</td>
<td>0.502</td>
</tr>
<tr>
<td>Length of Experience in Present Occupation (years)</td>
<td>4.7</td>
<td>29.7</td>
<td>0.009*</td>
</tr>
<tr>
<td>Length of Experience in Previous Occupation (years)</td>
<td>16.8</td>
<td>8.0</td>
<td>0.003*</td>
</tr>
<tr>
<td>Land Ownership (hectares)</td>
<td>2.5</td>
<td>1.3</td>
<td>0.003*</td>
</tr>
</tbody>
</table>

p = probability.

*Significant, p < 0.01.
rice in separate plots. This practice is more common in Nueva Ecija, where rice farming is traditionally dominant, with home farm production considered important. Most tilapia farmers (82%) reported no associated health problems. Those who did mention health problems gave, as the most common complaints: fatigue, hypertension (aggravated by heat), arthritis, and gastric ulcers. Among heads of nonadaptor households, 61% reported having more than one occupation. Their secondary and other occupations included livestock raising (23%), vegetable farming (20%), driving (6%), carpentry (6%), and vending/trading (5%).

**Gender Participation.** Tilapia pond farming in Central Luzon is predominantly male-oriented, particularly in relation to pond preparation, input procurement (fertilizer, feed), and application of basal fertilizer. Much (80%) of these activities is done exclusively by males. However, males and females share responsibilities for feeding the fish (18%), contacting harvesters (14%), harvesting (22%), marketing (29%), and record keeping (19%).

**Natural Capital**

**Access to Land and Water.** Access and tenure rights to land and water are fundamental for tilapia farming. The survey showed that tilapia farmers had access to land either through ownership or lease arrangements. On average, they devoted 0.5 ha of their owned land to fish growout and about 2 ha to other uses (rice, vegetables, etc.). Their lands were generally acquired through inheritance and purchase. For those who leased land from others for tilapia growout, the mean area leased was 0.7 ha. For tilapia farmers who did not own ponds (12%), access was acquired through guaranteed user rights, lasting 1–5 years. Some lessors even allowed indefinite use, for as long as the user needed the pond. In lease arrangements, the pond user paid about P10,000–25,000 per ha per year. For relatively poor pond owners, lease payments were not required, but the net profit was often divided equally between the owner and the tilapia operator. Pond caretakers shared at least 10% of the net profit, in addition to their monthly salary from the pond owner or financier.

**Sources of Water.** Most tilapia farmers (89%) obtained a reliable water supply through deep wells. This lessened water-related conflicts with rice farmers, who depended heavily on irrigation. Such water-use conflicts were rare (3%). Pampanga, in particular, has substantial groundwater reserves that can be extracted through pumps. Other water sources noted by respondents were irrigation (18%), rain (8%), rivers/stream (3%), and small water impoundments (1%). For most tilapia farmers, neither water availability nor the cost of good quality water limited their tilapia farming. However, 19% reported water problems, mainly unreliable water supply (half those with problems), together with seasonality of water supply (one third) and weak water pressure (10%) during the relatively drier months of March to April. More nonadopters than tilapia farmers (51% versus 19%) regarded insufficient water supply as a serious problem and discouraged them from tilapia pond farming. For nonadopters, water-related problems included seasonality (67%), unreliability (27%), poor water quality (3%), and climate change (3%). Nonadopters depended on various sources of water for their rice farms as follows: irrigation (21%), rain (46%), and rivers/streams (5%). Some nonadopters, particularly in Pampanga, have begun to use water from deep wells for a more predictable water supply.

**Social Capital**

Access to social capital hastens the acquisition of information, training, and advisory services for tilapia farming. Most tilapia farmers (82%) traced the origin of their tilapia farming practices to their own province, disseminated through an informal network of farmers, government agencies, and private sector groups (hatcheries, feed suppliers, etc.). Through these links, more than two thirds of them have received training, specifically in pond preparation (65%), tilapia husbandry (43%), tilapia nutrition (6%), and tilapia seed production (2%). The length of training reported was 1–6 days, with a mean of 2 days. The key players in the provision of training were feed suppliers, hatcheries, and government, including FAC/CLSU.

Most tilapia farmers (82%) were not affiliated with any livelihood association. However, for those who were members (18%), multipurpose cooperatives were the most popular choice (43% of the responses). Tilapia growers' associations accounted for 26% and the rest were rice farmers’ groups (13%), women's groups (13%), and irrigation associations (13%). The associations' role in technology dissemination was that of coordination with

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31 For small-scale tilapia farms, land leased from others was 0.2–1.2 ha. For large-scale tilapia farms, the range was 3–7 ha.

32 About 60% of the provincial area is estimated to be high yielding in terms of groundwater. Pampanga's deep groundwater areas are generally sedimentary formations, 90% of which are aquifers. Provincial Planning and Development Office. 2001. **Socioeconomic Profile of Pampanga.** San Fernando, Pampanga, Philippines.
government and nongovernment organizations on the provision of training and technical assistance. Tilapia growers’ associations imparted technical information directly to their members. Most nonadopters (85%) lacked affiliation with any livelihood association, but reported links to other farmers, friends, and input suppliers. Fewer nonadopters (47%) than tilapia farmers (68%) have received formal training.

**Physical Capital**

**Ownership of Assets and Access to Facilities.** Nearly all (94%) respondents owned their dwelling units. However, significantly more tilapia farmers than nonadopters had sturdy housing materials (cement for walls and galvanized iron sheets for roofs) (74% versus 59%) and owned water pumps (82% versus 63%). Almost all tilapia farmers and nonadopters owned television sets, electric fans, and water-sealed toilets. However, tilapia farmers had significantly more assets than nonadopters in terms of refrigerators (77% versus 58%), telephones/cellular phones (73% versus 52%), gold jewelry (71% versus 56%), and vehicles (39% versus 17%). Overall, tilapia farmers were relatively better off than nonadopters in terms of ownership of physical capital. Both tilapia farmers and nonadopters enjoyed easy access to roads and transport facilities, but tilapia farmers had better access than nonadopters to reliable water supply (73% versus 49%), markets (63% versus 54%), and communication facilities (63% versus 54%).

**Financial Capital**

**Access to Funds for Farm Operations.** Two thirds of the respondent small-scale tilapia farmers (66%) were self-reliant, drawing on their own funds. The absence of financial assistance from external sources was attributed to the lack of access to formal credit, high interest rates, lack of financial assistance from the government, and adequacy of family resources. Among the 34% who received financial assistance, funds mainly came from feed suppliers (51%) and relatives/friends (20%). The rest borrowed from moneylenders, financiers, banks, cooperatives, and feed dealers. Because feeds comprised nearly three quarters of the cost of tilapia production, some tilapia farmers borrowed feeds to reduce their cash outlay. The feed costs were payable upon harvest, with a mark-up of P10–20 per bag of feed. For those who borrowed in cash, the interest rate was 5–10% per cycle of 4 months. More than half the nonadopters (57%) did not receive external financial assistance for their rice farms, for the same reasons; for those who did borrow, the more common sources were relatives and friends, input suppliers, cooperatives, and traders. The mean amount of external financial assistance sought was lower for nonadopters than for tilapia farmers (P29,289 versus P128,000) because of the lower production cost of rice farms. Tilapia farmers received loans of P10,000–220,000 per cycle.

**Household Income.** The mean contribution from tilapia farming to total household income was 55% in Pampanga and 22% in Nueva Ecija (average 39%). This difference was due, in part, to the more commercial nature of tilapia farming in Pampanga. Apart from tilapia, farmers in the two provinces drew 29% of their income from rice and 6% from vegetables. Office employment, carpentry, trading, trucking operations, and driving were the other income sources. For nonadopters, the main income sources were rice farming, vegetable farming, and wages/salaries. The mean contribution from rice farming to total income was 66% and from vegetable farming, 9%. Wages contributed around 10%.

**Remittances.** Remittances34 accounted for 5% of the total household income of tilapia farmers and nonadopters. More tilapia farmers than nonadopters (31% versus 26%) received remittances from family members and relatives. Nonadopters received a significantly higher average amount per month (P9,023 versus P6,351). About half (54%) of the respondents who had remittances received them every month, while 21% received them every 2–6 months.

**Output Markets**

Tilapia production from freshwater ponds is largely market driven. The marketing of tilapia was relatively easy for most respondent tilapia farmers (89%); traders normally picked up their harvested tilapia at the farms. Most tilapia farmers (77%) sold to wholesalers-assemblers. The rest sold to retailers, consumers, and brokers. The wholesalers-assemblers transport live tilapia in aerated tanks to various markets within and beyond the borders of the study sites. In this way, harvests from small-scale tilapia farms enter larger consumer markets, allowing the farmers to participate

33 All these differences were statistically significant.
34 Funds sent by overseas workers to their families and relatives in the Philippines.
in opportunities generated by the growth and dynamism of tilapia farming, enhanced by good physical infrastructure (roads, transport, and communications) and by expanded market linkages.

Choice of tilapia market outlets is a function of preference for cash as the mode of payment, existence of a buyer-seller relationship, best price offered, and convenience. About half (52%) the respondent tilapia farmers felt that the buyer was the final decision maker on price; fewer (32%) believed that they were the decision makers on pricing. Not many (16%) felt that the buyer and the tilapia producer determined the price jointly. A deterrent to seeking alternative market outlets, as reported by 25% of the surveyed tilapia farmers, was the premium on trust that had been built with their buyers. There were cases in the past when buyers took the fish but failed to pay the farmers. This experience made producers more cautious and insistent on cash transactions. Other deterrents, as mentioned by a few (less than 10%) of the respondents, were the convenience of current marketing arrangements, satisfaction with the farm gate prices offered by current buyers, lack of alternative market contacts, and the expenses entailed in searching for other tilapia buyers. Nevertheless, 28% of the respondents saw no barrier at all to seeking other market outlets, while 15% were not interested in finding other buyers.

**Labor and Employment**

Tilapia growout at the study sites provided self-employment for farmers and their family members as well as outside employment for caretakers and laborers. Based on this survey, the working hours per worker on small ponds were 4–7 hours daily, generally spent on feeding the fish, cleaning the farm surroundings, and guarding the fish from poachers. Overall, the mean estimate was 2.4 persons per ha, which is relatively high because unpaid family labor is included. Small ponds comprised about 34% of ponds in the study area of 4,745 ha. This suggests direct employment of about 3,872 people. For large ponds, which occupied the remainder of the study area, the average employment generated was only 1.1 persons per ha—large farms had to optimize their resource use in order to stay profitable, given high operating costs and declining farm gate prices of tilapia, such that their direct employment was approximately 3,445 people. Thus, the ponds in the study area generated a combined employment of about 7,300 people. Roughly 24,000 people in Pampanga and Nueva Ecija, inclusive of tilapia workers and their household members, are likely to depend directly on tilapia farming.

Caretakers and salaried workers on small tilapia farms earned P2,000–3,000 per month. In addition, they sometimes received free food and 10% of net profits. Some large-scale tilapia farmers hired caretakers at P3,000 per month and gave them 15–20% of net profits. Thus, tilapia pond farming provided both employment benefits and income benefits to poorer workers who were not in a position to establish their own ponds. Tilapia farmers also hired seasonal labor during pond preparation and harvesting at P150–250 per day for at least 10 days per cycle. The actual number of seasonal workers is difficult to estimate.

Tilapia growout operations have backward linkages (hatchery/nurseries and suppliers of feeds and other inputs) and forward linkages (harvesting, postharvest handling, processing, and marketing), all of which also absorb labor. Such indirect employment could be substantial, but is difficult to quantify in the absence of accurate data.

Among tilapia farmers, the perceived constraints to finding employment elsewhere included old age (31%), uncertainty of finding an alternative job (23%), and limited skills for another job (3%). Others were simply not interested in considering other job options or abandoning their farms.

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35 Based on 7,300 tilapia workers and 3.3 dependents per worker.
Public and Private Institutions

The Fisheries and Aquatic Resources Management Councils (FARMCs), policymaking bodies for fisheries and aquatic resources in the Philippines, have national and local roles. The national FARMC assists in formulating policies for the protection, sustainable development, and management of fishery and aquatic resources. The municipal FARMCs are mandatorily charged with preparing 5-year municipal fishery development plans; enacts regulations in municipal waters. The creation of FARMCs is mandatory at the municipal and village levels or as an integrated council when dealing with a lake, dam, river, bay, or gulf shared by two or more municipalities or cities. There are no FARMCs in the tilapia freshwater pond farming areas of Central Luzon. FARMCs are not mandatory in these areas, but efforts to organize them have begun in Pampanga.

Local government units have complete jurisdiction over municipal waters and are responsible for the management, conservation, development, protection, and utilization of fishery and aquatic resources within their respective waters. They are tasked with institutionalizing the participation of stakeholders in determining the direction and extent of fisheries development and resolving conflicting usage of common resources. Outside municipal waters, BFAR has jurisdiction.

Linkages between public and private organizations are vital for research and development efforts on freshwater tilapia. Private seed companies and input suppliers are not only improving their products, but are also advising farmers on appropriate practices. Initiatives taken by the private sector to support the effective uptake of genetically improved tilapia seed include research (on-station and on-farm trials), extension, farmer financing, risk-sharing arrangements with feed suppliers and financiers, and collaboration with the public sector.

The rapid commercialization of tilapia farming has been accelerated by development and distribution of new tilapia breeds, government support for research and extension, collaboration between the government and private sector, support from international organizations, favorable market conditions, and availability of pelleted feed.

Support Services, Facilities, and Infrastructure

Collection and publication of statistics for freshwater pond aquaculture are the responsibility of the Bureau of Agricultural Statistics (BAS) and BFAR.

Comprehensive collection of rural aquaculture statistics is difficult and costly. Those published for tilapia production in freshwater ponds are probably underestimates, especially with regard to small-scale producers in Central Luzon and elsewhere.

As mentioned, tilapia farming in Central Luzon ponds has benefited enormously from substantial and continuous research, technology development, training, and extension, especially those undertaken at CLSU (FAC and College of Fisheries) and NFRTC/BFAR.

In 2002, these...
agencies, along with the GIFT Foundation International and Phil-Fishgen, established the Tilapia Science Center, located at CLSU, to foster collaboration in the support of tilapia farming in Central Luzon and countrywide. The subsequent creation of Philippine Tilapia Inc. in 2003 has provided a venue for stakeholders in the tilapia industry to work together through advocacy, participation in the tilapia congress, trade fairs, promotion of tilapia consumption, and implementation of a tilapia industry development plan. Central Luzon stands to benefit from these broad-based efforts.

The present survey showed that the most important providers of advice to small-scale tilapia farmers were other farmers (49%), government (35%), friends (30%), and relatives (27%). Input suppliers, such as feed dealers (30%) and hatcheries (10%), also emerged as players in technology transfer and information dissemination and complemented government extension efforts. The proximity of private tilapia hatcheries to growout farmers has helped lower tilapia seed transport costs and mortality.

Policy and Law

Official policies for freshwater aquaculture in the Philippines are markedly pro-poor, with numerous provisions that favor small-scale operations and community welfare; but these policies are not implemented effectively. They are hindered by vested interests and by complex and confusing legislation. The Fisheries Code of 1998 (Republic Act [RA] 8550) is the main legal framework and the basis of all Fisheries Administrative Orders. RA 8550 gives to municipal or city local government units, in consultation with local farmers and subject to review by the appropriate provincial Sanggunian (council), the authority to make ordinances and decisions and to appropriate funds for general welfare and for environmental protection. Recent surveys suggest that fish farmers in Central Luzon are aware of only the few administrative orders that relate to illegal fishing practices. Awareness of other regulations is limited and compliance poor. For instance, farmers with fishponds larger than 300 m² are required to secure an environmental compliance certificate from the Department of Environment and Natural Resources. Very few farmers are aware of this. Limited budgets, the voluntary nature of a code of practice for aquaculture, and weak enforcement capabilities of national and local governments constrain enforcement of environment-friendly regulations. Legal instruments have been prepared recently under the Fisheries Code, but it is hard to envisage that many small-scale farmers will comply.

NATURAL RESOURCES MANAGEMENT

Interrelationships with Agriculture. Central Luzon tilapia ponds (for hatchery, nursery, and growout) are surrounded by irrigated or rainfed agriculture, principally wetland rice farming. Tilapia farming here has always been pursued as a specialized farm enterprise for fish as a cash crop, with ponds made and managed for that single purpose. Despite much historical and ongoing research and development at FAC/CLSU, integrated rice-fish farming and crop-livestock-fish farming systems with farm ponds as pivotal, multipurpose assets, are not found in the region, or indeed anywhere in the Philippines, with the exception of some upland, subsistence farms in remote areas. Moreover, their future prospects seem limited, apart perhaps for some use of ricefields for nursing tilapia fry to advanced fingerlings, and even this is doubtful because one of the major thrusts in current rice research is to reduce water requirements and water depths in rice farming. Pond farming in Central Luzon is mostly driven to maximize fish production through intensive stocking and commercial feeds, and not to integrate farm enterprises, with the pond

41 Current reviews include:
(i) Oposa, Anthony. 2002. A Legal Arsenal for the Philippine Environment. Muntinlupa City: Batas Kalikasan Foundation. Oposa reviewed, among other instruments, Republic Act No. 8435, "Aquaculture and Fisheries Modernization," which provides a framework to "enhance profits and incomes ... particularly the small farmers and fishers, by ensuring equitable access to assets, resources" and to plan for "increased income and profit of small farmers and fishers;" Water Code (Presidential Decree 1067); Civil Code Provisions on Waters (Republic Act 386); Local Government Code of 1991 (Republic Act 7160) with respect to ecosystems, inland fisheries, and freshwater aquaculture; Pollution Control Law (Presidential Decree 984); Water Classification (DENR Administrative Order 34–90); Effluent Regulations (DENR Administrative Order 35, Series of 1990); and several instruments concerning water utilities.


44 These include (i) Fisheries Administrative Order 214, Series of 2001: Code of Practice for Aquaculture, which calls for, among other provisions, an environmental impact assessment to be submitted to the DENR before initiating any aquaculture development; and (ii) Fisheries Administrative Order 218, Series of 2001, Yearly Report on Aquaculture Projects, in which all owners/operators of fish cages, pens, ponds, hatcheries, etc., must report to BFAR their annual production by species, by 31 January of the succeeding year.
as a water and fertilizer supplier, waste recycler, and fish producer. The principal natural resources for tilapia ponds in Central Luzon are land and water. Feeds and fertilizers are sourced almost entirely from agricultural companies.

Land ownership, or security of tenure if leased, is vital for a farmer wanting to invest in constructing tilapia ponds. With heightened interest in tilapia pond farming because of its potential for higher income, rice lands are targets for conversion into fishponds. The exemption of aquaculture from the coverage of agrarian reform provides an added incentive for conversion of land to ponds. In terms of expected financial returns, tilapia farming is about 4 times more profitable per ha than rice farming, but it is much more capital intensive and much less predictable in generating returns due to hazards (especially floods, poaching, and predators).

There is little evidence in Central Luzon of conflicts over water use between small-scale tilapia farmers and rice farmers, as the former rely mostly on groundwater, pumped from deep wells. There are, however, some indications of water conflicts between large-scale pond farms and rice farmers. Farming fish in ponds has been cited as a more efficient use of water resources than rice production; partial sharing/reuse of water between rice and fish enterprises, where manageable, could be attractive. Most farmers totally drain their ponds at harvest time, but this is not possible in some areas (e.g., east Pampanga) in the wet season because of the high water table.

ENVIRONMENT

Fishponds

Small-scale tilapia ponds have no significant, negative environmental features in Central Luzon. Indeed, if managed for the purpose, they can serve as sources of water (often nutrient-rich) and fertile mud for application to rice and vegetable farming. However, nutrient-rich water discharges from groups of medium- and large-scale ponds into watercourses can cause pollution (high biochemical oxygen demand, elevated nitrogen phosphate, and suspended solids), especially in the dry season. The use of sodium cyanide in the preparation (elimination of predatory species) of medium- and large-scale ponds is also a cause for concern, particularly in Pampanga. This practice is banned but cyanide is widely available and the ban is not enforced.

In Central Luzon, the environmental issues that adversely affect tilapia pond aquaculture relate to conditions within the farming system and the effects of external environments on aquaculture. The respondents reported that the sustainability of tilapia farming was threatened by water pollution in ponds (31%) as well as by natural calamities, such as floods and typhoons (24%) and drought (4%). Apart from natural conditions, social conditions that affect tilapia farmers are theft/poaching of tilapia, unstable peace and order condition in some locations, and poisoning of fish by other people. Less than 5% of tilapia farmers considered that the increasing number of tilapia farmers was a threat. According to tilapia farmers, measures were being pursued to address natural environmental threats, namely, waste treatment, reduction of the use of chemicals, improvement of infrastructure/pond repair, and control of water that enters the pond.

Climate and Natural Disasters

El Niño-Southern Oscillation (ENSO) conditions occurred in the Philippines in 1982–1983, 1990–1992, and 1997–1998. ENSO years are typified by droughts and usually have fewer typhoons than normal years, but their impacts on freshwater aquaculture are generally negative.49

45 The current cost of constructing a pond is roughly P15–20 per m², equivalent to P150,000–200,000 per ha, using bulldozers and backhoe. Bulldozer rental alone is at least P1,200 per hour, requiring about 100 hours.


47 Water conflicts among large pond operators and irrigated rice farmers include protests about the National Irrigation Authority charging pond operators only 75% of the fees charged to rice farmers. See Clarke, Gerard, and Graham C. Maire. 1998. The Philippines: Blue Revolution? The Rural Extension Bulletin October 1998: 19–24. (Asian Institute of Technology, Bangkok, Thailand; and Institute for Aquaculture, University of Stirling, Scotland, UK). Pumping water for large fishponds may reduce domestic water supply in some urban areas.


49 In the 1997–98 ENSO, more than 5,000 ha of freshwater fishponds in Central Luzon and 4,000 pond farmers were affected by water shortages. In January–March 1998, 30–40% of freshwater ponds in Central Luzon ceased operation and the total loss for 1998 was 13,000 t, valued at about P650 million. As a contribution to disaster relief, BFAR then distributed 9.6 million tilapia fingerlings to less affected areas.

In June 1991, the eruption of Mount Pinatubo in Zambales Province adjacent to Pampanga had severe impacts on Central Luzon. In Pampanga, lahar (the term for the slurry of volcanic ash and water) buried about 10,000 ha of agricultural lands. The paucity of recent and disaggregated provincial data precludes a comparison of current fishpond areas with pre-eruption levels, but lahar deposits have altered the topography. The beds of many watercourses and river tributaries are now higher than the old riverbanks and the clogging of river channels, creeks, and canals has obstructed the natural flow of floodwaters and caused perennal flooding in low-lying areas. Although river dredging has begun, the enormous volume of lahar deposits will require years to dredge before former capacities to absorb floodwaters are restored.

**Biodiversity and Alien Species**

Tilapias are alien species in Central Luzon and throughout the Philippines. In general, Nile tilapia introductions for aquaculture worldwide have caused far fewer adverse environmental impacts than those of some other tilapias, but the species is potentially invasive. It was introduced into the Philippines for aquaculture because there were no comparable native species. The introduction and use of alien aquatic species and related inspections and quarantine have long been the responsibilities of BFAR—under the 1998 Fisheries Code and pre-existing legislation—but the controls have been inadequate because of lack of resources and lack of public awareness and concern. Philippine fish farmers, institutes, and the aquarium trade introduce alien aquatic species in contravention of national regulations and of the international conventions and codes of conduct to which the Philippines is party. This situation poses potential threats not only to biodiversity and the natural environment but also to tilapia farming because of the risks of introducing diseases and parasites. Introductions that are not officially sanctioned are rarely accompanied by a precautionary approach or by adequate quarantine measures. There is no evidence that Nile tilapia has had negative impacts on the aquatic environment and biodiversity in Central Luzon, which has few pristine or other waters containing native species to which it could conceivably pose any significant threats additional to those from pollution, siltation, and water abstraction. Only 8% of tilapia farmers in this survey reported tilapia escaping into ricefields. Most tilapia farmers (89%) believe that tilapia escapees from farms have no effects on the natural environment.

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**FISH QUALITY**

There is no postharvest processing of tilapia harvested from small-scale ponds in Central Luzon. Fish are not fed for the 24 hours before harvest. Whole, ungutted fish are taken fresh killed, moribund on ice, or live in aerated tanks, from farm gate to market. Off-flavors are a well-known problem in farmed freshwater fish, particularly those

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50 Based on the Socioeconomic Profile of Pampanga (footnote 32). Comparative pre- and post-eruption data (1990 versus 1996) showed that Pampanga’s wetland areas (swamps, marshes, and fishponds) fell from 42,341 ha to 40,681 ha. No breakdown is available on the area of fishponds lost due to lahar. Land devoted to rice production declined from 56,165 ha to 50,333 ha over this period.


52 The 1993 Convention on Biological Diversity (www.biodiversity.org), ratified by the Philippines, requires parties to “Prevent the introduction of, control, or eradicate those alien species which threaten ecosystems, habitats or species.” Responsible use and control of species introduced for aquaculture and fisheries are guided by FAO, of which the Philippines is a member State. They are part of the FAO Code of Conduct for Responsible Fisheries (http://www.fao.org/ht/en/codecom/codeon/spc). Prior appraisal of the possible impacts of alien species introductions is a major aspect of the FAO Technical Guidelines for Responsible Fisheries-Precautionary Approach to Capture Fisheries and Species Introductions (http://www.fao.org/DOCREP/003/W3592E/W3592E00.HTM). These have not yet been adequately applied in the Philippines.

53 The GIFT initiatives (footnote 17) established at BFAR/NFTTC a quarantine unit in which tilapia introduced from Africa and other locations were held under observation and treated for up to 6 months to remove any parasites and diseases. The unit was completely isolated from all other fish and waters, and its own water sterilized before disposal. The GIFT project also assessed the possible environmental impacts of dissemination of genetically improved Nile tilapia. See Bentzen, Hans B., Trygve Berg, and Peter J. Schiøt. 1992. *Environmental Effects of Release and Dissemination of Improved Nile Tilapia*. Report prepared by the Agricultural University of Norway for the United Nations Development Programme, Division of Global and Interregional Programmes. 10p. Distribution of GIFT germplasm followed voluntary biosafety protocols of the International Network on Genetics in Aquaculture. At the same time, policy and practices of ICLARM on alien species and related biosafety and conservation issues were published by ICLARM. See Pullin, R. 1994. Exotic Species and Genetically Modified Organisms in Aquaculture and Enhanced Fisheries: ICLARM’s Position. *Naga The ICLARM Quarterly* 17(4): 19–24, Manila.

54 The alien species most feared by farmers are piranhas and African catfish (*Clarias gariepinus*). The latter was introduced to the Philippines with no official permission or controls, and is probably established in open waters, including the Candaba swamp.
raised in ponds and lakes where there is no possibility of managing the diversity and abundance of plankton.\textsuperscript{55} In this study, 13% of tilapia farmers reported off-flavors, probably due to heavy reliance on commercial feeds (69%), rather than pond plankton produced by pond fertilization (2%).\textsuperscript{56} Almost all respondents felt that producing tilapia of marketable quality, along with fish safety, was not a problem. Tilapia farmers recognized that the top three determinants of tilapia quality were genetic strain (44%), feeds (37%), and water quality (24%). The importance of genetic strain suggests that research and development efforts to improve freshwater tilapia strains have influenced tilapia farmers positively.

\section*{CRISIS AND COPING STRATEGIES}

Less than half of the tilapia farmers surveyed reported any crisis in the last 12 months. The main crises cited were natural calamities, with frequencies of reporting as follows: typhoons (41%), drought (27%), and floods (19%). Other types of crisis that upset the cash liquidity of households were illness in the family (40%), financial loss (28%), and death of a household member (14%). To cope with these crises, households often fell back on their own savings (64%) or borrowed money from friends and relatives (45%). A few secured loans from moneylenders, pawned their jewelry, or mortgaged their land. There were certain instances, however, when illness or prolonged hospitalization of a family member depleted financial resources sufficiently to stop small-scale tilapia farming. Both tilapia farmers and nonadopters experienced similar types of crisis and used similar coping strategies, but significantly more nonadopters than tilapia farmers reported vulnerability to typhoons (69% versus 41%) and floods (42% versus 20%). Nonadopters were also more likely to sell livestock as a crisis-coping strategy (18% versus 10%). Livestock raising (goats, pigs, cattle, and chickens) provides some financial reserves to a household when natural calamities occur and when family or social obligations warrant extra cash outlays in times of illness or death.

\section*{OUTCOMES}

Asked to compare their present situation with that 5 years ago,\textsuperscript{57} respondent tilapia farmers perceived significant improvements in the following outcome indicators: cash income from tilapia farming, employment in tilapia operations, capacity to invest in tilapia operations, and household tilapia consumption. Improved cash income from tilapia farming was attributed to profitable operations (41%), good harvest (35%), and adequate capital (10%). It was also linked to knowledge of tilapia farming and having sufficient water. Tilapia farmers said that, over the last 5 years, their personal capacity to invest has improved with higher savings (37%). These farmers also perceived significant improvements in technology dissemination, technology adoption, overall condition of natural resources, shelter, access to credit, and overall food consumption in their households. They anticipate further positive changes in the next 5 years, but are not as optimistic about the overall condition of natural resources. Acidic soils, polluted water, and floods are perceived as main concerns in the future.

Nonadopters, in assessing outcomes 5 years ago and at present, also perceived significant gains in all outcome indicators, except access to credit for farm operations and overall state of natural resources. The former concern can be attributed to a perceived lack of affordable financing schemes for rice farming, and the latter to the occurrence of floods, siltation, and water pollution. Nonadopters, in general, are optimistic about most outcomes in the next 5 years, but fear a possible deterioration of natural resources.

Tilapia farmers felt that there was no more active information exchange/dissemination on tilapia farming than in the past. Both tilapia farmers and nonadopters agreed that more households were engaged in tilapia farming now compared to 5 years ago.

\section*{CONCLUSIONS}

Tilapia pond farming is a profitable livelihood that can contribute to reducing poverty in Central Luzon. The contributing factors have been (i) access to land (through land ownership and lease arrangements with guaranteed tenure rights); (ii) reliable water

\textsuperscript{55} The most common off-flavors (an earthy muddy taste from geosmin \textit{(trans–1, 10-dimethyl-trans–(9)-decenol)} and a musty taste from 2- methylisoborneol) are acquired by fish from a wide variety of bacteria, especially cyanobacteria. Source: Tucker, Craig S. 2000. Off-flavor Problems in Aquaculture. \textit{Reviews in Fisheries Science} 8(1): 45–88.

\textsuperscript{56} To deal with off-flavors, some tilapia farmers dissolve 1 kg of salt in 4 gallons of water, dip feed pellets in the salt solution, and feed tilapia with these pellets 1 week before harvest. Others hold the fish in a separate pond with flowing water for 2–3 days.

\textsuperscript{57} Respondents compared their situations 5 years ago with the present and 5 years hence using a technique that did not need baseline data. The baseline-independent method was drawn from Pomeroy, Robert, Richard Pollnac, Brenda Koton, and Cansesio Predo. 1997. Evaluating Factors Contributing to the Success of Community-Based Coastal Resource Management: The Central Visayas Regional Project I, Philippines. \textit{Ocean and Coastal Management Journal} 36 (1–3): 97–120.
supply and water pump ownership; (iii) access to working capital (from family savings and/or from external sources, such as feed suppliers, relatives, friends, and financiers); (iv) availability of infrastructure and other related facilities (roads, transport facilities, and communication facilities); (v) access to markets and positive financial returns from tilapia farming; (vi) dissemination of improved tilapia breeds through various hatcheries; and (vii) provision of training, extension, and related services by private and government organizations.

Large-scale hatcheries are key players in tilapia seed supply. Given the volume of tilapia seed that they produce and the geographic extent of the areas that they cover, they are major determinants of the choices of tilapia strains available to farmers.

The entry of harvests from small-scale tilapia farms into larger consumer markets has brought about direct benefits. From the survey results, small-scale farmers feel better off now than 5 years ago in terms of cash income from tilapia farming, employment, and consumption, and anticipate further positive changes in the next 5 years. Poor tilapia consumers (nonadopters in this case) have also benefited from the availability of tilapia as an affordable food fish and as a source of protein, micronutrients, and healthy lipids. Tilapia is regarded as a healthy alternative to meat and is sought for its taste, freshness, and low price. Central Luzon is of increasing importance in supplying tilapia from growout ponds to other population centers. At present, it is the country’s top producer of tilapia from freshwater ponds.

There is considerable scope for further growth of tilapia pond farming in Central Luzon, given the above conditions and a rapidly growing population/consumer base. The enforcement of environmental safeguards to reduce fish mortality and to ensure acceptable water quality, however, is extremely important. A stable peace and order condition is also a prerequisite for further growth of tilapia production. Lowering production costs, particularly feed costs, through less dependence on fishmeal-based feeds, along with reducing vulnerability to risks and changing economic conditions, are the major future challenges.
CASE STUDY 6
TILAPIA CAGE FARMING IN LAKE TAAL, BATANGAS, PHILIPPINES

BACKGROUND

Scope and Purpose

This case study focuses on an important tilapia farming area in a volcanic lake near Manila, Philippines. The study used primary and secondary data and published information to document the human, social, natural, physical, and financial capital available to households involved in the production and consumption of freshwater farmed fish and to identify channels through which the poor can benefit.¹ The history and biophysical, socioeconomic, and institutional characteristics of Lake Taal, Batangas, Philippines are described, followed by accounts of the technology and management used for tilapia cage farming and nursery operations, with detailed profiles of fish farmers and other beneficiaries. Transforming processes are discussed with respect to markets, labor, institutions, support services, policy, legal instruments, natural resources and their management, and environmental issues. The main conclusions and implications for poverty reduction are then summarized.

Methods and Sources

A survey was conducted of 100 tilapia cage farmers and 81 nursery pond farmers from the municipalities of Agoncillo, Laurel, San Nicolas, and Talisay, around Lake Taal, Batangas Province, Philippines. These four municipalities account for at least 98% of the total number of cages in the lake and associated nurseries. The survey was conducted in July–August 2003. Rapid appraisal of tilapia cage farming in Lake Taal, site visits, meetings, and interviews with key informants were undertaken prior to this survey. Survey respondents were identified through stratified random sampling based on the latest official records of each municipality. Separate sets of pretested questionnaires were used to obtain information from the two groups of respondents. Semi-structured questionnaires were used to interview other key informants and stakeholders, including fish traders, input suppliers, and fisheries groups. The study included meetings and interviews with Municipal Fisheries and Aquatic Resources Management Councils (MFARMCs) and the Integrated Fisheries and Aquatic Resources Management Council (IFARMC),² and regulatory/government agencies at regional, provincial, and municipal levels. Secondary data, both quantitative and qualitative, supplemented the discussions.

³ A. Morales led the survey of tilapia cage farmers and nursery pond farmers in Lake Taal. N. Bestari, P. Edwards, B. Katon, A. Morales, and R. Pullin collaborated on the methodology, information analyses, and preparation of this report.

² The establishment of Fisheries and Aquatic Resources Management Councils (FARMCs) is mandated under the Fisheries Code of the Philippines (Republic Act 8550). They are policymaking bodies for fisheries and aquatic resources in the Philippines at national and local levels. The national FARMC assists in formulating policies for the protection, sustainable development, and management of fishery and aquatic resources. Municipal FARMCs assist in preparing 5-year municipal fishery development plans; recommend the enactment of fishery ordinances to the local legislative council, and assist in enforcing fishery laws, rules, and regulations in municipal waters. FARMC members include representatives from fishers’ organizations/ cooperatives, local nongovernment organizations, local government units, local development council, private sector, and the Department of Agriculture. The creation of FARMC is mandatory at the municipal and village levels or as an integrated council when dealing with a lake, dam, river, bay, or gulf shared by two or more municipalities or cities.
History

Tilapia cage farming in Lake Taal began in the 1970s, encouraged by the rapid development of fish cage and pen culture in nearby Laguna de Bay, the Philippines’ largest inland lake. Aquaculture in Lake Taal could not copy closely the development experience in Laguna de Bay because of fundamental differences between the two lakes. Laguna de Bay is a shallow lagoon, with an average depth of 2 meters (m). It is highly eutrophic (nutrient enriched, resulting in dense plankton and organic detritus) because of the influences of agriculture, human settlements, and industry, and is ideal for the construction of pens for milkfish (Chanos chanos), locally called bagnet. By 1976, Laguna de Bay had 7,000 hectares (ha) of milkfish pens, yielding about 7 metric tons (t) per ha annually, based substantially on natural food organisms. Cage farming of Nile tilapia (Oreochromis niloticus) also developed rapidly in Laguna de Bay, with proliferation of adjacent hatcheries and nurseries. In comparison, Lake Taal is the deep, flooded caldera of one of the Philippines’ largest and still active volcanoes. It lacks shallow, soft-bottom substrates suitable for milkfish pens and is less eutrophic than Laguna de Bay. Aquaculture in Lake Taal developed mainly as cage farming of Nile tilapia (and to a limited extent milkfish and other species) with almost total reliance on artificial feeds. Production rose from 13,197 t in 1995 to 21,189 t in 2000.

Lake Taal has been much studied and was included in a recent comparative study of five tropical lakes and reservoirs.

BIOPHYSICAL CHARACTERISTICS

General Characteristics of Lake Taal

Lake Taal covers a total area of about 26,000 ha. It has a water area (total area less islands) of about 24,400 ha and a shoreline of about 120 kilometers (km). The annual average rainfall is 2,026 millimeters most of which falls in the wet season, May to October. The surface water temperature range is 22–35 degrees centigrade (°C). Its drainage basin extends over 64,000–68,000 ha (footnote 6 [v]). The average depth is 60–65 meters (m) and its maximum depth, 180 m or more (footnote 6 [v and vi]). As is common for deep lakes, the waters are stratified. The lake has a climate typical of the humid tropics. About 37 streams feed


8 The deeper waters of the lake (e.g., at 80 m) tend to be 0.5 to 2.0 °C cooler than the surface waters and the dissolved oxygen at the warm surface is less than that of cooler, deeper waters. Guerrero (2002) (footnote 7 [ii]) suggested a typical dissolved oxygen concentration gradient of surface water of 8 milligrams per liter (mg L-1), rising to 10 mg L-1 at 10 m depth and 12 mg L-1 at 20 m.
Lake Taal, but only a few flow year-round. There is an outlet to the sea at Balayan Bay via the 8.2-km long Pansipit River, which allows the entry and exit of migratory fish. The average flow rate for this river is reported to be about 15 cubic meters (m³) per second, but average flows do not mean much, given the large wet and dry season differences. Taal Volcano is active and has erupted about 40 times from 1592 to 1977.9

**Water Quality**

Data on the water quality of Lake Taal are scattered among many publications, some of which are difficult to access. The most recent and comprehensive compendium includes data from 1905 to 1995.10 The water is generally suitable for tilapia, but many of the key water quality parameters that influence fish growth and survival (especially dissolved oxygen) are highly variable with location, volcanic activity, season, and human influences, especially the overcrowding of intensively-fed fish cages. Reduced fish growth, fish health conditions, and survival, and occasional mass mortalities (fish kills) contribute to present risks.

**SOCIOECONOMIC AND INSTITUTIONAL ATTRIBUTES**

Lake Taal had an annual average tilapia cage production of 18,850 t in 1995–2002, valued at P952 million.11 It is the biggest producer of tilapia from freshwater cages and ranks next to Pampanga Province in terms of production of farmed tilapia. Average tilapia wholesale prices in Batangas were P44–57 per kg during the same period. Capture fisheries landings from the lake in 1998 were only 1,681 t, representing a quarter of total landings in 1992.12 This continuing decline in capture fishery production is largely attributed to overfishing and increased pollution.

Batangas Province had a population of 1.9 million in 2000, growing by 3% per annum.13 The average annual per capita consumption of fish and fish products was 32 kg.14 The poverty incidence of families in Batangas was 21%.15 The 2000 Family Income and Expenditure Survey for Batangas placed average annual family income at P139,072, an increase of 50.6% from the 1994 estimate of P92,305. Over the same period, average family expenditure grew from P73,594 to P114,894. At least 50% of families obtained their incomes from wages and salaries, compared to 28% and 21% of families who relied on entrepreneurial activities and other sources, respectively.16 Literacy and unemployment rates were 96% and 12%, respectively.17

Five privately operated processing plants utilizing fish and fishery products are located in Batangas Province. Facilities operated by the Philippine Department of Agriculture—Bureau of Fisheries and Aquatic Resources (BFAR) include an experimental fish farm, a hatchery/nursery, and a fish health laboratory. Batangas Province has a major fishing port, 8 major fish landing markets, and 6 ice plants with a rated capacity of more than 70 t/day.18

Lake Taal is a protected area under the National Integrated Protected Areas System by virtue of Presidential Proclamation Number 906. Responsibility for management of the lake is assigned to a Protected Area Management Board (PAMB).19 MFARMCs are present in selected municipalities.

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9 The status of Taal Volcano is monitored by the Philippine Institute for Volcanology and Seismology (http://www.phivolcs.dost.gov.ph/vmepd/qrn/taal.html), which has recognized that fish kills are among the historical “known precursors to eruptions.” The history of Taal Volcano eruptions, the origin of Lake Taal, and the changes in its topography have been reviewed by Emmanuel Ramos. 1999. Origin and Geomorphic Features of Taal Lake (footnote 6 ii]). A further general account, including changes in the locations and size of human settlements around the lake was written by Hargrove, Thomas T. 1991. The Mysteries of Taal. Metro Manila: Bookmark Publishing.

10 Zafaralla, Macrina T., Rowena A.V. Santos, Rolando P. Orozco, Fbel Ann Mercado, and Regina Banaticla. 1999. Taal Lake: Limnological Characterization and Sources of Ecological Perturbations (Chapter 41 in footnote 6 ii]). Surface water temperature range is 25–35.5 °C, with an average around 29 °C. The lake is slightly to moderately alkaline: pH 8.7–9.2 and total alkalinity 131–170 milligrams per liter (mg. 1-1) of calcium carbonate. Reduction in the lake's transparency (e.g., 4.5 m in 1989 to 1.75 m in 1998) is indicative of increasing eutrophication. By some accepted classification criteria, the lake was already eutrophic in 1979, with net primary productivity measured at 0.5 g of carbon fixed per square meter per day. Nutrients from surrounding human settlements and agriculture, as well as from fish cages (unaten feed, feces, dead fish) are the major causes. The presence of nitrite and ammonia are normally at near zero levels in the lake (footnote 6 iii]). However, ammonia can rise to high levels where there is decomposition of accumulated organic material; e.g., during fish kills (3.0 mg. 1-1 total ammonia in the August 1998 fish kill) and possibly during some volcanic activity (footnote 6 [iii]).


12 Magistrado, Leticia, and Maria Theresa M. Mutia. 1999. Status of the Open Fisheries and Aquaculture Productivity in Taal Lake (footnote 6 iii]).


14 Provincial Fisheries Profile. 2000.

15 Available: http://www.nscp.gov.ph/poverty/2000/povertyprov.asp. This indicates the proportion of families below the poverty line. The annual per capita poverty threshold for Batangas was P15,305 in 2000.

16 Other income sources include cash receipts, gifts, and remittances from abroad.

17 National Statistical Coordination Board (NSCB). Region IV. (http://www.nscb.gov.ph/ru4/)

18 Provincial Fisheries Profile. Office of the Provincial Agriculturist, Batangas. The five processing plants are engaged in fish paste and fish sauce production (2), fish drying (2), and smoked fish (1).

19 Republic Act 7586 mandates the creation of a PAMB for making decisions related to planning, resource protection, and general administration of the protected area, including the promulgation of rules and regulations promoting sustainable development.
and together they comprise the IFARMC of the province. Other fishery-related associations, including credit and multipurpose cooperatives, are present in some municipalities.

**Human Health and Nutrition.** Survey respondents reported that fish were consumed 5–6 times a week in their households. On average, tilapia was consumed 4–5 times a week by cage farming households and at least 4 times a week by tilapia nursery households. Among all respondents, during peak consumption periods, tilapia was eaten daily by 30% and at least 3–4 times a week by 33% of households. During lean consumption months, 49% consumed tilapia on 1–2 days a week. At least 83% of cage farmers and 93% of nursery operators experienced periods of food inadequacy in 2002, particularly during July (43%) and August (74%). July is the month after heavy expenditures on school fees; in August, tilapia farming is often affected by typhoons.

The main reasons given for eating tilapia were good taste (86%), freshness (83%), and familiarity with the fish (57%). The generally preferred size of tilapia of the respondents was 3–4 fish per kg. The prominence of tilapia in the diets of these households probably reflects its easy accessibility. Fish were preferred to vegetables in the daily food intake of the households.

**TECHNOLOGY AND MANAGEMENT**

**Seed Supply**

Tilapia seed (fry and fingerlings), is raised from captive broodstock in hatcheries and nurseries, which may be on the same premises. Nile tilapia are sexually mature in about 5–6 months and are easy to breed. They mature in growout cages but cannot normally breed there. Nile tilapia courtship behavior and spawning require a surface on which the female deposits eggs. These would fall through the mesh of a growout cage, even if spawning and fertilization were successful. The eggs are fertilized externally by release of sperm from the male. The fertilized eggs are immediately then taken into the female’s mouth and incubated there until they hatch, and thereafter until they become yolk sac larvae and then swim-up fry that eventually feed independently, no longer taking refuge in her mouth. All the tilapia species in genus *Oreochromis* show this behavior.

There are two other basic characteristics of tilapias that are of great importance for seed supply and growout. First, their prolific breeding, especially in ponds, can lead to unpredictable harvests, including significant quantities of undersized fish. Second, the males grow faster than females in ponds and cages. These two factors led to decades of research on how best to produce all-male tilapia seed. From a wide range of possible methods, so-called “sex reversal of tilapia” is by far the most widely practiced. It requires that the only feed available to swim-up fry, which are at that stage sexually undifferentiated, contain an androgenic hormone (usually methyltestosterone) and that this be their only feed for 21–28 days. With careful management, starting this treatment as close as possible to first feeding, feeding regularly, and keeping facilities clean to prevent access to natural feeds, the technique can yield reliably 95–100% male seed, called sex-reversed tilapia (SRT). Buyers expect SRT seed to be at least 98% male in order to avoid significant and unwanted breeding during growout. Some SRT hatcheries collect eggs from their female broodstock and transfer them to artificial incubators. Hatchery reputations depend on achieving the highest possible percentage of male seed. The SRT technique works with all tilapia strains and is safe for the fish and for consumers. There are no detectable hormone residues in the fish long before they reach harvestable size. SRT is a process, not a strain name. Based on this survey, 45% of the tilapia cage farmers have used SRT, citing fast growth as the primary reason. Non-users are deterred by the price of SRT seed, which is usually P0.10–0.15 higher than the price of mixed-sex seed.

A new approach to mass production of all-male tilapia seed, genetically male tilapia (GMT) was pioneered at the University of Wales Swansea, United Kingdom, and further developed in collaboration with BFAR. GMT can be produced by genetic modification and can be produced at a lower cost than SRT. The use of GMT can help to reduce the use of hormone-based sex reversal methods, which are controversial due to their potential impact on human health and the environment.

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20 BFAR uses a nationwide system of size and price categories for its accredited tilapia seed. The code numbers used are based on the mesh sizes of the nets used to grade the fish. For example, “size 24” fry (individual weight 0.045–0.096 grams (g) and “size 22” fry (0.129–0.145 g) cost P0.15 and P0.25, respectively, in 2000. “Size 17” fingerlings (0.468–1.200 g) and “size 14” fingerlings (1.30–2.96 g) cost P0.35 and P0.45, respectively.

21 The possible methods include hand sexing and discarding females (laborious and wasteful); stocking predatory fish species to eat the unwanted fry produced during growout (difficult to manage and forfeits the male growth advantage); and interspecific hybrid crosses that produce skewed sex ratios, sometimes 99–100% male (difficult to manage). These methods were compared by the Filipino developer of SRT: Guerrero, Rafael D. III. 1982. Control of Tilapia Reproduction. In The Biology and Culture of Tilapias, edited by Roger S. V. Pullin and Rosemary H. Lowe-McConnell. ICLARM Conference Proceedings 7, Manila. p. 309–316.

22 According to a Joint FAO/NACA/WHO Study Group: “Hormones are employed principally in hatcheries to induce spawning (e.g., carp) and to control sex of offspring, especially for tilapias. In view of the stages in the production cycle in which the hormones are used and the rates at which they are excreted by fish, there is no risk to consumers of the products of aquaculture.” Source: World Health Organization (WHO). 1999. Food Safety Issues Associated with Products from Aquaculture. WHO Technical Report Series 883. Geneva. 55 p.
with the Freshwater Aquaculture Center (FAC) of the Central Luzon State University (CLSU) in 1991–1994, and later with FishGen (http://www.fishgen.com).²³

Among the respondent tilapia cage farmers of Lake Taal, 42% have relied on seed produced in the hatcheries and nurseries of neighboring provinces, especially Laguna. A few small-scale, backyard tilapia hatcheries are now in operation close to the Pansipit River. More importantly, tilapia nursery ponds on the lake’s marginal lands and nursery hapas (fine mesh cages) in the lake have become major sources of fingerlings for 38% of the surveyed tilapia farmers.²⁴ These tilapia fingerlings are sold at sizes that assist farmers to reduce the growout period in cages and, consequently, improve fish survival.

The majority (80%) of tilapia nurseries that serve Lake Taal usually have 2–3 fingerling production cycles per year, each lasting 1.5–3.5 months depending on the desired fingerling size. The first cycle is usually January–March, and the second April–June. The nursery ponds are 48–2,100 square meters (m²) with an average of 261 m², and are about 1 m deep. For 91% of nursery pond operators, the average stocking density is about 1,312 per m² using fry (size 38) or fingerlings (size 32). All nursing (99%) relies on commercial feeds, usually given three times a day. Pond fertilization is less common, with organic and inorganic fertilizers used by 10% and 32% of respondents, respectively, reportedly because other farmers are not experienced in using fertilizers and regard the pond soil as already fertile. However, more nursery farmers plan to use fertilizers in the future. Nursery pond production was 774–813 fingerlings per m² per cycle, indicating 59% survival from stocking. Most nursery pond operators (61%) harvest a pond completely at one time. Only 11% of the surveyed nurseries have considered producing SRT, but they are concerned about the implied costs and profitability, indicating risk aversion to technologies that they have not yet tried.

Most nursery ponds were formerly small ricefields, converted to increase incomes and to diversify income sources. The primary reasons given for engaging in nursery operations around Lake Taal were profitability (94%), discussions with or encouragement by other farmers (53%), learning from observing a government-assisted demonstration farm (33%), and advice from family members and friends (25%). Social networks, aside from profitability, were thus important motivating forces for starting nursery operations. The barriers to entry were said to be lack of capital (61%), natural calamities (8%), and low fingerling prices (7%). Nursery farmers encountered the following input-related problems: high prices of feeds (65%) and of seed (45%), and inadequate supply of seed (39%). Their main production-related problems were bird and fish predators (85%), fish diseases (61%), and high seed mortality (51%). Problems related to profitability and to the environment were typhoons (90%), declining profits (74%), floods (72%), and pollution (56%).

Most (82%) nursery respondents plan to continue tilapia nursery operations in the next 5 years, because of their profitability. Of these, 56% said they will continue their present scale of operations and the others are planning to expand. Other respondents (11%) were undecided, mainly because of the uncertainty of financial sources, particularly financiers. The rest of the respondents might reduce (5%) or totally cease (3%) operations because of past financial losses. Confidence in the tilapia nursery business clearly depends on confidence in the future of tilapia growout. The main perceived threats to sustainable operations were reported to be natural calamities (22%), low price of tilapia (22%), the Government’s dismantling or prohibiting cages (21%), water pollution (15%), tilapia overproduction (6%), high feed prices (4%), and fish kills (3%).

²³ Mair, Graham C., and David O. F. Skibinski. 1994. Genetic Means for the Production of Monosex Tilapia. Final Report. Muñoz, Nueva Ecija, Philippines: Freshwater Aquaculture Center, Central Luzon State University; and Swansea, United Kingdom: School of Biological Sciences, University of Wales, Swansea.

²⁴ Nursery ponds are particularly well established in the municipality of Laurel, where their operators enjoy good access to suitable land and good water supply from watercourses and small impoundments. Many tenant farmers here, who are also recipients of Certificate of Land Ownership Award, converted, wholly or partially, their rice farms to tilapia nursery ponds. These certificates issued under the Philippines Comprehensive Agrarian Reform Program, which redistributes land ownership to tenants, giving access to resources and security of tenure. Most nursery pond operators buy small fry (size 38–32) which in 2003 cost P0.04–0.05 each from Laguna hatcheries—about half of their historical prices because of high availability and competition from hatcheries in other provinces. The fingerlings nursed in ponds are normally sold to growout operators on reaching sizes 12–17 (footnote 20), although some farmers stock smaller fry and fingerlings directly into growout cages. Prior to stocking, size 17–20 fingerlings are often nursed for 2–4 weeks to size 14 in large hapas located within larger growout cages. These nursing hapas are used infrequently and can last for 3 years.
Genetic Strains

Since the late 1980s, substantial genetic improvement of farmed tilapia has been achieved in the Philippines.\textsuperscript{25} Tilapia genetic improvement is a highly dynamic and competitive field of research and of private enterprise. Tilapia hatchery/nursery operators and fish farmers have access to a range of tilapia strains produced by public agencies and by public-private partnerships, private corporations, and small-scale hatcheries. Increasingly, the developers of a given tilapia strain are entering into agreements with other hatcheries to enroll them as accredited suppliers,\textsuperscript{26} and with farmers, offering a wide range of credit and technical support services to encourage customer loyalty.\textsuperscript{27}

The availability of tilapia strains from nurseries near the lake as well as in neighboring provinces was considered important by 92% of cage farmers and 72% of nursery farmers. The Genomar Supreme Tilapia (GST) strain was used by 42% of the cage farmers. Others reported use of so-called Niloticus (19%) and Tagalog (18%) strains, the breeding history and provenance of which are unclear. In 2002, the strains most commonly used by nursery farmer respondents around the lake were Tagalog (31%), GMT (28%), and GST (18%). Choice of tilapia strain was based mainly on expected growth performance and seed price. However, most farmers (63% of cage farmers and 72% of nursery farmers) would avoid buying seed of a given strain based solely on claims about its performance.

Growout

Tilapia cage culture in Lake Taal is intensive, with almost total reliance on inputs of commercial feeds and improved tilapia breeds. The number of fish cages in the lake increased from 1,601 in 1993 to 10,567 in 1999, declining to 6,843 in 2002. The total number is greater than these official records, because of illegal cages. These are clearly visible, particularly in areas where cages are prohibited.\textsuperscript{28} The cages are of two types: fixed (9%) or floating (91%). A floating net cage consists of a floating frame with a synthetic net enclosure below. Bamboo is the most common material used for the frame and also provides floatation. Recently, a few floating cages in Laurel were constructed with plastic drum flotation and metal frames. The life span of a bamboo frame varies with location: 1.5–2 years in calm waters; 1 year in rough waters. The synthetic nets last for at least 2 years. The design and operation of tilapia cages in Lake Taal seem to have remained relatively standard apart from progressive intensification of feeding and deepening of cages where possible.\textsuperscript{29} Most cages are 10 m x 10 m, with depths of 6–7 m and sometimes 15 m depending on location.\textsuperscript{30}

Stocking density varies with cage type and dimension and with farmers’ practices. The stocking density used by respondents was 71–76 fingerlings per m\textsuperscript{2}. The fingerling sizes used were 14 (65%) and 17 (20%). Seed survival at harvest was 58–63%. Feeding was done twice (56%) or three times (39%) a day, usually in the early morning

\textsuperscript{25} Through selective breeding, the development of genetically improved farmed tilapias (GIFT) was partly financed by ADB under technical assistance (TA) 5279-REG: Genetic Improvement of Tilapia Species in Asia, for $475,000, approved on 8 March 1988. ADB also supported dissemination of GIFT through TA 5558-REG: Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA), for $600,000, approved on 14 December 1993. Development of new strains of tilapia continues, with extensive use of genetic material derived from the GIFT, for example, the Genomar Supreme Tilapia (GST) and the BFAR strain (GIFT 2002 EXCEL). FAC sells its own strain, known variously as FAC-selected, FAST, and IDRCP strain (acknowledging support from the International Development Research Centre of Canada). The Tagalog or “native Philippine” strain is used widely in Lake Taal. Its provenance is uncertain but its appearance and performance suggest GIFT and/or other genetically improved strains in its breeding history. There is no standard strain nomenclature and no independent strain certification. The result is a confusing mixture of marketing claims.

\textsuperscript{26} Licensing and accreditation arrangements vary. BFAR distributes seed and broodstock to BFAR multiplier stations (the nearest to Lake Taal being at Bay, Laguna) and to private hatcheries that are encouraged to breed their own fish and to provide information and superior breeding material back to BFAR. Genomar Supreme Philippines holds the 8 current members of its Preferred Partner Hatchery Network (the nearest to Lake Taal being at Caluyao, Laguna) to contracts that preclude the unauthorized breeding of strains other than its GST strain.

\textsuperscript{27} Tilapia hatcheries provide incentives for customers to increase sales and patronage in the forms or combination of (i) increased mortality allowance (i.e., increase in the number of fingerlings given away on top of the volume ordered), (ii) guaranteed mortality replacements within a specific time period, (iii) technical assistance during stocking, (iv) regular farm visits, (v) fingerling price discounts, (vi) flexible payment terms, and (vii) free deliveries.

\textsuperscript{28} The construction of illegal cages, particularly at the edges of the Pansipit River, has been a perennial problem for local government officials, exacerbated by lack of effective monitoring and political will to control the situation.

\textsuperscript{29} The Tagaytay-Taal Integrated Master Plan (footnote 6 [i]) contains the following requirements: “The size of the cages should be standardized and their positions rearranged in such a way that a 3-m distance between cages will be maintained in order to allow unimpeded water circulation between the cages and serve as navigational lanes. The number and dimension/size of cages that an individual can operate should be regulated/controlled to allow equitable allocation of cage areas and maintain free water movement in the area to preserve its ecology. Individual ownership should be limited to only five cages with dimensions of 20 m by 10 m by 5 m, or 10 cages of the 10 m by 10 m by 5 m size. No other size of cage should be allowed outside these dimensions in order that they can be properly arranged in such a way that maximum water circulation is allowed between the cages and serve as navigational lanes. Only 1–2 rows of cages should be allowed for construction parallel to the shoreline within the fish sanctuary. The area occupied by the cages should not exceed 50 m offshore measured from the edge of the lake at its lowest water level. This way, only a narrow strip of water parallel to the shoreline will be occupied by the cages to reduce obstruction to water circulation inside the fish sanctuary. Accumulation of unconsumed feeds and fecal matter of the stocks underneath the cages will be minimized, if not totally prevented.”

\textsuperscript{30} Cage depth is size specific. Some operators use deep nets and adjust them by tying off a portion.
and late afternoon, using commercial feeds of varying formulations. The feed conversion ratios, that is, the weight of feed given divided by the weight of fish harvested, were poor (1.9) compared with those of intensive cages in general (about 1.0), indicating overfeeding and inefficiency. Fertilizers were not used for the cages. Tilapia were grown throughout the year, usually in 2 cycles. Some farmers (47%) stocked their cages in January to meet the huge tilapia demand during the Holy Week (March or April) and the fiesta season (May and June). 31 The growing period was typically 5–6 months per cycle (61%), longer than the 3–4 months of the earlier history of tilapia cage farming here. This was attributed to deteriorating water quality. Cage farmers practiced selective harvesting (49%) more than complete (30%) and partial (21%) harvesting.

Among the respondents, profitability (100%), food security (70%), and discussions with other farmers (29%) were the principal reasons given for entry into tilapia cage farming. Farmers considered tilapia farming as very profitable in comparison with the limited livelihood opportunities around the lake. The major impediments to entering tilapia cage farming were absence of capital (50%), water pollution (18%), natural calamities (12%), low market price (5%), and high feed cost (5%). Heavy competition, absence of training, and strict municipal ordinances were also perceived as barriers to entry.

The high costs of inputs—feed (80%) and seed (61%)—were also identified as major problems affecting the tilapia cage farmers. Shortage of seed supply was mentioned as a constraint by half (51%) of them. This reflects the fact that most of the major seed producers are distant from the lake. Other production problems were high fish mortality (93%), diseases (89%), bird predation (82%), parasite infestation (74%), poor water quality (74%), ineffective zoning enforcement (23%), and theft (18%). Most respondents also reported declining profits (95%) and natural calamities, such as typhoons (92%) and flooding (50%).

The majority of respondents (69%) said they would continue tilapia cage farming for the next 5 years, and a few (8%) plan to expand operations. Some respondents (29%) cited tilapia farming as “the only job they know.” Profitability (19%) and continued involvement of financiers (7%) were also reported as key factors that would assure the continuity of fish farming. Those who were undecided about the future (25%) were concerned about pollution, finding capital, and declining profits. The respondents perceived the following threats to tilapia farming: natural calamities (33%), water pollution (30%), fish kills (15%), declining tilapia prices (14%), increasing costs of feeds (8%), and overproduction (4%). A few respondents (2%) mentioned withdrawal of financiers and government decisions to dismantle cages as significant threats to their farms.

### Fish Health

For tilapia in Lake Taal, the most serious fish health problem is infestation by the facultative parasitic isopod crustacean, *Aliteralus typus* (locally called *timud*). 33 Poor water quality stresses fish and makes them also susceptible to bacterial and fungal infections. 34 Three quarters (74%) of cage farmers cited parasite infestation as a major impediment and risk.

There are plans to develop enterprises in Batangas to supply freshwater aquarium and ornamental fish. Hatchery operations for koi carp and other species are already established in the province. These development initiatives can pose serious risks to aquaculture, fisheries, and biodiversity of the lake if they allow the introduction of more alien species and their diseases and parasites. 35

### Production and Income

The average annual tilapia production from a 10 x 10 x 6–10 m cage was about 3 t per cycle or 6 t per year. Almost all (98.5%) of the harvested

31 Celebrations (fiestas) are held annually in most local communities, usually in May–June.
32 The financiers are from various places, either neighboring towns or Metro Manila.
33 This parasite infests farmed milkfish and tilapia in Indonesia, Malaysia, and Philippines. The *timud* attach to their host fish at fin bases, on the head, in the gill cavity, on the tail, and near the anus, feeding on blood and causing debility and death. When not attached to host fish, *timud* are free-living, occurring in dense patches of aquatic weed. For further general information, see Kabata, Z. 1985. *Parasites and Diseases of Fish Cultured in the Tropics*. London: Taylor and Francis. According to an unpublished report by Eldorado C. Mercene, obtainable from BFAR, Ambulogon station, Talisay, there was 40–80% *timud* infestation of Lake Taal tilapia cages in 1995 and substantial losses and damage to tilapia fingerlings and adults in 2000. Perennial infestations continue.
34 *Aeromonas hydrophila* is the principal bacterium known to cause damage to (ulceration, fish rot, eye opacity, etc.) and death of caged tilapia in the lake. This ubiquitous fish bacterial pathogen has its most severe effects under conditions of high stress. Parasitic fungi cause periodic losses of tilapia seed and adults. In 1997, a bacterial septicemia was responsible for fish kills in Lake Taal tilapia and streptococci were implicated. According to BFAR, however, no streptococci were found in samples collected in 1999. Streptococcal infections are a serious problem in aquaculture in general. See: Shoemaker, Craig, and Phil Klesius. 1997. *Streptococcal Disease Problems and Control. In Tilapia Aquaculture: Proceedings from the Fourth International Symposium on Tilapia in Aquaculture*, edited by Kevin Fitzsimmons. Ithaca NY: Northeast Regional Agricultural Engineering Service. p. 671–680.
35 This applies particularly to species of the family Cichlidae that are used extensively in the aquarium trade. All tilapias belong to this fish family.
fish were sold for cash, with only 0.5% consumed at home and 1.0% given away to friends, relatives, and neighbors. Tilapia cage farming is capital intensive but profitable. The average net income derived from a cage was ₱29,000 per cycle or ₱58,000 per year,\(^{36}\) almost entirely in cash. The average annual operating expenses were ₱107,000 per cycle or ₱214,000 per year.\(^ {37}\) These expenses comprised feeds (79%), seeds (18%), labor (2%), and fuel and miscellaneous items (1%). At least two thirds of the surveyed cage farmers earned not less than ₱30,000 per cage per year, and 15% of them earned ₱10,000–30,000 per cage. In 2002, 41% of the cage farmers stocked 1 or 2 cages and 49%, 3–6 cages. Some farmers became owner-operators and invested in cage farming by drawing from savings generated from past earnings as caretakers, or entering into financing agreements with input suppliers. However, most of the cage farmers were comfortable to remain caretakers instead of becoming owner-operators because of the financial capital requirements that acted as a major barrier to entry.

For tilapia nursery ponds, the average annual number of fingerlings harvested and sold from three production cycles was at least 2,000 per m\(^2\). The gross value of average annual sales of nursed fingerlings was ₱579 per m\(^2\), with average annual operating expenses at ₱328 per m\(^2\). On average, nursery farmers spent ₱60,236 annually per pond, apportioned as follows: seed (47%); feeds (40%); labor (6%); fertilizer and chemicals (4%); and other expenses, such as fuel, plastic bags, rubber bands, and oxygen (3%). Their mean annual net income was ₱39,525 per year or ₱13,175 per cycle. In 2002, 43% of nursery farmers owned or operated 1 or 2 ponds, 27% had 3 or 4, 15% had 5 or 6, and the remainder had 7 ponds or more.

**PROFILES OF TILAPIA CAGE AND NURSERY FARMERS**

**Human Capital**

Tilapia farming in and around Lake Taal is presently dominated by caretakers, for both nursery ponds (65%) and growout cages (64%). The remainder were owner-operators (34%) and caretaker-laborers\(^ {38}\) (1–2%). Most activities (75%) in both cage and nursery farming were male dominated. However, feeding and record keeping were performed by both males and females. The average age of all farmer respondents was 45 years, with 8 years of formal education and average household size of 6. Most farmers (76%) were local residents and the rest were from other parts of Luzon (22%) or elsewhere in the country (2%). For cage farming and nursery respondents, the average lengths of residence in the area were 37 and 39 years, respectively, and they had about 8 years of experience in tilapia farming.

Tilapia cage farming was reported as the main occupation of the surveyed cage farmers (93%) and 72% had a second occupation: fishing (21%) or livestock raising (18%). Other secondary occupations included crop farmer (5%), trader (3%), driver (3%), electrician (2%), carpenter (1%), shop mechanic (1%), and government employee (1%). Thus, cage farming is not a full-time job; cage farmers maximize their use of natural capital by combining farming and fishing, while multiple employment reduces risks and provides additional financial security.

Nursery operators reported also more than one occupation. Tilapia nursery farming (63%) and rice farming (16%) were the main primary occupations. Their main secondary occupations were fish or cage farming (36%) and livestock raising (27%), with other types of employment similar to those of cage farmers.

To improve their skills, 49% of cage farmers and 19% of nursery farmers had received training in one or more of the following: tilapia farming in

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36 The average net return per cage per cycle for cage farming was ₱26,926–35,288 and for nursery farming, ₱12,879–16,667.

37 The average operating expenses per cage per cycle for cage farming were ₱111,865–115,356 and for nurseries, ₱23,842–24,742.

38 Caretaker-laborers are caretakers who opt to receive a fixed monthly salary instead of entering into profit sharing arrangements without receiving wages or fixed remuneration.
general, feeding, farm management, and fish breeding. Most training was completed within a day. To some extent, all farmers received extension services, either from feed and seed suppliers or government agencies, or both.

**Natural Capital**

The waters of Lake Taal are owned by the state, not by individual fishers and farmers. Cage farming sites are leased for a fixed term. The Philippine fisheries, local government, and water codes provide for open access to aquaculture zones in Lake Taal, and these should not exceed 5–10% coverage of the total water area. The 10% benchmark is currently regarded as the administrative and legal limit, but this is a guess at what might be environmentally and publicly acceptable and was not scientifically derived. Based on this limit, the lake should be providing about 1,200–2,400 ha of legally approved water space for fish cages. Favorable cage sites require shelter from storms, high water exchange, road and boat access, and security. Such sites are limited and crowded, which reduces their water quality and increases the risks of disease transmission. The marginal farmlands that are used for nursery ponds and for support facilities for the cages are under private ownership.

The waters of Lake Taal have several uses—fishing, tourism and recreation, and fish farming. Fish cage farming and cage ownership are limited to residents of the adjacent municipalities, particularly members of fishing cooperatives. However, most local residents are unable to finance cage operations; thus, they make arrangements with nonresident financiers or absentee-investors and serve either as caretakers or permanent cage workers for cage farms that are usually registered under their names. A license is needed to operate a fish cage and it must be renewed annually.39

Tilapia cage and nursery farmers have small landholdings around Lake Taal. A respondent cage farmer owned, on average, 0.5 ha of land and a nursery farmer had 0.27 ha. Some (24%) nursery farmers were land tenants. Cage caretakers usually worked in tilapia farming because they lacked substantial land and other assets. For tilapia cage and nursery farmer respondents who owned land, the ownership was either acquired through inheritance (27%), purchase (25%), or through land reform (7%). Some nursery farmers were using their parents’ lands (8%).

The availability of water was not considered a major concern by 88% of the nursery farmers. At least two thirds of nurseries depended on the lake, rivers, and streams for their water supply. Others obtained water from irrigation canals (20%) and groundwater (10%). The majority of cage and nursery farmers felt that no dominant or influential groups controlled access to water (92%) or to land (93%) in and around Lake Taal. Moreover, 98% of all respondents reported no conflicts over the use of resources.

**Social Capital**

Social networks are common and strong among tilapia cage farmers in Lake Taal. Most (77%) of the respondents learned their fish farming practices from sources within Batangas Province, 10% from within the province and elsewhere, and 13% solely from outside the province. Farmers reported that they obtained information on tilapia farming from various sources, including a network of fellow farmers (60%), friends (56%), relatives (48%), their own experience (52%), government agencies (15%), feed suppliers (10%), seed suppliers (5%), financiers (3%), media (3%), educational institutions (2%), and nongovernment organizations (1%). Social networking plays a crucial role in accessing assets for tilapia farming, particularly with respect to the fish farmers’ depend-ence on external financiers. Mutual trust is paramount in a financier-caretaker relationship. Farmers of good reputation, belonging to a large social network, have good chances of obtaining access to financial resources and to farming opportunities through referrals and contacts established through the associations.

At least 60% of the cage farmer respondents were members of a livelihood-related association, with 47% belonging to multipurpose cooperatives that cater mostly to cage farmers. Some municipalities require membership in an association as a prerequisite for issuing cage licenses, following the recommendations of the Presidential Commission on Tagaytay and Taal. Other types of associations include FARMCs, fishers’ groups, and irrigation and drivers’ associations. Associations serve as a channel for information exchange among farmers; 35% of the respondent cage farmers attested to the role of associations in conducting training and seminars, and serving as channels for discussing resource management issues, including monitoring of the lake and cages. In contrast, most (88%) nursery farmer respondents were not members of

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39 Licenses are issued by the municipal government to farmers whose cage(s) is/are within their territorial jurisdiction. The license fees comprise a municipal mayor’s permit fee, a lake user fee, and other charges as prescribed under the existing ordinances of the municipality concerned. Annual license fees for a cage are P100–160; different municipalities apply different rates.
any livelihood-related association. They relied on their own social networks for information and advice on tilapia farming.

Physical Capital

Most respondents had lived in the area for more than 3 decades, and 91% of cage farmers and 98% of nursery farmers owned their dwelling units. Caretaker-laborers, hired from other areas (4%), were given accommodation as part of their remuneration. Many respondents (85% of cage farmers and 89% of nursery operators) had houses built with permanent structures.40 Most respondents owned modest household appliances and facilities, such as a television, radio, electric fan, refrigerator, and water-sealed toilet. More cage farmers (77%) than nursery farmers (47%) owned gold jewelry. Further, 64% of cage farmers and 51% of nursery farmers had telephones or cellular phones. Nursery farmers had more bicycles (41% versus 34%) and more tricycles (20% versus 10%) than cage farmers, but both groups were equal in ownership of motorized vehicles (31%). As expected, more cage farmers (77%) owned boats than did nursery farmers (14%), and more nursery farmers owned water pumps than cage farmers.

The respondents reported that their access to facilities ranged from fair (neither easy nor difficult) to very easy. Most cage farmers and nursery farmers shared this view in terms of road access (75% and 78%, respectively), transport facilities (84% and 83%), communication facilities (84% and 64%), market access (94% and 85%), and reliable water supply (96% and 93%).

Financial Capital

Tilapia cage farming in Lake Taal is sustained largely by external sources of financing. High operating costs and the inherent risks of fish farming deter the local inhabitants from using their own limited financial assets for fish farming. These conditions have given rise to the emergence of financier-caretaker relationships, which have gained local acceptance: 64% of the cage farmer respondents were caretakers and recipients of financial assistance provided by financiers. These relationships depend on an agreement between a financier (usually a nonresident) and a local resident (caretaker). The former is expected to provide the financial resources while the latter manages the fish farm. The net proceeds after each crop cycle are then distributed between both parties, based on their initial agreement.41

The other respondent cage farmers (35%) received financial assistance other than from financiers. They mobilized their financial capital by obtaining credit from feed suppliers, relatives and friends, local moneylenders, and farmer cooperatives. For cash loans, the monthly interest rate was 1.5–20.0%, with repayment periods of 1–30 months. Feed suppliers typically sell feeds on credit, with payment after harvest or over an agreed period. Feed suppliers mark up their retail feed prices to cover their costs of capital. The same financial arrangements apply to tilapia nurseries. At least 65% of nursery farmers were direct recipients of financial assistance from financiers. For nursery owner-operators who were able to obtain their financial capital from elsewhere (15%), the sources were relatives, friends, feed suppliers, and banks.

In 2002, the main sources of income for cage farmer respondents were cage farming (74%), trading (6%), and fishing (6%). Only 10% of them received remittances from family members either on a monthly (2%), quarterly (4%), or annual (4%) basis.42 Remittances averaged 2% of their household income during the year.

The main sources of income for nursery farmer respondents in 2002 were tilapia farming (62%), rice farming (13%), and livestock raising (10%). As with the cage farmers, only a few (6%) received remittances, from family members (5%) and friends (1%). Reliance on remittances is clearly uncommon among cage and nursery farmers in Lake Taal.

TRANSFORMING PROCESSES

Markets

The growing acceptance of tilapia among Filipinos has increased the demand for the product, leading to the development of new technologies, market expansion, and the opening of opportunities and services, including those for the poor. Market competition has played a significant role in transferring improved technologies, offering competitive prices, and increasing access to tilapia for poor

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40 Construction materials include cement, bricks, expensive wood products, and galvanized iron sheets.
41 Existing financier-caretaker sharing arrangements on net profits are either 50:50, 60:40, or 80:20 in favor of the financier. Sometimes, a caretaker works for another caretaker (primary), and they divide the share of the primary caretaker. In other cases, caretaker-laborers opt to receive a fixed monthly income, or a fixed income and a small incentive derived from net profits. For some partnerships, financial losses from the previous cycle are carried over the next cycle under an arrangement known as a “roll-back” system. This roll-back system requires caretakers to share with the financiers the risks of cage farming.
42 Remittances are transfer payments to the Philippines, usually wages and salaries sent home by Filipinos employed outside the country.
Decision making on product pricing was attributed by the respondents to farmers (43%), financiers (23%), and wholesalers (34%). Prices were determined by fish size using an 8-tier structure.\textsuperscript{44} This has encouraged small-scale farmers to grow tilapia to bigger sizes. However, the growing number of unorganized intermediaries, particularly wholesalers, and tilapia oversupply in markets have decreased prices received by small producers and market intermediaries. Mechanisms to improve product flow are badly needed.

**Public and Private Institutions**

Tilapia farming in Lake Taal has benefited greatly from public and private research and technical support. Choices of tilapia strains and improved management practices are products of such collaboration through various networks. In Batangas, there are two BFAR stations\textsuperscript{45} that have provided research, training, and information dissemination in support of tilapia farming and related issues in Lake Taal, particularly on coexistence with fisheries and environmental aspects, such as fish kills and the upwelling of noxious deep waters. The presence of these institutions has increased farmer awareness and understanding of the natural hazards of the lake.

FARMCs were created to increase fishers’ and farmers’ participation in managing fisheries and aquatic resources in a sustainable manner. The presence of an IFARMC in Batangas Province and municipal FARMCs around Lake Taal has led to increased participation of both fishers and farmers in the management of the lake. A resolution for the harmonization of the diverse municipal policies and ordinances pertaining to tilapia cage farming in the lake was endorsed to the Batangas Provincial Council in 2003 by the IFARMC and concerned municipalities. The resolution seeks to increase benefits for farmers and the local communities and aims to improve lake management. FARMCs are also active participants in the provincial government’s drive to eliminate illegal structures along the Pansipit River in order to improve water flow and the passage of migratory fish. Tilapia cage farmers are expected to benefit from the anticipated improvement in water quality through increased farm productivity.

\textsuperscript{43} The special services, such as discounted prices, higher mortality allowances, and better payment terms, are beneficial; these increase patronage and establish good business relationships.

\textsuperscript{44} In general, the number of fish per kg determines price. The top price is for tilapia of 1-2 fish per kg (individual weight, 500–1,000 g) and the lowest (8th tier) is for 10 fish per kg (about 100 g each).

\textsuperscript{45} These are the Ambulong Fisheries Station in Tanauan and the Butong Fisheries Biological Complex in Taal.
The fisheries and fish farming in Lake Taal are not currently represented in the PAMB, which is the legally mandated body for managing the lake and its resources. The PAMB of Lake Taal is currently modifying its mode of operations to enable adequate consideration of the interests of fisheries and aquaculture. The modification contains provisions for establishing subcommittees to address specific concerns. The PAMB is expected to contribute to more sustainable management of the lake and its resources.

The fish farming cooperatives in Lake Taal facilitate information exchange and aquaculture-related training and discussions. They help in monitoring the condition of the lake and cage farmers' compliance with local regulations. They also help farmers to apply for loans to finance their operations. Similarly, fishery-related cooperatives serve as conduits for local government units (LGUs) in implementing assistance programs for fish farmers.

**Labor and Employment**

Tilapia cage and nursery farming generate employment opportunities for small-scale operators, caretakers, laborers, and their households. In addition, fish farming has created spin-off jobs, including cage making, harvesting, handling, fish trading and vending, and nursery fishpond preparation. Local economies have improved with the entry of input suppliers, especially feed companies; their presence has increased local employment in retailing, transporting, and distributing feed. Table 1 summarizes the estimated employment in tilapia farming in Lake Taal.

Based on the present survey, the average monthly salary of regular workers or laborers in tilapia cage farming and nurseries in 2003 was P2,000. These workers also received benefits in terms of rice, other food provisions, and, to some extent, housing. For seasonal laborers, the average daily wage was P138. The perceptions of tilapia farmers about their prospects of changing employment were mixed. Some (21%) anticipated no constraints in this regard. Others were worried about employment prospects due to either unfamiliarity with other jobs (16%), old age (12%), or lack of capital to start a new business (11%).

**Support Services, Facilities, and Infrastructure**

Some tilapia cage farmers (23%) and nursery farmers (11%) regarded government extension services as weak sources of information and advice. In two municipalities, there had been reduction in extension personnel because of reduced budgets, which resulted in part from decentralization of government services. As mentioned, social networks have been effective in disseminating information on tilapia farming among small-scale farmers, including technology and market information. Seed and feed suppliers also provide technical support to both cage and nursery farms.

The national Government has a credit program that extends financial assistance to small-scale farmers and fishers through the Quedan Rural Credit and Guarantee Corporation (QUEDANCOR). These loans are available to fish farmers in Lake Taal, facilitated by LGUs and provided to eligible farmer groups at an annual interest rate of 12% and a

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46 The cooperatives were created initially to comply with licensing requirements and to operate fish cages. There are currently at least three fish cage cooperatives in Laurel, Batangas.

47 The local government of one municipality is seeking assistance from the provincial government to finance cage culture operations.

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### Table 1: Employment Generated by Tilapia Cage Farming in Lake Taal, Batangas

<table>
<thead>
<tr>
<th>Type of Employment</th>
<th>Number of People Employed</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cage Caretaker/Operators</td>
<td>2,280</td>
<td>3 cages per farmer, with about 6,840 cages in 2002</td>
</tr>
<tr>
<td>Family Members</td>
<td>4,560</td>
<td>2 family members assisting each cage operator/caretaker</td>
</tr>
<tr>
<td>Wholesalers/Traders</td>
<td>30</td>
<td>Based on key informant interviews and survey estimates</td>
</tr>
<tr>
<td>Harvester Group</td>
<td>360</td>
<td>Each wholesaler has a group of harvesters of at least 12 people</td>
</tr>
<tr>
<td>Drivers and Helpers</td>
<td>90</td>
<td>A wholesaler has a driver and 2 helpers to deliver to the main markets</td>
</tr>
<tr>
<td>Cage Makers</td>
<td>90</td>
<td>About 4 persons can make 1 cage per day; 300 workdays per year</td>
</tr>
<tr>
<td>Tilapia Vendors/Retailers</td>
<td>260</td>
<td>Survey estimates</td>
</tr>
<tr>
<td>Nursery Farmers</td>
<td>350</td>
<td>Estimates based on municipal records</td>
</tr>
<tr>
<td>Family Members</td>
<td>700</td>
<td>2 family members assisting each nursery farmer</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,720</strong></td>
<td></td>
</tr>
</tbody>
</table>

*These estimates do not include laborers working specifically for pond preparation. Employment in hatcheries was excluded because Batangas nursery and cage operations are mostly dependent on outside seed suppliers.*
Making cages from bamboo

service fee of 3%. The provincial BFAR office supervises the implementation of national fisheries and aquaculture programs, including tilapia farming. In coordination with the regional office of the Bureau of Agricultural Statistics, BFAR also monitors fish production and prices in Batangas.

Private service facilities, such as ice plants, supply the marketing needs of tilapia cage farmers and traders. Ice is critical to keep products fresh until they reach the market. Some entrepreneurial tilapia farmers rent out their boats to other farmers to transfer feeds bought in bulk. Wholesalers who pick up harvested tilapia at the farm gate use their own trucks. Different levels of government develop and maintain facilities and roads, particularly from farms to markets. Most respondents regarded their present access to roads, transportation, markets, and water supply as fair. Access to cellular phones has greatly improved communications.

Policy and Law

Official policies for freshwater aquaculture in the Philippines are markedly pro-poor with numerous provisions that favor small-scale operations and community welfare, but these policies are not implemented effectively. They are hindered by vested interests and by complex and confusing legislation. The Fisheries Code of 1998 [Republic Act (RA) 8550] is the main legal framework and the basis of all Fisheries Administrative Orders. RA 8550 gives to municipal or city LGUs, in consultation with local farmers and subject to review by the appropriate provincial Sanggunian (council), the authority to make ordinances and decisions and to appropriate funds for general welfare and for environmental protection. The results have been mixed. At the municipal level, there have been more than 20 legislative instruments of relevance to fishing and aquaculture in Lake Taal. Fishers and farmers are not fully aware of these and many have not been effectively implemented. More legal instruments have been prepared under the Fisheries Code, but it is hard to envisage that compliance with these will be swift or widespread.

48 Current reviews include (i) Oposa, Anthony. 2002. A Legal Arsenal for the Philippine Environment. Muntinlupa City: Batas Kalikasan Foundation. Oposa reviewed, among other instruments: Republic Act No. 8435, “Aquaculture and Fisheries Modernization,” which provides a framework “to enhance profits and incomes ... particularly the small farmers and fishers, by ensuring equitable access to assets, resources” and to plan for “increased income and profit of small farmers and fishers”; the Water Code (Presidential Decree 1067); Civil Code Provisions on Waters (Republic Act 386); the Local Government Code of 1991 (Republic Act 7160) with respect to ecosystems, inland fisheries, and freshwater aquaculture; the Pollution Control Law (Presidential Decree 984); Water Classification (Department of Environment and Natural Resources, Administrative Order 34–90); Effluent Regulations (Department of Environment and Natural Resources, Administrative Order 35, Series of 1990); and multiple instruments concerning water utilities.

49 For example, Mercene-Mutia (2001), using 1997 data, assessed the effects of local government implementation of the national open-access policy for municipal fisheries. The verdict was essentially negative. Open access was said to have resulted in unregulated entry of fish farming practices like fish cage culture, which tend to increase the pollution load in the lake. The main solution recommended was that “national government agencies (Department of Agriculture, BFAR, Department of Environment and Natural Resources) should form an agreement with local government units for a continuing assessment of the fishing resources in Lake Taal.” Mercene-Mutia, Ma. Theresa. 2001. Assessment of Local Government’s Implementation of Open Access Policy in Taal Lake, Philippines. p. 123–132 in footnote 6 [iv].

50 Mercene-Mutia (footnote 49), noted that most fishers and cage operators were aware of very few ordinances: e.g., prohibition of active fishing gears, registration of fish cages, and registration of boats (fees are paid for both), regulation of cage construction, and prohibition of waste disposal in the lake. It was reported that 64% of those interviewed felt that local fishing ordinances were either not strictly implemented or were ignored. Similarly, the Department of Tourism (footnote 6 [i]) noted “Non-Enforcement of Fishing Regulations” and that fishers “stubbornly insist their unlawful methods of fishing.”

51 These include (i) Fisheries Administrative Order 214, Series of 2001, Code of Practice for Aquaculture, which calls for, among other provisions, an environmental impact assessment to be submitted to the Department of Environment and Natural Resources before initiating any aquaculture development; and (ii) Fisheries Administrative Order 218, Series of 2001, Yearly Report on Aquaculture Projects, in which all owners/operators of fish cages, pens, ponds, hatcheries, etc., must report to BFAR their annual production by species, by 31 January of the succeeding year.

52 Laws and regulations have been widely ignored in and around Lake Taal. For example, Fisheries Administrative Order No. 217, Series of 2001, Obstruction to Defined Migration Paths provides for the freedom of passage of migratory species though the Pansipit River. Rafael Guerrero (footnote 7 [ii]) mentioned the “political will” that has, from time to time, made possible the clearance of the obstructions (fish cages and traps) in the Pansipit River, but emphasized the need for “full enforcement of existing fisheries laws and ordinances... full implementation of the regulatory measures with utmost “political will” (and) a study to determine the carrying capacity of the lake.”
NATURAL RESOURCES MANAGEMENT

Official statistics on inland capture fisheries are the responsibility of BFAR and the Bureau of Agricultural Statistics. Their accuracy has been questioned in an FAO report. For Lake Taal, the number of fishers and their catches are probably significantly higher than those officially reported, even with the general decline in the lake’s fisheries. In 1999, BFAR recorded a total of 1,180 fishers in Lake Taal. They were most numerous in the three municipalities that also have the most cage farmers.

Many measures have been designed to contribute to the sustainable management and conservation of the lake’s fisheries. In 1975, a 1,289-ha fish sanctuary was established for conservation purposes under Fisheries Administrative Order No. 118. In 1996, the entire area of Taal Volcano and Lake Taal was designated under the Philippine National Integrated Protected Areas System as a “protected area,” in which ecological processes, genetic diversity, and sustainable use of natural resources must be maintained. Despite such measures, overfishing and the use of illegal gears have continued, and obstructions in the Pansipit River have reduced the number of migratory fish species in the Lake Taal from 31 in 1927 to 5 in 1996 (footnote 7 [ii]). Moreover, there has been a decline in the fisheries catch, the most visible and widely reported aspect of which concerns the fishery for the lake’s unique endemic freshwater sardine, Sardinella tawilis (locally called tawilis).

The abolition of the Presidential Commission on Tagaytay and Taal in 2000 has meant that policies and decision making related to sustaining and conserving the lake are now the responsibility of the PAMB. LGUs are expected to take the lead in implementing policies and regulations. A major challenge is how to reconcile and to strike a balance among the competing uses of the lake. Lake Taal is a major tourist destination. The existing Tagaytay-Taal Integrated Master Plan was conceived for this purpose (footnotes 6[i] and 29). To date, however, tilapia cage farming has not been adequately managed in terms of its relationships with other lake users and its environmental impacts.

There are reports of longstanding conflicts between the lake’s fishers and the tilapia cage farmers (footnote 7 [iii]). The former, their own illegal practices aside, blame the latter for the decline in the lake’s fisheries, including impeded navigation, lowered water quality, and obstruction of the Pansipit River. Moreover, it is a source of frustration for the fishers to see the fish sanctuary heavily occupied by fish cages. Fish cages, like most structures in open waters, attract wild fish, and this attraction is particularly strong in Lake Taal because of the output of uneaten feed and fecal matter from the cages. Fishers are naturally attracted to fish near the cages, but are repelled by cage farmers who fear poaching and sabotage. During the present survey, respondents reported no such conflicts—although this might be because they were reluctant to make public their personal interests or problems.

53 Coates, David. 2002. Inland Capture Fisheries of Southeast Asia: Current Status and Information Needs. RAP Publication 2002/11. Bangkok: Asia-Pacific Fishery Commission and the FAO Regional Office for Asia and the Pacific (RAP). For the Philippines, it was reported that much of the statistics were based on projections rather than on accurately collected data and that there were insufficient financial and human resources to remedy this. Inland capture fisheries production in Southeast Asia was considered to be underestimated by a factor of 2.5–3.6.

54 These municipalities (with numbers of registered fishers) are Laurel (120), Agoncillo (160), and San Nicolas (420). The other seven municipalities had 36–96 registered fishers. Fisher respondents to a BFAR 1999 survey mentioned the presence of fish cages as a problem for them and that the cages caused “pollution.” A later study (footnote 7 [ii]) recorded 3,761 fishers (20,000 households) and cited survey findings (footnote 7 [ii]) that 58% of these obtained their primary income (average P182/day) from fishing and regarded the presence of “too many fish cages” as a major problem.

55 For example, in 1993, the Provincial Council of Batangas approved Fisheries Ordinance 4, Series of 1993, “Ordinance Providing for the Protection and Rehabilitation of Taal Lake’s Fisheries and Ecosystem” which prohibits “active and other forms of destructive fishing gear/method” and delineates areas in which fish cages and fish traps can be operated. It also set limits for structures in the Pansipit River that would impede fish migrations and recruitment to fish populations in the lake—one among many instruments enacted to protect this river’s role in sustaining the lake’s fisheries.

56 The total fisheries catch of the lake declined from 8,792 t in 1993 to 1,681 t in 1998 and tawilis catches dropped from 29,000 t in 1984 to 6,000 t in 1995 (footnote 6 [iii]). However, the reasons for fluctuating tawilis catches are poorly understood. It almost disappeared in the 1960s, when aquaculture could not have been a contributory cause.
ENVIRONMENT

Water Quality, Fish Cages, and Nutrient Loading

Lake Taal is not a stable environment for tilapia farming. The unpredictability of the volcano and associated seismic activity, with sulfide and ammonia releases from the lake floor, mean that fish in the lake are always at risk. More importantly, the daily addition of artificial feeds to the cages adds large amounts of nitrogen and phosphorus to the lake. The lake’s increasing eutrophication has been broadly welcomed as an “enrichment” (footnote 6 [i]) that is expected to increase fisheries production by providing more zooplankton as feed for tilapias (footnote 6 [v]). This is a simplistic view. The contributions of denser plankton to feeding caged tilapia will be uncertain and water quality (especially dissolved oxygen) is likely to fluctuate more widely. Moreover, the ecology and biodiversity of the lake will change, with uncertain consequences for wild fish.

Fish Kills

Fish kills were known in Lake Taal before aquaculture began there, but the numbers of fish killed were small and no records were kept. Lake Taal, as is common for volcanic lakes, experiences periodic upwellings or overturns (locally called duong) in which deep (sometimes sulfide- and ammonia-loaded) waters containing little oxygen come to the surface because of certain combinations of atmospheric conditions, winds, and currents. Fish are killed mainly by low dissolved oxygen, with sulfide and ammonia poisoning sometimes as contributory factors. Overturns often follow heavy rains that make surface waters colder and heavier, causing them to sink and to be replaced by deeper waters. Southeasterly winds (locally called salatan) are also major causes of overturns in Lake Taal. Since 1997, fish kills from overturns in the lake have caused serious losses to fish farmers and probably also to fishers—although the quantities of fish lost in open waters are less easily estimated than those in cages. Table 2 summarizes some records of fish kills for which overturns were suspected as the main cause. The severity of low dissolved oxygen as a cause of fish kills and poor growth performance is exacerbated.

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Table 2: Summary Data on Significant Fish Kills in Lake Taal from Oxygen Depletion during Overturns

<table>
<thead>
<tr>
<th>Year (months)</th>
<th>Location</th>
<th>Fish</th>
<th>Total Quantity Lost (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997 (June–July)</td>
<td>Agoncillo and San Nicolas</td>
<td>Tilapia (market size)</td>
<td>52</td>
</tr>
<tr>
<td>1999 (May)</td>
<td>Laurel</td>
<td>Tilapia (market size)</td>
<td>20</td>
</tr>
<tr>
<td>2000 (April)</td>
<td>Cuenca</td>
<td>Milkfish (2 fish per kilogram)</td>
<td>63</td>
</tr>
<tr>
<td>2000 (April)</td>
<td>Talisay</td>
<td>Tilapia (market size)</td>
<td>2</td>
</tr>
<tr>
<td>2000 (May)</td>
<td>Agoncillo, San Nicolas, Leviste, Laurel</td>
<td>Milkfish, tilapia, and various benthic species (sizes not given)</td>
<td>&gt;1,200</td>
</tr>
<tr>
<td>2000 (June)</td>
<td>San Nicolas, Pansipit River</td>
<td>Tilapia and milkfish (and snails)</td>
<td>50</td>
</tr>
<tr>
<td>2000 (August)</td>
<td>Various</td>
<td>Milkfish (all sizes) and tilapia (market size)</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>


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57 Assuming a feed conversion ratio of 1.5 (weight of dry feed given: weight of fish harvested), about 64% of the nitrogen and 81% of the phosphorus in the feeds is released into the lake environment. This estimate is based on data published by Edwards, Peter. 1993. Environmental Issues in Integrated Agriculture-Aquaculture and Wastewater-fed Fish Culture Systems. In Environment and Aquaculture in Developing Countries, edited by Roger S. V. Pullin, Harald Rosenthal, and Jay L. Maclean. ICLARM Conference Proceedings 31, Manila. p. 193–170. According to Yambo (2000) (footnote 6 [iii]), 16 kg of phosphorus are released into Lake Taal for every 1.5 t of feed given. Dela Vega (2001) Feeds and Feeding of Tilapia in Cages in Taal Lake. Paper presented during the 5th Southern Luzon Zonal Research and Development Review, Development Academy of the Philippines, Tagaytay City, 4–5 October 2001, as cited by Basiao (2003) (footnote 5 [ii]) estimated that the average wastage of tilapia feed in Lake Taal was 2.6 kg (dry weight) per cage (presumably 10 x 10 x 5–7 m) per day; i.e., “624 t for one culture period with 2,000 units of cages.”

58 The value of plankton as a source of food to caged tilapia depends on its density and species composition. The Nile tilapia gut is highly acidic and adapted to the digestion of blue-green algae (cyanobacteria); it cannot digest green microalgae to the same extent. The composition of Lake Taal phytoplankton has been reported as containing significant proportions (31%) (footnote 10) or very low proportions (2.4%) (footnote 6 [v]) of blue-green algae. There will be considerable variation with location and season. The lake’s zooplankton is typically tropical.

59 Overturns in deep volcanic lakes are different from the low dissolved oxygen conditions that cause fish kills in shallow, unstratified waters with dense fish populations, such as the fish pens and cages of Laguna de Bay. In Laguna de Bay, the low dissolved oxygen that causes fish kills results almost entirely from the high oxygen demand (by the fish and other lake biota) exceeding the oxygen supply from photosynthesis (by phytoplankton) and from oxygen diffusion at the water’s surface. Such dissolved oxygen conditions normally occur in still, hot weather and when photosynthesis is greatly reduced or absent, as with extensive cloud cover and at night. The phytoplankton then use oxygen but supply little or none. Overturns in Lake Taal occur in both hot and cold weather. Water with much reduced oxygen content is brought to the surface. The dense caged fish populations and the plankton around them (denser than in open waters) already have a high oxygen demand, which then cannot be met. The problem is again exacerbated at night and under heavy cloud cover, when photosynthesis is absent or reduced. Low dissolved oxygen also has chronic sublethal effects in suppressing fish growth, but this does not appear to have been studied in Lake Taal.
by other factors: poor fish health (parasitic infestation and bacterial infection) and poor water quality (especially elevated ammonia). The majority of cage respondents (78%) reported that they had experienced fish kills, which they attributed to lack of oxygen (71%), polluted water (59%), and diseases and parasites (31%). Most of the fish kills occurred in May (29%) and June (26%).

Climate and Natural Disasters

El Niño-Southern Oscillation (ENSO) conditions have occurred in the Philippines in 1982–1983, 1990–1992, and 1997–1998. ENSO years are typified by droughts and they usually have fewer typhoons than normal years, but their impacts on freshwater aquaculture are generally negative.60 Clearly, the main threat of a major disaster in Lake Taal is that of the periodic activity of the volcano (footnote 9). The eruption of Mount Pinatubo caused ash to fall on Lake Taal, but no serious effects were recorded.

Biodiversity and Alien Species

Tilapias are alien species throughout the Philippines. They were introduced for aquaculture because there are no comparable native species. The introduction and use of alien aquatic species, and related inspections and quarantine, have long been the responsibilities of BPAR under RA No. 8550 (the 1998 Fisheries Code) and preexisting legislation, but lack of adequate resources and of lack of public awareness and concern have made effective controls impossible. Philippine fish farmers, institutes, and the aquarium trade introduce alien aquatic species in contravention of national regulations and of the international conventions and codes of conduct to which the Philippines is a party.61 This situation poses potential threats not only to biodiversity and the natural environment but also to tilapia farming, because of the risks of introducing diseases and parasites. Introductions that are not officially sanctioned are rarely accompanied by a precautionary approach or by adequate quarantine measures. In general, Nile tilapia introductions have caused far fewer adverse environmental impacts than those of some other tilapias, but it is potentially invasive as an alien species and a potential threat to native aquatic biodiversity in pristine and other waters.62

Tilapias (including Nile tilapia) have been implicated in the decline and even extinction of some Philippine endemic freshwater fishes, for example, some cyprinid species of Lake Lanao, Mindanao. Much of the literature tends to blame alien species as the sole or principal cause for such losses, while neglecting other major causes such as siltation (from logging of watersheds), pollution, overfishing, and the interactions of these factors. Nile tilapia is not known to be a significant predator on other fish. It eats primarily blue-green algae, other plankton, and detritus. It is unlikely that it could cause significant depletion or extinction of any of Lake Taal’s native species. Moreover, the lake has only limited areas of the shallow soft bottom habitats that are essential as breeding grounds for tilapias. There is, however, speculation to the contrary.63 The possibility that Nile tilapia populations in Lake Taal pose threats to its natural biodiversity should be more thoroughly investigated. Lake Taal contains water hyacinth (Elodea colonica), an invasive floating weed that can seriously hamper fish cage operations, as it has in many other lakes. The other potentially problematical floating weed, Pistia stratiotes, is probably absent from Lake Taal (footnote 6[i]). Cage farmer respondents (64%) reported that tilapia escape from their cages. The majority (86%) believed that this had no effect on the environment. Piranha (30%) and sharks (28%) were the alien species that farmers feared most as potential introductions.

60 The 1997–1998 ENSO caused the water level of Lake Taal to fall by 2–3 m, stranding some tilapia cages at the lake’s margins. Cage productivity declined to about 1–2 t per cage per cropping cycle, compared with the normal 3–4 t. About 6.5 ha of tilapia nursery ponds were affected by water shortages, with the loss of about 3 million fingerlings. Source: Luistro, Aída P 1999. The Impact of El Niño on the Fisheries in the Southern Tagalog Region (Region 6). In Fisheries Production and the El Niño Phenomenon, edited by Hermínio R. Rabanal. PCAMRDR Book Series No. 27/1999. Los Baños, Laguna, Philippines: Philippine Council for Aquatic and Marine Research and Development (PCAMRDR). p. 117–128.

61 The 1993 Convention on Biological Diversity (www.biodiversity.org), ratified by the Philippines, requires parties to: “Prevent the introduction of, control, or eradicate those alien species which threaten ecosystems, habitats or species.” Responsible use and control of species introduced for aquaculture and fisheries are guided by FAO, of which the Philippines is a member state. They are part of the FAO Code of Conduct for Responsible Fisheries (http://www.fao.org/fi/agrem/codecom/codecom.asp). Prior appraisal of the possible impacts of alien species introductions is a major aspect of the FAO Technical Guidelines for Responsible Fisheries-Precautionary Approach to Capture Fisheries and Species Introductions (http://www.fao.org/DOCREP/003/ W3592E/W3592E00.HTM). These have not yet been adequately applied in the Philippines.


63 For example, Zafarall et al. (1999) (footnote 6 [ii]) have commented: “Predation by tilapia has drawn the sinarap population to extinction in Lake Buhi. Will it do the same to the tawilis?” However, the problem alluded to in Lake Buhi has multiple environmental causes. Similarly, Basiao (2003) (footnote 5 [ii]) noted that important natural fishery resources in the Philippines, including tawilis in Lake Taal, “might have been threatened because of introduced species associated with cage farming.”
FISH QUALITY

The timing of cage harvests depends largely on destination markets. This is undertaken to ensure product freshness and quality on reaching the next market channel. For instance, if the fish are intended for local and neighboring markets, harvesting starts before dawn so they are available before markets open. Tilapia intended for Metro Manila markets are usually taken in the afternoon to consignment markets that start early in the evening. Tilapia are taken fresh killed, or moribund on ice, from farm gate to market. Cage respondents attribute the good quality of harvested tilapia to water quality (96%), genetic strain (81%), and the quality of feeds used (38%). Off-flavors are a well-known problem in farmed freshwater fish, particularly those raised in ponds and lakes where there is no possibility of managing the diversity and abundance of plankton.64 In Lake Taal, respondents perceived that no off-flavor problems exist (98%). There appear to be no serious human health concerns related to tilapia cage farming and nursery operations.

CRISIS AND COPING STRATEGIES

In the 12 months before the present survey (i.e., mid-2002–mid-2003), the five major types of crisis reported by all respondents were: typhoon (75%), flood (45%), financial loss from livelihood occupation (41%), illness in the family (39%), and drought (20%). The others were death of a household member, loss of job, eviction, and fish kills. Farmers coped with these crises by relying on family savings (51%), obtaining loans from friends and relatives (40%), selling livestock (18%), getting a loan from a money lender (9%), selling household assets (6%), and pawning jewelry or mortgaging land (3%). Farmers are very vulnerable to external risk, especially natural calamities, which have severely affected their financial situations and their capacity to continue tilapia farming. Exposure to such risks might explain why most farm respondents are caretakers.

OUTCOMES

Respondents were asked to assess their situation over time, using a baseline-independent method.65 Comparing their situation at present with that 5 years ago, tilapia cage farmers perceived that they have continued to benefit from tilapia farming in terms of employment and positive incomes. However, while employment gains have remained favorable, cash incomes have declined over the period. These perceived differences were statistically significant,66 as were those for perceived declines in the state of natural resources, in farm investments, and in access to credit. Nevertheless, farmers perceived improvements in technology dissemination and access to information. Moreover, their incomes had enabled them to acquire household assets and improve their homes.

Nursery farmers believed that tilapia nursing had been instrumental in increasing their food consumption, employment, farm investments, and shelter improvements over the past 5 years. Nursery farming was presently seen more favorably than cage farming for several reasons: the local demand for nursed fingerlings was very high and local production was not sufficient to meet it, and nursery operations were less risky and less capital intensive than cage farming. The survey also indicated that nursery farmers were learning new techniques to improve production. This shows the dynamism of the nursery operations and substantiates other statistically significant perceptions of nursery farmers that access to technology at village level had improved over that 5 years ago, and had helped new entrants to nursery farming. Nursery farmers shared with cage farmers the perception that the lake’s resource base was deteriorating. Nursery farmers knew that their survival depended on stable and continuous cage operations.

Cage farmers felt that technology dissemination, its adoption in the villages, and household shelter improvement will continue to improve over the next 5 years. They expect the resource base to continue to deteriorate, but are hopeful that tilapia farming will remain a major source of employment for their families. Nursery farmers are very optimistic that tilapia nursing will continue to improve their overall food and tilapia consumption, provide additional employment and cash incomes, and increase their capacity to invest in

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66 The test of means was the statistical method used. The difference between the two periods being compared was statistically significant (p<0.01) at the 1% level.
tilapia farming. They also expect that access to tilapia technology will further improve, with increased adoption in their respective communities.

CONCLUSIONS

Tilapia cage farming in Lake Taal, Batangas contributes to reducing poverty by providing direct employment: for cage farmers and caretakers, for those working in the lakeside nurseries that supply tilapia seed to the cages, and in fish handling and marketing and fish feed supply. Cage farmer respondents continue to earn their incomes and gain additional employment from tilapia farming, but their current income benefits have declined compared to those 5 years ago. Respondents from nursery farms said that they were better off now than 5 years ago in terms of food consumption, employment, investments, and home improvements, but were well aware of their dependence on the continuation of the cage growout operations. Both types of respondents believed that tilapia farming would remain their primary source of livelihood for the next 5 years. In addition, they expected continuous improvements and access to tilapia technology and adoption.

For both cage growout of tilapia and associated nurseries, access to livelihood assets, together with robust markets (input, output, and labor markets), available services and infrastructure, and supportive policies and institutions, are vital factors for success. The main factor that initiated and caused the rapid expansion of tilapia cage farming in the lake was its provision of water space owned by the Government and, therefore, available for occupation by would-be tilapia farmers that had no land. Moreover, the lake water was of good quality for tilapia cage farming, apart from ever-present risks of volcanic activity, overturns of noxious deep waters to the surface, and typhoons—risks that farmers appear willing to carry for want of other opportunities to farm fish. However, the expansion of cage farming in the lake has been largely unconstrained by attempts to limit entry and to manage cage farming in concert with the other uses of the lake, principally fishing and tourism. The very success of cage farming in Lake Taal threatens its future because of overcrowded cages, declining water quality, fish kills, and poor feed conversion efficiency that all contribute to worsening harvests and eroded profit margins. These problems are, however, beginning to be addressed though improved policies and management to reduce the numbers of and areas occupied by cages to sustainable limits and to lessen conflicts.

Cage farming of tilapia in Lake Taal is an important contributor to keeping tilapia prices stable, thus helping to make tilapia more affordable to poor consumers. Lake Taal tilapias have a high reputation for quality. It is important that their contributions to rural and urban food security be maintained. Well-sited and well-managed tilapia cage farms and nurseries merit strong efforts to safeguard their future against further mismanagement, environmental deterioration, alien species, fish diseases, fish kills, and rising feed costs. Only if these manageable risks can be addressed effectively can cage farming operations in Lake Taal be sustainable and sufficiently profitable to withstand the inevitable occasional losses from adverse natural events.
CASE STUDY 7

OVERVIEW OF SMALL-SCALE FRESHWATER AQUACULTURE IN THAILAND

BACKGROUND

This case study was prepared to provide an overview of small-scale freshwater aquaculture in Thailand to illustrate the contextual importance of aquaculture—its historical development, technology and management, markets, development policy and the role of the Government, community-based development initiatives, pertinent safeguards, relevant lessons, and ways to benefit the poor.¹

Fish is the traditional source of animal protein in the Thai diet as indicated by common Thai expressions: *kin kao kin pla leo yang?* (have you eaten rice and fish yet?) and *nai nam mee pla nai na mee kao* (in the water are fish, in the field is rice).² The great importance of fish in the Thai diet may be best illustrated by quotations from H.M. Smith, an American who was the first Director General of Fisheries in the country: “fisheries … produce the principal animal food consumed by the Siamese people … there is an enormous consumption of fish in the households of peasants, and probably the chief value of the freshwater fisheries lies … in providing a cheap, readily available and nutritious animal food for the millions of farmers and small tradesmen and their families.”³ Fish is second only to rice for Thais and has good quality, containing easy-to-digest protein, all amino acids required for human growth, unsaturated fat, and vitamins and minerals.⁴

Estimated annual per capita consumption of fish based on a field survey of consumers in 1998–1999 was an average of 28.8 kilograms (kg) of which more than 90% was in the form of fresh fish.⁵ The highest per capita fish consumption by region was 33.8 kg in Northeastern Thailand. Freshwater fish accounted for 70–90% of the total quantity of fish consumed in all regions. Fish ranked first among animal protein sources, followed by chicken, pork, and beef. The national average fish consumption per capita in 2001 was 33.5 kg according to the statistics of the Department of Fisheries (DOF).⁶ This national average hides the large variation between communities with good access to fish and those without. The wide range in fish consumption also mirrors wide differences in income. Very low fish consumption levels of about 3–5 kg per capita occur in remote communities of Northern Thailand. However, these may not include fish obtained and consumed from outside the village.⁷

Thailand is situated in the Indochina peninsula of Southeast Asia with an area of nearly

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¹ This case study was undertaken by P. Edwards and Cherdak Virapat in collaboration with N. Bestari and R. Pullin.
⁴ Department of Fisheries (DOF). 2000. *Fish Processing*. Bangkok: DOF. (In Thai)
⁶ Pongpat Boonchuwong, Director of Fishery Economic Division, Department of Fisheries, Bangkok. Personal communication, 2003.
514,000 square kilometers (km²). It is bounded on the west and northwest by Myanmar, on the north and northeast by the Lao People’s Democratic Republic, on the east by Cambodia, and on the south by Malaysia. The country’s climate is monsoonal with clearly defined wet and dry seasons. The rainy season runs from May to October, the cool dry season from November to February, and the hot dry season from March to May, except in the south where there is no pronounced cool season. The annual precipitation varies from 760 millimeters to as much as 4,200 millimeters. Both droughts and floods are common, especially in Northeastern Thailand.

Thailand has achieved significant economic development in recent years; its gross domestic product (GDP) grew by more than 8% annually in 1990–1996 prior to the Asian financial crisis. Gross national income per capita was $2,020 in 2000, with 13% of the population below the national poverty line. The fisheries sector contributed 1.9% to the GDP in 2000; freshwater fisheries contributed about 10% of the total fisheries contribution.

The importance of floodplain fisheries has been dramatically reduced as a consequence of national development programs, especially the construction of multipurpose dams. Although these dams have created reservoirs for water storage to be used in irrigation and/or electricity generation, they have diminished flooding in the floodplains and reduced areas that have served as natural spawning and nursing grounds for most fish species. This, coupled with pollution and environmental degradation, has resulted in a drastic decline of fish populations and catches. The freshwater fish fauna of Thailand is rich because there is a vast network of rivers and canals, especially in the central plains, and numerous swamps, reservoirs, and water storage tanks. However, freshwater fisheries have declined, providing a major stimulus for the relatively recent development of aquaculture in the country.

Aquaculture production in Thailand is influenced by geographic factors and the country’s tradition of fish culture. Thailand has riverine systems of nearly 120,000 km, 300,000 hectares (ha) of natural lakes, and 255,000 ha of reservoirs. There is a great diversity of freshwater aquaculture systems and species in Thailand, including several that have relevance for small-scale producers and national food security. According to DOF statistics, more than 20 fish species are farmed, with total freshwater fish production of 271,000 tons (t) in 2000. Although data are not compiled by scale and intensity of fish farming, herbivorous and omnivorous fish species with greatest relevance for small-scale aquaculture—such as carps, gouramis, and tilapias—comprise about 60% of the total. With production of 82,000 t in 2000, tilapia are the major herbivorous species. Four farming systems are recognized officially: fishponds, which make up 89% of the total inland aquaculture production; and fish culture in ricefields (7%), in ditches (2%), and in cages (1%). Most freshwater production takes place in the central plains (58%) and least in the south (6%) where marine fish are readily available. The two regions where poverty-focused aquaculture has greatest relevance are Northern and Northeastern Thailand with 19% and 18% of the total inland aquaculture production, respectively, but with 22% and 50%, respectively, of the total number of farms in the country. The Northeastern region has the largest number of small-scale fish farms (Table 1) according to official statistics. These data are likely to be a gross underestimation because of the difficulty in identifying small and widely scattered aquaculture farms in the region.

DOF has been responsible for rural fisheries development since 1982 under the Fifth National Economic and Social Development Plan (1982–1986). Many important projects, such as the Village Fish Pond Development Project (VFPDP) and several projects under royal initiatives, have been carried out. The VFPDP is a state-sponsored initiative in support of community fishpond development projects, which has continued to date. Its objectives are to increase fish production for local consumption to generate local employment and to reduce malnutrition and poverty. Under the VFPDP, the mandate of DOF is to (i) support the

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10 Freshwater capture fisheries in Thailand might have passed their climax of development almost 80 years ago due to overfishing. Construction of modern irrigation systems led to further declines. The valuable carnivorous snakehead (Channa striata) used to be the most abundant staple food fish. Giant freshwater prawns (Macrobrachium rosenbergii) were also abundant and consumed in large numbers. The fisheries may have been adequate for the needs of a relatively small population, but the current overall high level of consumption of freshwater fish depends on aquaculture. (Edwards, Peter, Karl E. Weber, Ed W. McCoy, Chintana Chantachaaeng, Chintana Pucharaprakiti, Kamtorn Kaewpaithoon, and Samart Nitsmer. 1983. Small-Scale Fishery Project in Pathumthani Province, Central Thailand: A Socio-Economic and Technological Assessment of Status and Potential. Asian Institute of Technology Research Report 158. Bangkok: Asian Institute of Technology.
12 DOF has initiated a variety of rural development models thought to be appropriate for community development to increase fish production in community ponds, public waters, and school ponds. The VFPDP, one of the most important rural fisheries development programs, started in 1978 as a pilot project in 14 villages of 12 provinces in Northeastern Thailand. Although referred to as village fishponds, the water bodies are natural, improved, or engineered multipurpose reservoirs.
Table 1: Freshwater Aquaculture Farms in Thailand

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Number of Farms</th>
<th>Total</th>
<th>Pond</th>
<th>Ricefield</th>
<th>Ditches</th>
<th>Cages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>256,082</td>
<td>239,122</td>
<td>11,396</td>
<td>4,655</td>
<td>909</td>
<td></td>
</tr>
<tr>
<td>Northern</td>
<td>56,455</td>
<td>55,313</td>
<td>233</td>
<td>633</td>
<td>276</td>
<td></td>
</tr>
<tr>
<td>Northeastern</td>
<td>127,522</td>
<td>120,180</td>
<td>6,889</td>
<td>101</td>
<td>352</td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>45,390</td>
<td>37,716</td>
<td>4,201</td>
<td>3,217</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>Southern</td>
<td>26,715</td>
<td>25,913</td>
<td>73</td>
<td>704</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Area (hectare)</th>
<th>96,145</th>
<th>68,516</th>
<th>25,244</th>
<th>2,347</th>
<th>38</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>9,627</td>
<td>9,172</td>
<td>316</td>
<td>123</td>
<td>16</td>
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<tr>
<td>Northeastern</td>
<td>29,702</td>
<td>23,642</td>
<td>6,012</td>
<td>39</td>
<td>9</td>
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<tr>
<td>Central</td>
<td>54,313</td>
<td>33,346</td>
<td>18,894</td>
<td>2,062</td>
<td>11</td>
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<tr>
<td>Southern</td>
<td>2,503</td>
<td>2,356</td>
<td>22</td>
<td>123</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Production (metric ton)</th>
<th>271,012</th>
<th>240,907</th>
<th>19,936</th>
<th>6,707</th>
<th>3,462</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>51,016</td>
<td>49,708</td>
<td>244</td>
<td>118</td>
<td>946</td>
<td></td>
</tr>
<tr>
<td>Northeastern</td>
<td>47,929</td>
<td>42,324</td>
<td>4,455</td>
<td>16</td>
<td>1,134</td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>156,220</td>
<td>133,481</td>
<td>15,157</td>
<td>6,252</td>
<td>1,330</td>
<td></td>
</tr>
<tr>
<td>Southern</td>
<td>15,847</td>
<td>15,394</td>
<td>80</td>
<td>321</td>
<td>52</td>
<td></td>
</tr>
</tbody>
</table>


rehabilitation or construction of village fishponds (reservoirs, swamps, and tanks); (ii) train local support personnel; (iii) increase the supply of fish seed or fingerlings; and (iv) provide technical advisory services. The rationale of VFPDP stems from aims to strengthen social cohesiveness and develop community awareness, and the fishponds generally serve as core facilities that provide self-help opportunities. Apart from generating direct benefits in terms of fish production and improved water supply, the VFPDP trains villagers to be self-reliant. The dissemination of fish farming technology has resulted in the establishment of many fishponds by private individuals and communal fishponds in villages. In 2001, the Government decentralized authority for management of natural resources, including fisheries in all community waters, to the subdistrict governments, locally known as Tambon Administrative Organizations (TAOs). TAOs have become local institutions responsible for rural development. In the context of these decentralization measures, the DOF’s budget for village pond construction was being progressively transferred to TAOs during 2001–2004.

HISTORICAL DEVELOPMENT

Aquaculture may have started as early as 1691 in Thailand although this was for ornamental gold fish rather than for food.13 Aquaculture for food fish appears to be a relatively recent development because of the former abundance of wild fish. The native riverine catfish (*Pangasius hypophthalmus*) has been farmed on a small scale in pens and ponds in Central Thailand since the middle of the 19th century. It is generally considered that Chinese immigrants introduced organized aquaculture to Thailand in the early years of the 20th century using fish fry imported by boat from the People’s Republic of China. Chinese carps (Chinese silver carp [*Hypophthalmichthys molitrix*] and grass carp [*Ctenopharyngodon idella*]) were cultured on a small scale, mostly in Bangkok where there was a ready market among the large immigrant Chinese population.

DOF started to study the lifecycle of the native snakeskin gourami (*Trichogaster pectoralis*) in 1932—its entire lifecycle is carried out in the flooded ricefields—but was unable to convince people to farm it, possibly because wild fish were still abundant. During the 1950s, with technical assistance from the Food and Agriculture Organization (FAO) of the United Nations, DOF imported and disseminated Mozambique tilapia (*Oreochromis mossambicus*) which soon became a popular farmed fish in ponds. However, interest in this fish waned because of reservations about the quality and flavor of its flesh. Later, tilapia farming became established following introduction of Nile tilapia (*Oreochromis niloticus*) in 1965 after His Majesty King Bhumipol received specimens as a gift from His Imperial Highness Emperor Akihito of Japan when the latter was Crown Prince.

DOF promoted rice-fish farming in Northern and Central Thailand in the 1950s, but this system is still not well developed to date. An exception is the farming of snakeskin gourami southeast of

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Bangkok where farmers converted unproductive ricefields in relatively saline soils of the lower Chiangrak-Klong Dan irrigation scheme to an extensive fish farming system. Since the 1960s, DOF has placed great emphasis on the artificial spawning of Chinese carps, common carp (Cyprinus carpio), silver barb (Barbodes gonionotus), and riverine catfish. The availability of seed of these fish species led to a large increase in aquaculture production.

BIOPHYSICAL FEATURES

Water for small-scale rural aquaculture is generally available, especially in floodplain and irrigated areas. However, the water supply for aquaculture is restricted in drought-prone areas in the northeast where there is significant poverty (footnote 2), and in ponds inappropriately located in hilly areas.

In areas where agricultural chemicals are used intensively, water is contaminated with pesticides at low concentration.\(^\text{14}\) Measurements in 25 river basins, including Bangpakong, Chaopraya, Kok, Pasak, Sakakrang, Songkhla Lake, Tha Chin, and Yom, showed them to have poor average water quality in terms of dissolved oxygen (DO), biochemical oxygen demand, coliform bacteria, and ammonia-nitrogen.\(^\text{15}\) The average DO levels in the lower Tha Chin River were reported to be as low as 1 milligram per liter, unsuitable for fish and aquatic organisms. Water quality in the main rivers in the north (Nan, Ping, Wang, and Yom) remains generally good, especially in the upstream flow from the northern mountains, and the average concentration of DO was more than 5 milligrams per liter. Nonpoint source pollution became significant in many parts of the country during the late 1990s, especially in water from agricultural areas.

In some areas, especially in the northeast, saltwater intrusion has a strong effect on freshwater aquaculture. Water temperature is also important for rural aquaculture. In the winter in the north, temperatures may drop to less than 10 degrees Celsius and cause detrimental effects on fish culture. In newly constructed ponds, water turbidity is common.

TECHNOLOGY AND MANAGEMENT

Seed Supply. More than 600 million fry of tilapia, the dominant fish in small-scale freshwater aquaculture, both mixed sex and monosex male (through hormone-induced sex reversal), were produced in 2001. This seed supply represented 45% of the estimated total fish seed produced in the country (1,520 million). The Government’s share in producing fish seed was about 17%, two thirds of which were produced in inland fisheries stations.\(^\text{16}\) At these stations, seed is produced for various purposes: stocking community ponds, free distribution and sale to fish farmers, and for experiments. Private farms produce and nurse seed to various size classes to meet requirements of fish farmers. For cage culture practices, a relatively large size of seed (20–30 fish per kg or larger than 10 centimeters) is required.

Major Hatcheries. For monosex tilapia seed, the main sources are in a few subdistricts of Chonburi and Chachoengsao provinces, and DOF hatcheries. A well-established network of local and distant traders links producers to customers all over Thailand. Demand for tilapia fry was estimated at

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\(^\text{15}\) Department of Water Resources. 2003. *Records of the First Step in the Year 2003: Think of Water Think of Us. Bangkok.* This was due to overloading of wastewater from household communities, industries, and animal farming. The effects are more pronounced in the dry season.

\(^\text{16}\) DOF started a program to establish fish breeding centers (FBCs) under VFPDP in 1982. At present, there are 162 FBCs in the country based in local communities and sometimes at schools, comprising 84 in the northeast, 36 in the north, 19 in Central Thailand, and 23 in the south. However, only 39 FBCs are currently in operation, with a seed production capability of about 6.8 million fingerlings in 1997. There are some problems regarding resource allocation among local management organizations—there is a lack of continuous input by local management committees and support from the Government, and inefficient transfer of appropriate technology to local operations.
400 million in 2000.\textsuperscript{17} The major sources of monosex tilapia seed are Charoen Pokaphan Group and other private hatcheries. Large private hatcheries are located in the west at Prachinburi (Namsai Farm), northeast at Udon Thani (Udonpatana Foundation), Khon Kaen (Boonhome Farm), Kalasin (Viboon Farm), north at Chiangmai (Chiangmai Patana Farm), and south at Petchaburi (Manit Farm).

**Major Species.** Nile tilapia is currently the major species with 30% of the total national inland aquaculture production, followed by silver barb with 17% and common carp with 2% (footnote 11). Production data for Chinese carps (less than 1%) and Indian major carps (rohu \textit{(Labeo rohita)}, and mrigal \textit{(Cirrhinus mrigala)}, at 0.4% each) probably underestimate their importance for the poor because these species are widely cultured, especially in Northeastern Thailand. The availability of Nile tilapia has been a major factor in expansion of small-scale aquaculture. DOF promotes a stocking program of tilapia in various waterbodies throughout the country, such as village fishponds, public waters, irrigated reservoirs, domestic water supply reservoirs, and some multipurpose reservoirs.

**Growout Farming.** The average annual yield across all aquaculture farm types in 2000 was about 2.8 t/ha and for ponds, 3.5 t/ha (Table 1). Tilapia and herbivorous and omnivorous carps for small-scale aquaculture are largely farmed in polyculture in ponds. The conclusions of a survey of fish farms (footnote 10), carried out in Pathumthani Province in Central Thailand more than 2 decades ago to identify aquaculture techniques for small-scale farmers, are still relevant: small-scale farmers are constrained by limited on-farm sources of fertilizers and feeds and access to, and affordability, of marketed feed. Of course, without proper pond management, fish production is low: the average yield of 490 poorly managed village fishponds in Northeastern Thailand in the mid-1990s was only 416 kg/ha.\textsuperscript{18}

Large commercial fish farms are either integrated with feedlot livestock and/or use waste food from factory canteens and restaurants or various by-products from agroindustrial factories. Most integrated fish farmers are primarily livestock entrepreneurs who have constructed ponds in the floodplain to raise the level of the animal quarters to prevent animals from drowning in the rainy season. Livestock quarters are located above or adjacent to the pond, such that their manure fertilizes the fishponds and spilled feed provides nutritional inputs for fish. Such integrated farms still provide the bulk of low-value fish for urban consumers. These types of aquaculture are dominated by entrepreneurs in peri-urban areas, especially in the provinces in Central Thailand, and have little relevance for small-scale farmers.

Technical constraints facing new entrant small-scale farmers have been largely resolved through research partnerships between the Asian Institute of Technology and DOF. Much of the research was carried out in resource-poor Northeastern Thailand. Although much of Thai aquaculture comprises intensive farming systems, several aquaculture systems with relevance to small-scale farmers were developed over the past few decades in former ricefields, such as farming of snakeskin gourami.\textsuperscript{19} Nile tilapia seed production,\textsuperscript{20} giant freshwater prawn \textit{(Macrobrachium rosenbergii)} farming, and inland culture of (marine) shrimp \textit{(Penaeus monodon)}. Most farmers who grow these species are now better off; many were relatively poor rice farmers before they took up aquaculture.\textsuperscript{21}

Fish health is a major concern in aquaculture. When fish farmers change their farming practices from extensive and semi-intensive to intensive farming, they inevitably face increased risks of fish diseases. DOF has published guidelines for the proper use of drugs and chemicals for fish disease protection and treatment.\textsuperscript{22}


\textsuperscript{20} The major area for tilapia seed production is a small area in three contiguous subdistricts of Chonburi and Chachoengsao provinces in Central Thailand. Former rice farmers produce 2–3 centimeter long seed as swim-up fry in shallow ponds fertilized with manure from feedlot livestock farms; the manure is delivered to the pond side in plastic containers (Little, David, Chang K. Lin, and Warren A. Turner. 1995. Commercial Scale Tilapia Fry Production in Thailand. *World Aquaculture* 26(4): 20–24).


\textsuperscript{22} Aquatic Animal Health Research Institute. 2002. Guidelines for Use of Drugs and Chemical Agents in Fish Disease Protection and Treatment. Bangkok: Department of Fisheries. (In Thai)
ACCESSING MARKETS

Domestic marketing of freshwater fish is complex, involving several channels and types of markets and parties. In general, the distribution and marketing of freshwater fish is efficient and market access by fish farmers, including small-scale producers, is not a constraint. Fish marketing is primarily in the hands of the private sector, with the exception of a state enterprise, the Fish Marketing Organization, which operates an assembly market in Bangkok. Many private assembly markets have been established in the last few years near production centers as well as in Bangkok and surrounding provinces. Fish trading in assembly markets is done through auctions and negotiations.

Prices at the farm gate and in wholesale and retail markets are very competitive, with many buyers and sellers along the intermediation chain. Postharvest support facilities are adequate; freshwater fish are easily delivered from production centers to markets throughout the country. Fish transportation benefits from reliable road networks, which link all districts and provinces. With numerous fish producers and suppliers and equally numerous buyers along the fish marketing chain, prices of freshwater fish are competitive. Market participants include (i) farmers who sell their fish to wholesalers, retailers, or collecting agents, depending on quantities; (ii) fish collectors who act as intermediaries between fish farmers and fish traders by gathering fish from various farms and benefitting from price differentiation in postharvest grading of fish into size categories; (iii) fish agents who earn commission fees from transactions between buyers and sellers at assembly markets; (iv) fish wholesalers who purchase fish from assembly markets or buy directly from fish farmers, and sell to retailers; (v) fish processors who buy fish directly from fish farmers, assembly markets, wholesalers, and other processors; and (vi) fish retailers who sell to consumers.

Fish prices vary by location (Table 2). They tend to be lower in Central Thailand (the main region for inland aquaculture) than in the northeast and south. The snakehead fetches the highest prices. Inexpensive tilapia and silver barb, along with Indian major carps (mrigal and rohu) are of more relevance to the poor. Rural markets require relatively small tilapia for consumption, while urban markets require larger tilapia. Price fluctuations at the farm gate and in wholesale markets are generally harmonized because the time lag between harvest, marketing, and final sale to consumers is short. In general, fish

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23 See footnote 5 for an overview from which this account is largely derived.
24 Typically, large tilapia comprise no more than 2 fish/kg, medium sized are 3–5 fish/kg, and small tilapia are more than 5 fish/kg.

### Table 2: Average Retail Prices of Freshwater Fish Species in Selected Thailand Provinces in 2000 (baht/kg)

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Bangkok</th>
<th>Ang Thong</th>
<th>Chantaburi</th>
<th>Khon Kaen</th>
<th>Udon Thani</th>
<th>Nakon Sawan</th>
<th>Pitsanuloke</th>
<th>Chiangmai</th>
<th>Pattani</th>
<th>Phuket</th>
<th>Songkhla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catfish</td>
<td>23.57</td>
<td>18.88</td>
<td>23.40</td>
<td>36.54</td>
<td>38.19</td>
<td>19.23</td>
<td>28.96</td>
<td>32.84</td>
<td>27.56</td>
<td>37.25</td>
<td>32.62</td>
</tr>
<tr>
<td>Snakehead</td>
<td>49.09</td>
<td>44.19</td>
<td>—</td>
<td>56.05</td>
<td>67.10</td>
<td>59.39</td>
<td>49.35</td>
<td>62.24</td>
<td>35.89</td>
<td>—</td>
<td>50.82</td>
</tr>
<tr>
<td>Mrigal</td>
<td>10.52</td>
<td>—</td>
<td>—</td>
<td>32.44</td>
<td>28.96</td>
<td>21.64</td>
<td>31.06</td>
<td>30.00</td>
<td>30.00</td>
<td>—</td>
<td>30.00</td>
</tr>
<tr>
<td>Tilapia</td>
<td>16.14</td>
<td>16.37</td>
<td>15.22</td>
<td>32.52</td>
<td>35.16</td>
<td>26.42</td>
<td>31.24</td>
<td>31.10</td>
<td>37.77</td>
<td>34.95</td>
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<tr>
<td>Silver Barb</td>
<td>16.30</td>
<td>13.86</td>
<td>23.32</td>
<td>30.00</td>
<td>33.89</td>
<td>21.23</td>
<td>28.76</td>
<td>29.89</td>
<td>30.67</td>
<td>26.27</td>
<td>34.75</td>
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<td>Giant</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Gourami</td>
<td>15.00</td>
<td>50.00</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td>Rohu</td>
<td>13.18</td>
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<td>29.79</td>
<td>35.48</td>
<td>19.28</td>
<td>25.00</td>
<td>29.31</td>
<td>39.23</td>
<td>30.01</td>
<td>30.34</td>
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<td>Snakeskin</td>
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<tr>
<td>Gourami</td>
<td>44.08</td>
<td>50.00</td>
<td>—</td>
<td>24.35</td>
<td>—</td>
<td>49.09</td>
<td>25.00</td>
<td>—</td>
<td>40.00</td>
<td>—</td>
<td>36.26</td>
</tr>
</tbody>
</table>

— = data not available.
prices are higher in January–September than in other months.

Freshwater fish are sold either alive or dead. Valuable carnivorous fish, such as sand goby (Oxyeleotris marmoratus), snakehead, and walking catfish are more likely to be marketed alive than less expensive herbivorous and omnivorous fish, which are usually sold on ice. Live fish fetch a premium price of up to 50% over iced or chilled fish. Small fish are sold to low-income consumers in rural areas. These fish are mostly produced by small-scale fish farms. Large fish, preferred by relatively wealthier consumers and by restaurants, are mostly supplied by commercial cage and fishpond operators. Fish are usually sold to fish agents at harvest at the farm gate, although some farmers transport and retail fish themselves.

Wholesale markets are mostly in large cities; many also offer retail outlets. Fish are transported early in the morning to wholesale markets, either directly from farms or from assembly markets by wholesalers for distribution to retailers. Retail markets are scattered in urban and peri-urban areas, generally with numerous stalls supplied with electricity and clean water on a concrete floor inside a traditional open hall. Freshwater fish in retail markets are sold live or dead; whole or in pieces; and fresh or processed, e.g., dried, salted, minced, fermented, and made into fish balls. Freshwater fish are also retailed in supermarkets with a price markup of 40–50% above common retail prices. Wholesalers also export valuable species, such as marble goby and low-value riverine catfish, chilled and frozen, to neighboring countries. Processors and cold storage operators also export carnivorous, herbivorous, and omnivorous species—among the latter mrigal, rohu, silver barb, and tilapia—to the Middle East and riverine catfish to Asia and Europe.

The marketing margin, the difference between the price paid by the consumer and that received by the producer, varies by species. The farmers’ share of the retail prices for silver barb and tilapia can amount to about 50% and 60%, respectively. Typically, the marketing margin for tilapia of 40% is made up of 16% direct marketing costs and the remaining 24% gross margins shared among fish collectors, wholesalers, and retailers. Retailers pay marketing costs related to cleaning, gutting, and cutting fish prior to sale. Retailers also bear the risk of not selling their fish fresh, a situation that can significantly lower the retail prices.

THE ROLES OF GOVERNMENT IN AQUACULTURE EXTENSION

The Government has promoted aquaculture for decades, through both research and extension services. The government strategy for promoting small-scale rural aquaculture in the past included the provision of subsidized inputs. The Government has provided substantial support and incentives to farmers by providing free advisory services for the promotion of aquaculture technologies, and subsidized inputs for pond construction, seed, feed, and lime to fish farmers. The Government has, however, realized that subsidies do not necessarily lead to sustainable aquaculture development, and that it is necessary to extend adequate and appropriate information on aquaculture technologies to targeted fish farmers effectively.

DOF has played an important facilitating role in rural aquaculture development, planning, and implementation. Its services include aquaculture extension and transfer of fish farming technologies to farmers. While fisheries organizations or

25 Most tilapia are for domestic consumption. Marketable size is about 2–3 fish/kg. Tilapia from cage culture are sold to restaurants, food shops, supermarkets, and retail shops in local provinces. Recently, cold storage industries have started to buy tilapia for processing and export. Importing countries include Australia, France, Italy, and the United States. Cold storage industries purchase fish of 400 grams upwards for export markets as frozen products and fish of 100–400 grams for filleting as frozen products or processed products for export.

26 The administrative structure of DOF has two parts: central administration and regional administration. The central administration includes 28 divisions and the regional administration covers 75 provincial fisheries offices (PFOs). The organizational units within DOF that share responsibility for aquaculture management and development include three bureaus and one division (Bureau of Inland Fisheries Research and Development, Bureau of Coastal Aquaculture Division, Bureau of Fishery Technology Transfer and Extension and Feed Quality Control Development Division); four institutes (National Inland Fisheries Institute, National Institute of Coastal Aquaculture, Aquatic Animal Health Research Institute, and Aquatic Animal Genetics Research and Development Institute); 31 fisheries centers; and 75 PFOs.
cooperatives may be found in areas where there are considerable aquaculture activities, the roles of these farmers’ organizations are primarily related to marketing, an area of common interest among farmers. DOF has not been able to mobilize the support of these organizations to deliver its extension programs because of various shortcomings affecting the farmers’ organizations and the aquaculture extension services. Privately managed cooperatives in freshwater aquaculture have generally faced financial and human resource constraints. However, community participation in aquaculture development through village committees, district councils, or subdistrict TAOs has been evident. In this context, fish farmers and villagers participate in planning and making decisions on their community resource use and conservation.

The Government is attempting to make the extension system more responsive to farmers’ actual needs, particularly by providing information more appropriate to farmers’ conditions. In October 2002, it reorganized the overall agricultural extension system and the central responsibilities of DOF in terms of technology development and extension. These are now limited to training functions and providing assistance in the preparation of extension materials in the newly established Bureau of Fishery Technology Transfer and Extension. Under the new extension system, the Department of Agricultural Extension has been mandated to be the sole government agency to organize training as well as farmer selection in all agricultural disciplines, including fish farming. Under the new arrangements, all training activities are decentralized and conducted through the Tambon Technological Transfer Center, which is meant to be a one-stop service center where farmers and local residents can get advice and information, and contact experts in various disciplines.

COMMUNITY-BASED RURAL AQUACULTURE DEVELOPMENT

Community-based aquaculture in Thailand has contributed to the development of self-help initiatives, local ownership, and decision making in the communities. DOF has promoted small-scale and community-based freshwater aquaculture for many years, including through the VFPDP (footnote 12), and there have been both successes and failures. The main factors that have influenced the success of community-based aquaculture are (i) the demand for and the extent of interest in fish farming; (ii) social capital, including organizational arrangements that contribute to strong community participation, sharing access to resources, and conflict resolution; and (iii) government assistance and partnerships with the communities. Drawing from experience, constraints to rural aquaculture include water shortages, unfavorable biophysical conditions, low natural productivity, and such farm management issues as stocking density, pond management, access to feed, and harvesting methods. Fish farming has also been affected by environmental degradation, limited financial and human resources, inappropriate links between extension and research, and external shocks such as the effects of the Asian financial crisis of 1997.

One of the most promising government support programs for poor communities to increase rural fish production is the School Fishpond Program (the Lunch Program) under Her Royal Highness Princess Maha Chakri Sirindhorn. The target areas are village schools, mainly primary and, to a lesser extent, secondary schools, in remote areas. The main objective of this program is to improve the nutritional status of school children in these areas by providing fish for consumption through self-help initiatives in fish farming. The program, which began in 1992, includes construction of fishponds, aquaculture training, and provision of fish seed and technical advice to schools. The Lunch Program has also piloted an integrated fish-poultry farming project to increase fish production at low cost. Table 3 shows production of the pilot project in 2000. Despite encouraging outcomes, constraints affecting the program include limited water supply, inadequate feed

29 In the past, the Fisheries Extension Division, the Office of the Fisheries Inspector, and the Fisheries Engineering Division of DOF were the three main organizational units involved in planning, budgeting, and monitoring of extension projects. The Training Division was responsible for setting up curricula and organizing training courses on fish farming techniques of various species, including tilapia. Farmer selection and basic training were carried out by the PFOs located in 75 provinces throughout the country. For advance training, lecturers were drawn from the Fisheries Development Center and Fisheries stations in addition to the PFO staff.
30 These changes in the extension system are in accord with the recent move to decentralize government functions in Thailand. Small-scale aquaculture is expected to receive less direct attention from DOF. There are no more district-level fisheries offices; they have been transferred to the provincial level. The needs of small-scale fish farmers are currently addressed through projects sponsored by Royalty and the mobile units of the Department of Agricultural Extension, which has focused mainly on agriculture to date. The Tambon Technical Transfer Centers are generally weak, with inadequate human resources. The Ministry of Agriculture recently announced that it would reintroduce district fisheries offices, who would be assigned to areas where fish are locally important.
products from coastal aquaculture. Current strategies focus on (i) developing and improving aquaculture techniques by conducting research to increase fish production and to reduce production costs; (ii) conducting research on fish species with high economic potential to improve their desirable characteristics, and to develop good practices for hatcheries and aquaculture farms; and (iii) providing technical services and certifying registered hatcheries and farms.\footnote{32}

The National Fisheries Policy hinges on the assumption that future rural aquaculture development will remain at a small-scale and subsistence level, mainly for domestic consumption and local household food security, especially for the rural poor. This limits the scope for intensifying the system. The major role of researchers, therefore, is to find innovative and viable low-cost, low-input technology options for such conditions. Appropriate technology options for small-scale freshwater aquaculture have been developed in Northeastern Thailand through research partnerships between DOF and the Asian Institute of Technology, but these options require adaptation to the specific conditions of farmers with limited resources.\footnote{33}

The Government decentralized authority for management of fishery resources in all community waters to TAOs in 2001. TAOs had previously facilitated aquaculture development in their jurisdictions by requesting government support for fishpond construction, with DOF providing technical assistance. Achievements of these fishpond development initiatives have been variable. Principal shortcomings were inadequate fishpond management, ineffective extension services, deficient comanagement mechanisms and practices for common and shared assets, and poor access at the village level to information on aquaculture. The TAOs still have limited experience in natural resources management and need to develop their credibility and establish the trust of the communities. In the past, the communities did not have the opportunity and experience to make appropriate and enforceable resource management decisions. The TAOs can, and increasingly must, play a role

Table 3: Pilot Integrated Fish and Poultry Farming Project Production Statistics under the School Lunch Program in 2000

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Schools</th>
<th>Layer Chickens</th>
<th>Number of Eggs Produced</th>
<th>Fish Production (kg)</th>
<th>Total Income (B’000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeastern</td>
<td>4</td>
<td>1,250</td>
<td>351,852</td>
<td>405</td>
<td>598</td>
</tr>
<tr>
<td>Northern</td>
<td>4</td>
<td>900</td>
<td>246,145</td>
<td>421</td>
<td>459</td>
</tr>
<tr>
<td>Central</td>
<td>3</td>
<td>550</td>
<td>147,119</td>
<td>308</td>
<td>231</td>
</tr>
<tr>
<td>Southern</td>
<td>1</td>
<td>504</td>
<td>129,936</td>
<td>365</td>
<td>235</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>3,204</td>
<td>875,052</td>
<td>1,499</td>
<td>1,523</td>
</tr>
</tbody>
</table>


and other inputs, and limited knowledge in fish farming. There is scope for improvement and expansion to take advantage of the village schools as institutions that act as a focal point in remote areas at the grassroots level. There are opportunities for adaptive and hands-on learning in fishpond management and other aquaculture related issues. Through a series of simple activities involving village fishponds or small waterbodies, students and the communities can participate in an experiential learning process that actively demonstrates the potential benefits of improved fishpond management to livelihoods and human nutrition.

DEVELOPMENT POLICY FOR SMALL-SCALE FRESHWATER AQUACULTURE

National development by the Government takes place through the National Economic and Social Development Plan (NESDP). The principal strategic objective of the NESDP is to promote economic development by utilizing natural and human resources to increase production, generate employment, and increase national incomes. The direction of rural aquaculture development has developed from the fifth to the eighth NESDPs. The relevant stated goals were to (i) alleviate malnutrition (NESDP 5, 1982–1986); (ii) accelerate fish culture activities (NESDP 6, 1987–1991); (iii) increase opportunity for establishment of individual fishponds (NESDP 7, 1992–1996); and (iv) increase human resource capacity in managing integrated community fishponds (NESDP 8, 1997–2001).\footnote{31}

Thailand’s National Fisheries Policy on aquaculture aims to (i) increase fish production to meet the demand for domestic consumption; (ii) increase income for fish farmers; and (iii) raise the standard of living of small-scale fish farming households, as well as to increase fish production as export


\footnote{32 The main policy goal for inland aquaculture is to provide fish protein for the rural poor, based on providing government support under conditions through which the rural people can participate and eventually become self-reliant. In contrast, the main policy goal of marine aquaculture development is to increase production for export rather than for local consumption.}

in arbitrating and facilitating the management of community natural resources. There are opportunities for capacity building and for forging close partnerships between the stakeholders in the communities and government services, including fisheries officers and TAO officials, through a participatory learning process and iterative improvements.

Currently, the Fisheries Act (1947) prohibits private pond construction in the public domain. However, fish farmers have rights to construct fishponds on their own land (property). Fish farmers can also operate cage culture in public waters. Such fish cage farms have to fulfill certain requirements for obtaining government permission, such as nonobstruction of waterways or transportation, nondisturbance to the public, a suitable location, and approval by district and provincial authorities. Licenses for fish cage farming are normally granted for 5 years. At present, subdistrict governments, Royal Irrigation Department, Royal Forest Department, and the Electricity Generation of Thailand are also involved in authorizing cage culture in their areas of jurisdiction. The Fisheries Act does not require freshwater aquaculture activities operating on private property to register and obtain permission. Nevertheless, the Government requires all aquaculture operators to register with the competent authority and get permission before operating.

Fish farmers have traditional rights to access a water supply from rivers and reservoirs. Changes to the Water Law are being considered, with the possible introduction of charges for water, especially for recreational use, such as watering golf courses. Fish farmers have exclusive rights to produce. The Government has no policy to regulate fish producers, unless they farm restricted species, i.e., endangered species listed by laws. However, in the future, the Government will apply concepts and practices guided by the FAO Code of Conduct for Responsible Fisheries and associated guidelines. The code puts emphasis on environmental aspects (effluents and water discharge), drugs and chemicals used in aquaculture, improvement of quality of fish products, preservation of fish products after harvesting, and quality control of fish products.

SAFEGUARDS FOR FRESHWATER AQUACULTURE

Aquaculture Zoning. Aquaculture zoning can serve as a tool for planning and implementing aquaculture activities to mitigate adverse environmental impacts. For example, in the absence of zoning, the rapid expansion of marine shrimp farms into freshwater areas of several provinces in Central Thailand has generated conflicts in uses of land and water resources. Salinity intrusion was attributed to shrimp farming that affected freshwater ecosystems, ricefields, and orchards. This situation led to the enforcement, from December 1997, of Article 9 of the Environmental Act of 1996 to ban low-salinity shrimp farming in freshwater areas throughout the country.

Integrated Agriculture-Aquaculture. Integrated agriculture-aquaculture has been practiced for almost a century, initially in Bangkok but at present throughout the country. The most popular systems are fish/poultry culture, fish/pig culture, and mixed culture (fish, pig, poultry). DOF has conducted several programs to increase fish production through integrated farming. The Bank for Agriculture and Agricultural Cooperatives (BAAC), with support from the Belgian Administration for Development Cooperation (BADC), developed guidelines for integrated fish farming in Northeastern Thailand. Integrated livestock/fish farming

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systems safeguard the environment because the livestock manure is used as organic fertilizer for the fishponds, which also function as waste stabilization ponds. A technology divide has developed over the past decade in which traditional semi-intensive aquaculture using on-farm and locally available agricultural residues is being replaced by relatively high-cost intensive culture using formulated pelleted feed. However, a third system—a semi-intensive system based on inorganic fertilization and supplementary feeding—can effectively intensify fish production for small-scale farmers and reduce the cost of production for large-scale producers. This system is more environmentally friendly than intensive production that relies solely on pelleted feed.

**Biosafety and Disease Prevention.** Introductions and transfers of alien aquatic species have been made deliberately and accidentally. Alien species were introduced mainly for aquaculture and the aquarium trade and in many cases were imported illegally without adequate quarantine. Freshwater aquaculture is constantly exposed to the risk of possible adverse impacts from introductions of alien species and farmed organisms, particularly from the introduction of diseases and parasites. Enforceable and effective safeguards need to be developed, taking into account practical recommendations for biosafety measures. However, the implementation of aquaculture health management guidelines for transboundary movements of live aquatic animals (such as health certification, quarantine, and diagnostic procedures) depend not only on political will, but also on sustained investments and conducive behavior of farmers, researchers, and the general public, in order to minimize preventable and potentially damaging risks from irresponsible introductions and dissemination of alien aquatic species and farmed organisms.

## LESSONS LEARNED

Fish farming has developed rapidly over the last few decades, partly in response to a decline in capture fisheries and to a rising demand for fish. Small-scale farmers have benefited from the development of aquaculture, although existing data do not allow measuring the socioeconomic benefits to these farmers. Fish are an important component of the Thai diet and contribute significantly to national food security and human nutrition. Fish provide a traditional source of animal protein, fatty acids, and micronutrients.

Fish marketing in Thailand is competitive and largely in the hands of the private sector. With good road networks, transportation, supporting infrastructure, and telecommunications, fish and fish products flow freely in the country. This enables Central Thailand to supply fish to deficit areas such as Northeastern Thailand where retail prices of fish are generally higher than in other parts of Thailand. Northeastern Thailand is home to the majority of small-scale farmers in the country, and these small-scale producers have faced increasing pressure to improve farm productivity and reduce production costs to remain competitive in a free market system.

The rural poor comprise producers and consumers, and suppliers of labor. In the context of small-scale aquaculture, the rising opportunity cost of labor because of rapid economic development and employment opportunities in Thailand as well as overseas has placed additional pressure on farm productivity, which must rise if fish farming is to remain an attractive livelihood option. This economic environment places restrictions on the appropriateness of technology for small-scale aquaculture. Low-cost and affordable technology does not necessarily provide high returns on labor inputs, while intensive farming can create a demand for financial and other resources that the poor do not have. In many areas of Northeastern Thailand, labor migration to urban areas, particularly to Bangkok and its vicinity, has caused farm labor scarcity. These conditions restrict farm households from adopting labor-intensive farming techniques.

DOF has played a major role in the development of aquaculture in the country over the last few decades. DOF started to promote farming of native snakeskin gourami in the 1930s, but did not succeed due to low demand for farmed fish at that time and an abundant supply of and high demand for wild fish. Mozambique tilapia was promoted in the 1950s, but its culture did not succeed because of unfavorable characteristics that constrained on-farm productivity, and the species did not meet consumers’ tastes and preferences. However, promotion of Nile tilapia since the 1960s has been a

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success, and it is now among the major farmed fish species in Thailand. These development milestones have emphasized the importance of demand, market conditions, and the appropriateness of the product to meet the demand. Introduction and promotion of fish species for farming require an astute demand assessment and the ability to sustain a viable supply. Nile tilapia meets the demand of Thai consumers, as well as the needs of farmers to produce fish at reasonable cost to generate attractive returns.

DOF has placed great emphasis on the development of fisheries stations, which have catalyzed the development of the private sector’s dominant role in seed production and seed supply to support the increasing importance of fish farming. While the Government has played an instrumental role in placing the necessary facilities for initiating and ensuring seed supply to promote fish farming, its role has not hindered the private sector from developing and taking over the seed supply business. Overall, the private sector provides a reliable supply of seed in Thailand, with complementary development initiatives in the feed industry. Without a reliable seed supply, fish farming would not have developed into a major industry. Seed supply has been a major constraint to the adoption of aquaculture in many countries. The Government has sustained its research and development initiatives on fish breeding to maintain good quality broodstock to ensure open public access to farmed species and strains of good performance. The roles of the private and public sectors in seed production and quality assurance are complementary.

WAYS TO BENEFIT THE POOR

The primary means used by DOF to reduce poverty through aquaculture, especially in Northeastern Thailand, is the VFPDP. The program, which attempts to increase fish production through community-based management of natural, modified, or engineered water bodies at the village level, has had variable success. However, the recent decentralization of authority for management of natural resources, including fisheries, to subdistrict governments, has offered new opportunities for increasing community participation in making decisions on use of natural resource assets. The VFPDP program recently entered a new phase with assistance from the Swedish International Development Cooperation Agency and the Asian Institute of Technology.

DOF also currently assists the rural poor through aquaculture extension services based on the distance extension approach, using technologies appropriate for household-level and pond-based aquaculture. Most local communities and individual farming households have limited resources at their disposal; thus, less technical but demand-led approaches are required to reach poor target groups. Nevertheless, challenges in developing viable technology options for aquaculture continue to emerge in the rapidly changing rural economy.

In responding to challenges to make aquaculture benefit small-scale farmers, several factors should be considered: (i) livelihood options of targeted groups, including existing sources of household incomes; (ii) opportunity cost of labor, employment opportunities, and labor market characteristics, including labor migration; (iii) affordability and the extent to which targeted users of technology have access to livelihood assets for fish farming; and (iv) markets and marketing of farm inputs and outputs, and their specific relevance to fish farms. Responding to the challenges requires capacity building of local government agencies and local service providers. Adaptable approaches are needed without relying on rigidly predetermined packages of technology. Analyzing the characteristics of households or small-scale farmers and assessing the specific features of their operating environment are important elements in appraising ways to make aquaculture work for small-scale farmers.

Innovative approaches to enhance learning and community participation in the planning and use of water resources for integrated aquaculture-agriculture can improve livelihood options and enhance benefits for targeted groups. DOF could support such approaches by targeting agents of learning and information dissemination, such as teachers, students, community-based organizations, village leaders, and extension officers. Understanding relevant features of water resources management and their competing and complementary uses can prevent conflicts and mitigate adverse environmental impacts. Further, addressing issues related to common property rights and access to land and

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46 See Case Study 8: Development of Technology and Extension for Small-Scale Fish Farms in Northeastern Thailand.

water resources may ease access gaps to critical livelihood assets for the poor to engage in small-scale aquaculture.

A promising way to alleviate malnutrition among poor children in remote rural areas is the School Fishpond Program mentioned earlier. While the program provides immediate direct nutritional benefits among students of targeted schools, the benefits go beyond the school boundaries; the program serves as a catalyst in the communities to promote the use of water resources for integrated aquaculture-agriculture. The schools act as a focal point, providing outreach to students, parents, and other members of the communities, and a hub for information exchange and dissemination.
CASE STUDY 8

DEVELOPMENT OF TECHNOLOGY AND EXTENSION FOR SMALL-SCALE FISH FARMS IN NORTHEASTERN THAILAND

BACKGROUND

Purpose and Scope

This case study was undertaken to examine the processes in developing appropriate technology options for small-scale fish farming and to assess the relevance and role of extension for resource-poor fish farmers in the poorest part of Thailand, where fish farming is a recent innovation. The study drew on the experience of cooperative efforts of the Asian Institute of Technology (AIT), through its Aqua Outreach Program (AOP), and the Department of Fisheries (DOF) of Thailand to develop technology and extension for small-scale household-level fish farming. These efforts were in Northeastern Thailand, the poorest region of the country, and have involved partnerships with local government agencies, nongovernment organizations (NGOs), and farmers. Freshwater aquaculture is relatively new in the area.

Agriculture in developing countries may be divided into green revolution agriculture and resource-poor agriculture. The former is usually found in national agricultural heartlands in fertile areas, either irrigated or rainfed lowlands near major urban areas. The latter is often found in complex, diverse, and risk-prone (CDR) areas, often peripheral areas, where farming systems are much more fragile, as in rainfed dryland, upland, and swampy lowland. Northeast Thailand is a classic example of a CDR region, in contrast with resource-rich Central Thailand, in both agriculture (crops and livestock) and aquaculture.

AIT has researched the development of aquaculture for small-scale farmers in Northeastern Thailand in cooperation with DOF since 1981. Their initial research collaboration involved on-farm trials with integration of ducks and fish, and later an on-farm assessment of buffalo manure as a pond fertilizer. The AOP began as a single project in 1988 with the establishment of a field office at the Udon Thani Freshwater Fisheries Development Center of DOF. The Department for International Development (DFID) of the United Kingdom wished to disseminate the results of strategic research into small-scale inland aquaculture, which it had funded over the previous decade through AIT, to farmers in Northeastern Thailand. From 1992, the AOP developed into a program of capacity building with national research, development, and extension.

1 This case study was undertaken in consultation with Supawat Komolmarl of the Fisheries Development and Technology Transfer Bureau of the Department of Fisheries of Thailand, and N. Innes-Taylor and Danai Turenguang of the Aqua Outreach Program of the Asian Institute of Technology. P. Edwards led the preparation of this report in collaboration with N. Bestari and R. Pullin.

2 Setboonsarng, S. 1994. Evolution of Freshwater Aquaculture in Northeast Thailand: Growth of a New Technology. Tunghai Marine Laboratory Conference Proceedings 4: 297–318. Although aquaculture is increasing, most of the increase is by better-off farmers, especially in peri-urban areas, and aquaculture remains underdeveloped in most rural areas.


educational institutions also in Cambodia, Lao People’s Democratic Republic, and Viet Nam.\(^6\) Although the AOP has always focused on the development of aquaculture for the rural poor, for the last few years it has worked in partnership with national and subregional institutions at provincial and district levels to support livelihoods through aquaculture, and more recently aquatic resources development.

The first major aim of the research partnership between DOF and the AOP was to develop appropriate technology for poor farmers in resource-poor areas of Asia, with Northeastern Thailand as a pilot area, because of its marginal characteristics. The research partnership proceeded along a learning curve as it developed appropriate technology and extension for small-scale farmers. The pilot trials showed that the technologies produced by the research were relevant for pro-poor aquaculture under the social and economic conditions prevailing at the time the research was carried out. The technologies comprised nursing fish fry to large fingerlings in hapas (fine mesh net cages) in the farmer’s pond, and supplementing buffalo manure with urea for pond fertilization for growout (farming of fish seed to market size). As the Thai economy expanded rapidly, the opportunity cost of labor and, therefore, of remaining labor on-farm, also rose and a more productive growout technology was needed. This consisted of hapa nursing followed by growout of sex-reversed Nile tilapia in an inorganically fertilized pond. A distance extension system was piloted because there was no conventional aquaculture extension system.

**Brief History**

Northeastern Thailand comprises 19 provinces. The AOP has worked in 14 of them with various organizations from 1988 to the present. Total freshwater fish production in 2000 in Northeastern Thailand was 47,929 metric tons (t), with most produced from pond aquaculture (88.3%), followed by rice/fish farming (9.3%), and cage aquaculture (2.4%); there is also a very small amount of aquaculture in ditches.\(^7\) According to DOF statistics, aquaculture production has increased five-fold in the northeast region over the past decade, from 9,043 t in 1990. However, official statistics on fish production are unreliable. Freshwater fish consumption (total consumption of freshwater fish from all sources) in the northeast, based on a food consumption survey in the early 1990s, was estimated to be six times higher than the DOF figure for freshwater fish production (capture fisheries and aquaculture).\(^8\) Furthermore, the contribution of small-scale pond aquaculture is likely to be even more underestimated.\(^9\) Many small-scale farmers do not practice fish farming in the conventional sense of regular stocking and harvesting, and pond draining and filling. They usually harvest small amounts of fish periodically for household consumption and may farm fish for longer than one year if they perceive that they have sufficient fish to meet their needs, and may not stock their ponds regularly. Many farmers may be unable to culture fish year-round because ponds frequently dry up in the dry season (or flood in the rainy season). Widely scattered small-scale farmers purchasing a few hundred to a few thousand fingerlings, usually from an entrepreneur, farming fish in a pond measured in only tens to hundreds of square meters, and selling surplus fish in the village or small local markets are frequently unnoticed or invisible to DOF (footnote 9).

**Relevance**

DOF built the first fishery station in Sakon Nakhon in upper Northeastern Thailand in 1942, primarily for the fishery in Nong Harn Lake. Subsequently, DOF stations have been constructed in almost all provinces in the region and are instrumental in promoting seed production. Research on breeding fish and dissemination of seed have been major activities of the fisheries stations. Aquaculture in Northeastern Thailand may have originated through a countrywide program in the early 1950s assisted by the Food and Agriculture Organization (FAO) of the United Nations, based on Mozambique tilapia (*Oreochromis mossambicus*). The aim was to develop inland fish production but although the tilapia became the most popular farmed fish in the mid-1950s, interest waned because of reservations about the quality and flavor of its flesh and also probably because of precocious breeding in ponds,

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\(^6\) Sources of funds for the AOP comprised funding from DFID complemented with that from the Swedish International Development Cooperation Agency and later by the Danish International Development Assistance; also there were specific research projects facilitated by the AOP and funded by DFID and the European Union.

\(^7\) Department of Fisheries (DOF). 2003. *Freshwater Fishfarm Production 2000*. Bangkok: DOF. Although aquaculture has increased rapidly, it is from a relatively small production base, considering the large size of the region.

\(^8\) Mekong River Commission. 1992. Main Report. In *Fisheries in the Lower Mekong Basin (Review of the Fishery Sector in the Lower Mekong Basin)*. Bangkok: Mekong Secretariat. 92 p. Although the comparison was made over 10 years ago, the discrepancy is unlikely to have changed because the methods of collecting data remain the same.

which limited its size. With the major exception of the Village Fish Pond Development Project, the efforts of DOF have centered mainly on high-input systems using formulated feed and integration of fish, particularly Nile tilapia (O. niloticus), with feedlot livestock. Neither of these two systems is appropriate for small-scale farmers, who initially view fish farming as a supplementary occupation, mainly to satisfy household consumption.

**Biophysical Features**

Northeastern Thailand covers an area of 168,854 square kilometers, one third of the area of the country, and had a population of 20.8 million in 2000. Most of the region is occupied by the Khorat Plateau, a low plateau with an average elevation of 160–200 meters above sea level. As the plateau has a sandstone base, it generally has nutrient-poor soils. It is characterized by a rather erratic monsoon rainfall regime with most rain in June–October and more or less dry conditions during the remainder of the year. Average rainfall is less than 1,000 millimeters in the southwest, increasing to about 1,800 millimeters in the northeast, but the region is drought prone because the effectiveness of rainfall is reduced by the predominant sandy soils.

There are considerable fluctuations in wet-season rice yields because of inadequate supplementary irrigation during droughts; most farmers are unable to develop year-round cultivation of crops because of limited irrigation systems. For purposes of water resource planning, the northeast region has been divided into three major zones: areas irrigable by large reservoirs, which can benefit 8–9% of farm families; areas irrigable by pumping from large rivers, which can benefit a further 10% of families; and the remaining areas inaccessible from large reservoirs and reliable rivers, which contain 80% of the rural population. In the last mentioned areas, basic village water requirements are met mainly by small tanks or reservoirs, or village ponds, either natural or dug, or by shallow or deep wells, and increasingly by household-level ponds.

Farm and household-level multipurpose ponds are common because of unreliable water supply. Drinking water is mostly rainfall collected by the roof of the house and stored in large jars; ponds may be used for bathing and washing clothes and dishes, as well as for livestock and crops. Many such ponds function also as trap ponds for wild fish; they include depressions and pits in and alongside ricefields, serving as sumps into which water and fish are drained at the end of the rice planting season. When the AOP began in 1988, there were many ponds in Udon Thani Province that either were not stocked with fish or were farmed ineffectively. DOF requested AOP to explore how to improve the existing ponds for aquaculture rather than pay for the construction of new ponds.

The problem of drought in Northeastern Thailand has intensified over the last 30 years as cash crop cultivation, especially of cassava, kenaf, and sugarcane has led to the clearance of forests from the rolling uplands. Forest resources in Thailand as a whole decreased from 27.3 million hectares (ha) in 1961 to 13.1 million ha in 1995. The reduction of forest cover in Northeastern Thailand has been equally dramatic, declining from 7.1 million ha to 2.1 million ha over the same period. Clearance of forests has increased run-off and incidence of flash floods, reduced water tables, and deposited salt dissolved from upland soil layers in surrounding rice lowlands. Many village ponds, which previously provided adequate wild fish for local consumption, have become shallower and clogged due to sedimentation and growth of aquatic weeds.

**Socioeconomic Setting**

The Northeastern region, because of its biophysical features, is characterized by mainly low-input, low-yield agriculture that does not offer an adequate living to the large numbers of farmers. The difficulty of marketing relatively small

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11 The Village Fish Pond Development Project is a state-sponsored initiative to support community-based fish production in rehabilitated or newly constructed “village fish ponds” (reservoirs, swamps, and tanks). It started as a pilot project in 1978 but continues as a major initiative of DOF to promote rural aquaculture.


14 AIT. 1978. Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources, Volume 1: Main Report. Bangkok: Asian Institute of Technology. Although this study was carried out over 2 decades ago, the conclusions remain valid because they are based on the geomorphology of the region.

15 Kenaf is a fiber much like jute, although coarser and less pliable, obtained from the stems of Hibiscus cannabinus. It probably originated in Africa but has been introduced into most tropical countries.

amounts of high-value produce from widely scattered farms and the attraction of off-farm employment in the dry season have precluded the optimal use of the few irrigation schemes (which occupy less than 10% of the region) and the more than 80% of rainfed farms. There is some intensive, market-oriented agriculture for vegetables and flowers, often under contract to agribusiness, but it is far from widespread. Nor has the long advocated shift to commercial cattle rearing and fruit growing developed on a widespread scale.

Farm households have increasingly sought to augment their earnings through off-farm employment. This was initially a seasonal migration to sugarcane fields and orchards of Central and Eastern Thailand or for temporary urban employment, but more recently there has been a mass exodus of the agricultural labor force. Many young people have moved on a semi-permanent basis, particularly to Central Thailand for employment in the service, construction, and industrial sectors. Older and more skilled workers have also moved as contract workers to seek opportunities in the Middle East and East Asia. Their remittances do offer some financial resources for investment in agriculture and aquaculture, although these are constrained by the reduced availability of the on-farm labor force.

The Asian financial crisis in 1997 and subsequent economic recession led to a mass layoff of workers, leading to a return migration of the labor force (footnote 16). However, the highly seasonal and unstable farming systems were unable to provide returning migrants with an adequate livelihood; many households found it difficult to make a living with declining off-farm sources of income.

There appears to have been a marked general decline in wild fish, the main source of animal protein in the diet, over the last 3 decades because of siltation of natural waterbodies and increasing pressure on stocks because of human population growth (footnote 13). The practice of trapping wild fish in ricefields is probably as old as rice cultivation itself in Northeastern Thailand, although the culture of fish in ricefields appears to be a relatively new activity in the region and is of limited occurrence.17 Farmers usually only enhance the natural fishery by raising the height of the ricefield dike and/or excavating a small area to form a trap pond.

DEVELOPMENT OF APPROPRIATE TECHNOLOGY

Improvement of the livelihoods of poor farmers depends on the development of appropriate technology. A farming systems research and extension approach was followed to ensure that the technology developed was relevant and would be adopted by small-scale farmers in the region. The approach involved three stages of research (Figure 1).18

The first stage was situational analysis to assess the need for, and the potential benefits from, aquaculture technology for small-scale farming households. Then followed identification of appropriate technologies from a review of relevant knowledge, on-station and on-farm research to further develop a new technology, and adaptive field trials with farmers to test and refine technical recommendations so that they could be readily adopted by the small-scale farmers who received them. Finally, research was carried out on the production of extension materials and ways to disseminate them widely.

Relevance of Semi-Intensive Technology

Research carried out by AIT and its partners has focused on semi-intensive fish farming systems using low-cost inputs (fertilizers and supplementary feeds) rather than expensive, nutritionally complete formulated feeds that are used in intensive aquaculture (footnote 5). Semi-intensive systems are more


appropriate for rural aquaculture to satisfy the needs of small-scale farming households and poor consumers: a semi-intensive system can be developed by modifying a traditional extensively managed ricefield or pond, either a wild fish capture or a culture system, rather than by introducing a completely new system. Nutritional inputs for fish can be low cost, using on-farm products or by-products. If the system is intensified through the use of organic and inorganic fertilizers for fishpond fertilization and supplementary feeds, production costs may still be substantially lower than the costs of systems that rely completely on formulated feed. With reduced production costs, poor consumers may benefit from low-cost fish that can be made available in the markets at competitive prices.
Baseline Survey

The AOP began in 1988 with a baseline survey carried out in Udon Thani Province to characterize small-scale farmer practices in aquaculture (footnote 13). Interviews of almost 500 fish farming households in 56 villages revealed their relatively limited knowledge of aquaculture, with yields of only 0.38–0.50 t per hectare (ha) per season, equivalent to 43–57 kilograms (kg) from an average pond of 1,136 square meters (m²). Only 6% of farming families in these villages cultured fish, indicating considerable unfulfilled potential (Table 1).

Most farmers obtained small (2–3 centimeter [cm]-long) fingerlings, which were widely available from DOP and private hatcheries (footnote 13). These fingerlings were usually stocked directly into ponds at a very high density, partly in an attempt to offset predation by prevalent, wild carnivorous fish. A polyculture of indigenous and alien carps and tilapia was stocked. Low levels of nutritional inputs were used infrequently and fish were partially harvested throughout the season, mostly for subsistence.

Farmers had a relatively poor resource base from which to provide pond nutritional inputs. Manure is used as a fertilizer to enhance the growth of natural organisms in the pond—plankton in the water column and insects and worms on the pond bottom—that provide fish feed. Farmers add supplementary feed to the fishponds to complement the natural food organisms stimulated by the fertilization with manure. Although 41 different types of pond nutritional inputs were recorded, most farmers used only 2–4 types. The most common input was rice bran, used as a supplementary feed, an off-farm input requiring purchase. Farmers milled their rice at village ricemills, which kept the rice bran as payment for rice milling services. The second most common input was buffalo manure, which was used by almost half the farmers who used the animal for ploughing. Very few farmers used pig or poultry manure. Most kept small flocks of scavenging poultry rather than poultry feedlots that would have been readily combined with aquaculture. The few farmers who raised pigs were mainly rice millers with readily available rice bran at marginal cost.

Despite being widely recommended as a pond fertilizer, on-station research at AIT and on-farm research in Northeastern Thailand demonstrated the limited value of buffalo manure as a fertilizer for fishponds because of low nutrient and high tannin content. The limited primary productivity resulting from the (low) nutrient content was inhibited by low light penetration into the water because of staining by tannin. Farmers collected about 4 t of fresh buffalo manure over 6 months but obtained only minimal fish yields.

Terrestrial and aquatic vegetation was only seasonally abundant. Farmers commonly used termites as feed for fish but the supply was rapidly exhausted; their rate of use by mostly new entrant farmers far exceeded the termite growth rate. Crop by-products, such as soybean and groundnut meal, were rarely used to feed fish because these crops were not part of the local farming system. Off-farm inorganic fertilizers for ponds and formulated feed for fish were rarely used.

The concept of pond fertilization to produce protein-rich “green water” through plankton growth was not widely appreciated—less than 30% of farmers believed the green color to be the most suitable color of pond water for culturing fish. More than 40% thought that clear water, which is infertile, was the most suitable for farming fish.

The farmer’s fish culture strategy was not very profitable because they (i) stocked small fingerlings that were largely eaten by wild carnivorous fish in the pond, and (ii) added little of nutritional value to the fishponds for any surviving fingerlings to eat. Farmers complained that stocked fish often disappeared and those remaining grew little. Failing to meet aspirations, many farmers abandoned their fishponds, which filled with emergent aquatic plants because sunlight penetrated through the clear infertile water to the pond bottom.

Development of Appropriate Seed

A precondition for the adoption of fish farming is the ready availability of fingerlings. Expansion of fish farming in Northeastern Thailand has been stimulated by the increasing availability of seed over the past 2 decades. Hatcheries were initiated

| Table 1: Total and Fish Farming Households in 56 Villages of 4 Districts in Udon Thani |
|--------------------------------------|------------------|------------------|
| District    | Total Households | Fish Farming Households (%) |
| Nong Saeng  | 1,684            | 4.6               |
| Nong Wua Sor| 2,234            | 5.6               |
| Kut Jap     | 1,525            | 9.8               |
| Kumphawapi  | 2,265            | 5.8               |
| Total Survey| 7,708            | 6.3               |

19 Rice bran is a valuable supplementary feed, but it cannot be considered as a complete or major feed because it is not a nutritionally balanced feed for fish when used as a major input.

by and originally limited to DOF provincial fishery stations, but are now dominated by private entrepreneurs. DOF has encouraged fish seed production by private hatcheries and has disseminated technical knowledge through a network of fishery stations, one in every province. Fish hatcheries are concentrated in Nong Khai and Mahasarakham provinces, with about 500 and 200 hatcheries, respectively, but there are isolated hatcheries throughout the region. Mobile traders distribute fingerlings by motorcycle and pick-up truck. Small-scale farmers in the region most commonly stock a mixture of indigenous silver barb (Barbodes gonionotus) and alien species: common carp (Cyprinus carpio), mirgal (Cirrhinus mirgala), rohu (Labeo rohita), and Nile tilapia.

Because the disappearance of the small fingerlings stocked by farmers in their ponds was a common problem, stocking larger, more predator-resistant fingerlings was a logical goal to improve the survival of stocked fish. Wild carnivorous fish were practically impossible to exclude from ponds, as well as being prized by farmers because of their high market value. Where significant numbers of wild fish still occurred in the floodplains of the Mun and Chi river valleys in the southeastern part of Northeastern Thailand, aquaculture was not relevant: farmers perceived the wild fish more as product than predator. Farmers reported that it was not difficult to prevent wild fish from entering their ponds, but they were unwilling to do so because they believed that some stocked carp and tilapia fingerlings would survive nevertheless.

Trials were carried out with 18 farmers who were carefully selected because of their relatively poor socioeconomic status and their interest to participate. It proved very difficult to recruit farmers for the trials because the AOP provided only technical assistance, unlike other projects that provided financial support (footnote 5).

The AOP developed a farmer-friendly seed nursery technology that was relatively simple, using readily available materials. Nursing fry to fingerlings in conventional nursery ponds has rarely succeeded at the village level in the region because it is a specialized business that requires off-farm inputs and a reliable water supply. Furthermore, most farmers are unwilling to drain ponds for preparation as fry nurseries, considering that water is a scarce resource. Elimination of widespread predatory carnivorous fish using pesticides or quicklime is difficult and costly (footnote 22). The technology consisted of nursing fry for 6–8 weeks in a small nylon net cage (hapa) suspended in a fishpond until they reached a more predator-resistant fingerling size, 6–8 cm, when they were released into the pond for growout. The hapa could be placed wherever there was enough water to nurse fry early in the season, either in the corner of a fishpond or in a ricefield trap pond or sump.

As aquaculture expands in production and area, seed quality has become an issue, especially for new-entrant, small-scale farmers attempting to raise fish, who may fail and lose interest if seed quality is poor. Seed quality appears to be affected by many factors: it can suffer physical or physiological trauma at many points from the

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24 The hapa nylon material is readily available and already used by farmers for making fishing gear or for temporarily holding fish in hapas following harvest. Farmers were advised to nurse a polyculture of fry at a stocking density of 150 per m² in 50–70 cm deep hapas, either 5 or 20 m² in size depending on the size of their growout pond. Feed was a rather expensive high-quality diet (a 2:1 ratio of poultry feed concentrate to fine rice bran by volume) but was necessary because the fish were nursed at high density; however, the quantities fed were small.


hatchery, through networks of private seed traders to the farmer’s pond. Even seed from broodstock of high genetic potential may not grow well if mishandled prior to stocking in the pond, and certainly will not grow well if the farmer’s growout husbandry is poor. A systems approach to this complex issue is required.26

**Development of Appropriate Growout Technology**

Supplementation of buffalo manure with urea was recommended to farmers for fertilizing their fishponds to make “green water.”27 Farmers were recommended to use small amounts of fresh manure daily and limited applications of urea that the farmers were likely to use and able to afford.28 Farmers were also advised to stock fingerlings at a low density, 1–2 fingerlings per m².

**Farm Level Impact of Trials**

Using this technology, estimated fish production at the end of the growing season, from summation of farmers’ records of fish caught during the growing season and fish harvested on draining the pond, averaged 182 kg from the average pond of 1,136 m², or an extrapolated 1.6 t per ha per season. This was three times the average yield recorded in the baseline survey.

The contribution of fish farming to the household economy, according to the baseline survey, was marginal: income from fish was about $70, a mere 3% of an average annual farm income of about $2,440 (Table 2). Off-farm earnings were more than 40% of total household income.

The recommendations involving nursing and pond fertilization more than doubled the income from fish, increasing its share of total farm income from 2.9 to 6.5%. The recommendations were sufficiently low cost to be accessible to poor farmers with access to a pond. However, with average land holdings of about 8.1 ha (50.5 rai), the regional average of 4.5 ha (28 rai) in 1988, the average farm income of families farming fish during the 1989 baseline survey was as much as 80% higher than the regional average gross regional product per capita for rural areas of baht 7,020 ($278) in 1988 (footnote 27). Thus, the low-input package was not attractive to many farmers because it made only a minor contribution to their total income.29

**Relevance of Integrated Farming**

A scaled-down integrated feedlot livestock-fish culture system was piloted before the commencement of the AOP with 8 farmers in Udon Thani Province. Thirty egg-laying ducks were confined over a 200-m² pond, so that all manure and spilled feed fell into the pond. This system produced impressive harvests of 100–200 kg of fish. However, most farmers abandoned duck rearing once the AOP had withdrawn its support. The farmers subsequently faced difficulties in obtaining formulated feed ingredients and in marketing small numbers of duck eggs.30 This integrated system was short-lived because it did not take into account market conditions of input supplies and farm outputs.

Integrated agriculture-aquaculture farming systems have been promoted as a possible alternative for agricultural development in Northeastern Thailand in recent years. A combination of ricefield,

<table>
<thead>
<tr>
<th>Table 2: Contribution of Aquaculture to Annual Farm Income (farm trials in Udon Thani Province)</th>
<th>Production Value (in $, unless otherwise specified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Income</td>
<td>4,360</td>
</tr>
<tr>
<td>Farm Income</td>
<td>2,440</td>
</tr>
<tr>
<td>Off-farm Income</td>
<td>1,920</td>
</tr>
<tr>
<td>Fish Farming Income</td>
<td>71</td>
</tr>
<tr>
<td>Fish Farming Income (% total income)</td>
<td>1.6</td>
</tr>
<tr>
<td>Fish Farming Income (% farm income)</td>
<td>2.9</td>
</tr>
</tbody>
</table>

26 Participatory methods are being used to obtain information on current practices from a broad range of stakeholders to better define researchable issues. (see reference SOS 1998, in footnote 21; MacNiven, Angus. 2003. Action Research: The Human Dimension in Learning How to Improve Fish Seed Quality. Aquaculture News May: 18–19). Ongoing studies using participatory action research in Northeastern Thailand should contribute to stakeholder knowledge and enable them to develop self-help competencies so that they will be able to safeguard seed quality.


28 On-station research at AJT developed a fish production response curve to buffalo manure supplemented with inorganic fertilizers using an optimal total nitrogen loading rate of 4 kg nitrogen per ha per day (footnote 20). Partial budget analysis considering only fertilizer cost and farm gate price of fish gave a benefit:cost ratio of 5 to 6. Only urea was recommended to farmers because triple superphosphate was not available in the project area, but farmers’ fish grew well. Adequate phosphorous relative to nitrogen was probably supplied by buffalo manure and rice bran, which farmers continued to use.

29 As is usual with the introduction of a new technology, the adopters of the low-input, low-cost technology were the better-off farmers. Only households with a larger than average resource base of 6 ha in Northeastern Thailand are able to make their living predominantly from agriculture. Most farming households are forced to seek substantial earnings off-farm, which reduces the availability of on-farm labor for aquaculture (footnote 27).

kitchen garden, orchard, and fishpond is believed to offer farmers a more stable livelihood than cultivation of rice alone, or rice and another commercial crop. However, a survey of households with varying lengths of experience in such integrated farming in Buri Ram and Khon Kaen provinces revealed low fish yields, similar to those reported in the AOP baseline survey, because of limited pond inputs. Although sale of fish in the local market was not yet a problem, farmers experienced difficulties selling fresh fruit and vegetables there. The promotion of integrated agriculture-aquaculture was recommended to be linked with small-scale agroindustries for farmers to have a sustainable livelihood (footnote 16). Extensive poultry production is a traditional activity in Northeastern Thailand but small flocks of scavenging birds are mainly raised as foods for social celebrations and are typically eaten within the household and sold locally. Attempts to intensify poultry production and to integrate manure supply with aquaculture failed mainly because of prevailing social practices and the limited availability of on-farm poultry feed.

The Bank for Agriculture and Agricultural Cooperatives promoted integrated feedlot livestock-fish farming in Northeastern Thailand, although it was necessary to organize farmer groups to source and mix feed ingredients and distribute formulated feed to member farmers in order to save on purchase of agroindustrial feed. Challenges facing integrated systems include overall profitability and cashflows. While small-scale fish farming may be highly profitable because of the reduced costs of feed and reasonable fish yields, the accompanying small-scale livestock feedlots, such as for poultry production, may not yield any profit. For example, a crop cycle of fish may require the equivalent of four production cycles of broiler chickens, which require cash expenses for the purchase of 1-day-old chicks and feed. Furthermore, farmers faced fluctuating and often low prices for livestock and livestock produce.

High-Input, Low-Cost Technology

Through on-station research, the AOP developed a low-cost, high-input technology package based solely on inorganic fertilization of a Nile tilapia monoculture. This technology option was to improve the attractiveness of aquaculture for potential new entrant farmers. It was also intended to satisfy the desire of several cooperating farmers who had gained confidence that fish could be reared successfully, to increase fish production with significant surplus for sale. A biologically optimal pond fertilization rate of 4 kg nitrogen and 1 kg phosphorous per ha per day was recommended. A farmer-managed on-farm trial was carried out by 12 small- and medium-scale farmers in Udon Thani, Nakhon Phanom, and Sakon Nakhon provinces in Northeastern Thailand. Their average extrapolated fish yields were almost 6 t per ha per 8-month cycle. Farmers were recommended to nurse sex-reversed Chitalastra strain Nile tilapia fry from AIT in a hapa suspended in the pond before stocking the fingerlings at 2–3 per m². Farmers in Northeastern Thailand are often reluctant to fertilize ponds with manure, particularly pig manure, but inorganic fertilization was acceptable to all. The substantial fish yield, more than three times that obtained by farmers with the low-input package described above, was because the fertilization produced intense, green, plankton-rich water. The farm gate value of fish was three times greater than the estimated production cost of the high-input technology.

Although most farmers were satisfied with the 200–250 gram (g) size of fish harvested from the trials, 3 of the 12 farmers expressed a desire for larger, 300–500 g, fish that would fetch a premium price in urban markets. A technical recommendation to make supplementary feed using limited locally available and on-farm resources had been developed by the AOP, but was not commonly adopted because of the labor involved in collecting feed ingredients as well as their limited supply. Three of the eight indicative components of low-cost, semi-intensive fish culture (Table 3) were widespread in farming communities in Northeastern Thailand prior to the start of the AOP. A further

33 Edwards, Peter, and Geoff Allan. 2001. Review of Feeds and Feeding for Inland Aquaculture in Mekong Region Countries. Consultancy Report for the Australian Centre for International Agricultural Research, Canberra. However, some AOP cooperating farmers who learned how to use inorganic fertilizers for their fishponds to “green” the water either ceased or reduced their use of inorganic fertilizers, and started to integrate fish with feedlot livestock. They reported little to no profit from livestock but benefited from free manure.
four have been developed over the past 15 years through the AOP. The eighth component, cost-effective supplementary feeding would take the technology close to its production ceiling for static water pond culture. One of the three farmers mentioned above developed such supplementary feeds to intensify production further once he had learned, and had gained confidence with, basic aquaculture techniques.36

### EXTENSION OF APPROPRIATE TECHNOLOGY

Once the initial packages of low-cost recommendations had been developed and field-tested with farmers, the AOP began to assess ways to disseminate them widely to farmers through DOF.37 DOF had very few extension officers at the provincial level in Northeastern Thailand and none had been formally trained in extension theory and practice.38 Therefore, AOP explored alternative extension strategies. A distance extension approach was chosen because farmers were literate and mobile and had close links with other government agencies represented at grassroots, commune, and village levels.

Doubts were growing about the effectiveness of the conventional training and visit system (TVS) for agricultural extension in developing countries (footnote 9). The TVS is part of the top-down transfer of technology paradigm for agricultural research and development in which technical messages developed largely by scientists on research stations are passed on through a dense network of extension agents in contact with farmers at the village level. Established throughout Asia, TVS-based extension services are unsustainable financially and unable to cope with the complexity of farming systems in CDR areas.39

Conventional extension services tend to be crop specific, but governments have been reluctant to establish parallel structures in other sectors, such as fisheries. Until recently, DOF had a maximum of 6 extension agents per province.40 The Government is currently attempting to address the human resource constraint in Northeastern Thailand by establishing mobile extension units—using staff of different sectors and an extension agent—to consult with farmers on their farming problems.41

Printed and audiovisual materials were used complementarily: the former to provide the target farmer with the recommended technology, the latter to create awareness and explain where the farmer could obtain printed materials. Printed technical messages were written in straightforward language using local dialects with no technical terms. The aim was to make the messages instantly obvious; they were short and well arranged. An attempt was made to make the materials attractive to gain attention, stimulating to read, and entertaining. The process of developing these materials was lengthy. Awareness was generated in the extension trials using local radio and television, as well as posters in target villages. In one extension trial, messages recorded on audiotape in the form of a folk opera performance were distributed on the air over village broadcasting systems.

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36 One of the three farmers was enterprising enough to produce an effective low-cost diet in adequate quantity to supplement green water produced by high-input inorganic fertilization. He obtained an extrapolated harvest of 6 t per ha per 5-month cropping cycle, a significant increase on 6 t per ha per 8 months obtained with only inorganic fertilizers, and a crop comprising higher-value fish of up to 500 g per piece. He cooked broken rice to form a paste as a binder and when it had cooled he mixed in rice bran, soybean meal, fish meal, and pig oil. The mix was fed to fish in manually prepared moist balls in a feeding tray. He modified the recipe, which he obtained from a fisheries textbook, by reducing the amount of fish meal to lower the cost. He lamented that he was unable to purchase an expensive vitamin and mineral premix but was fortunate that there were adequate micronutrients for fish in his “green water” ponds. He was also enterprising in obtaining off-farm ingredients to prepare his supplementary feed on-farm. He had set up an arrangement through which the feed merchant in the provincial town sent him, by the local bus, ingredients ordered by telephone, resulting in considerable savings in time and expenditure. His cost of production was B16/kg compared to an average farm gate price of B36-40/kg for a 500-g fish.


Conventional extension materials contain too much information written in a scientific format in too educated a language for farmers to understand. DOF produced 42 different extension materials from 1987 to 1991, 31 in printed form. The language used was central Thai, with many technical terms but even then, only 4–5 had relevant content for small-scale farmers. Furthermore, farmers could only obtain them by traveling to the provincial office (footnote 40).

It was necessary to develop both appropriate extension materials and channels of extension to farmers based on results of on-farm trials (footnote 37). Figure 2 shows the design process for the development of the AOP extension materials, involving active participation of field staff and farmers to make the materials relevant to farmers’ culture, language, learning experience, and lifestyle. They were field tested with farmers who had not been involved in on-farm trials, and modified iteratively several times to make them suitable for the wider farming community. The nonspecialist local government channels comprise the general agricultural extension service, the agricultural bank, health centers, and schools at subdistrict and district levels. Two sets of extension messages were developed by the AOP, the first a low-input scenario comprising two booklets and two leaflets42 and the second comprising two booklets.43

The AOP has carried out several studies to evaluate the effectiveness of the distance extension. The evaluation was initially conducted in Udon Thani Province where the low-input technology was developed, but subsequently was done in close collaboration with DOF to develop extension channels (footnote 37). DOF used the existing extension materials in 1994 in six additional districts in three provinces: Udon Thani, Sakhon Nakhon, and Nakhon Phanom. Since 1996, a more comprehensive evaluation was carried out to assess the wider impact in Northeastern Thailand. Over a 6-year period since their initial testing, extension materials were distributed widely to other organizations: the Department of Vocational Education, NGOs, other development projects, and individual farmers. Materials have been distributed during training programs run by DOF, NGOs, and the AOP.

The impact studies have shown that carefully designed extension materials developed in dialogue between farmers and government officers, and well tested in terms of content and presentation, can be adopted by small-scale farmers without regular extension advice (footnote 37). Just as important, impact studies showed that such extension materials are more effective than training on its own. About 60% of the 182 farmers who received extension materials in one impact study tried them out, and about 50% continued to use them regularly or when they perceived a need for them. There was also evidence of considerable farmer-to-farmer spread of the technical recommendations.

More than 70% of the farmers followed the recommendations to some degree; more adopted the green water recommendation than the nursing recommendation. While fertilization was practiced by 15% of farmers prior to their exposure to the AOP recommendations, almost none had ever used inorganic fertilizers in aquaculture. The introduction of inorganic fertilization into Northeastern Thailand appears to be due to the AOP. More than 80% of farmers who adopted the green water recommendation made changes and adapted it to their context, using less because they could not afford urea or because they had pigs or poultry. However, they adopted the principle of the green water recommendation. This indicates that it is important not to be too prescriptive about technical

42 Booklets: How to Grow Large Fish, Nursing Fry in a Hapa; How to Grow Large Fish, How to Make Green Water. Leaflets: How to Grow Large Fish, Fish Polyculture; Feed to Make Large Fish, Feed Available at Farm Level. Aqua Outreach Program. Udon Thani.

43 Booklets: How to Grow Large Fish, Greening Water with Chicken Manure and Urea; How to Grow Large Fish, Method of Making Green Water by Using Chemical Fertilizer. Aqua Outreach Program. Udon Thani.
recommendations so that farmers can better adapt them to their resource base and experience.

An estimate was made of the overall impact of the AOP’s recommendations in Northeastern Thailand (footnote 37). About 6,000 sets of extension materials were distributed throughout the region in 1991–1995. With a modest 40% adoption among recipients of extension, and the average increase in fish production of 200 kg from an average size pond of just over 1,000 m², the incremental increase in fish production would be 480 t per year worth $500,000 at the farm gate in 2003 constant prices. Since 1996, DOF alone has distributed a further 6,000 sets of extension materials to farmers. In 2001 and 2002, the DOF Extension Division printed 20,000 sets of each of the booklets on nursing in pond hapas and pond fertilization. Once developed and proven effective, the returns on the dissemination of extension materials are high. The incremental increases in fish yields are significant at about 2 t/ha, and these generate additional revenues of $2,000/ha/year to farmers, or $200 per year for small-scale farmers owning 0.1 ha of fishponds.

INSTITUTIONAL ISSUES

The goal of the AOP is to improve the livelihoods of the rural poor and the immediate objective is to develop processes and capacity of national institutions to achieve this goal (footnote 5). In the context of capacity building, the AOP initially experienced difficulties due to prevailing institutional practices of DOF in the mid-1990s. Although DOF provided the AOP a base in Northeastern Thailand at their Udon Thani fisheries station from 1988, there was little initial interaction between AIT and DOF. At that time, DOF was not convinced that the AOP had much to offer through farming systems research. Development of appropriate technical recommendations would take some time. The AOP requested DOF to recruit field staff of mixed background from agriculture, education, and social science to carry out the baseline survey. There were concerns that DOF staff then assigned to the AOP would have the tendency to offer farmers conventional advice for aquaculture, rather than explore the overall contextual dimensions of the farms. Recruitment of field staff for the AOP through DOF was not possible because they did not have an appropriate academic background in fisheries biology.

By 1992, the AOP initiatives had demonstrably addressed the problems faced by small-scale farmers, and thus provided options for DOF to address extension needs in Northeastern Thailand. Extension was the first element of the farming systems and extension process to gain acceptance by DOF when it agreed to pilot the distance extension method in 2 districts in each of 3 provinces (Udon Thani, Nakhon Phanom, and Sakhon Nakhon).

The acceptance of on-farm trials as research by DOF proved more difficult than the distance extension approach. Trial farmers from earlier years of cooperation had begun to ask AOP staff how they could increase production to have surplus for sale in local markets. This provided demand-led opportunities for the AOP to field test the high-input inorganic fertilization (which had been developed at AIT under the United States Agency for International Development-funded Collaborative Research Support Program in Pond Dynamics/Aquaculture [footnotes 34 and 35]). As this field test was linked to the promotion of sex-reversed tilapia for stocking, it appealed to DOF, which had a tendency to look for new techniques. Training of DOF staff from several northeastern provinces was carried out by AIT. The need for conducting research with farmers was recognized by DOF, but the central committee reviewing such proposals for research would not have accepted them on conventional scientific merit. Nevertheless, when it was suggested that on-farm trials were not research but actually a step in the extension process, the Extension Division of DOF accepted the approach and provided a budget for the purpose.

The period 1995–1998 was one of considerable achievement in capacity building, as the AOP approach and initiatives were introduced to three more provinces: Mahasarakham, Mukdahan, and Roi Et. By 1997–1998, DOF was interested in further expansion to cover all provinces in Northeastern Thailand. A highly favorable internal evaluation of the AOP and the cooperation between AIT and DOF by an independent group in DOF in 1998 provided support to this expansion.

Unfortunately, the capacity-building process stalled in 1998 when two major developments occurred almost simultaneously, the Asian financial crisis and the change in DFID policy. In tightening its budget in response to the financial crisis, the Government cut its spending drastically. Travel by government officials to rural areas, including Northeastern Thailand, was curtailed. The travel restriction halted crucial dialogue between partners. The change in DFID policy toward a strongly pro-poor stance and the relevance of aquaculture to poverty reduction in general, and AIT’s role in particular, caused DFID not to consider a further phase of funding for the AOP. From the mid-1990s, rapid economic growth in Thailand meant that the opportunity costs of staying in low-return agriculture and the kind of aquaculture typified by the first AOP package, were high. The high-input inorganic fertilizer increased operating costs, and thus
the approach compromised to some extent the poverty focus of the AOP. Subsequently, the AOP obtained funding from the Swedish International Development Cooperation Agency for a project that began in 2001, focusing on traditional village fishponds (communal waterbodies) and local management of small-scale communal fisheries. Nevertheless, DOF has maintained the distance extension approach in Northeastern Thailand, using materials developed by the AOP.

LESSONS LEARNED

Research carried out by DOF and the AOP has developed and promoted appropriate systems for small-scale pond aquaculture that have relevance for poor farmers. Prior to the establishment of the AOP, small-scale farmers were obtaining extrapolated fish yields from ponds of only 0.4–0.5 t per ha. Two major problems were identified: (i) stocking readily available small fingerlings, which were mostly eaten by wild carnivorous fish; and (ii) surviving fingerlings failed to grow because of insufficient nutritional inputs. Appropriate technical recommendations were developed by the AOP through farming systems research in partnership with farmers and that considered the farmers' resource base and experience. These recommendations emphasized (i) nursing fry in a hapa in the farmer's pond to produce larger, more predator-resistant fingerlings for subsequent stocking in the pond; (ii) a low-input growout technology to produce fish largely for subsistence; and (iii) a high-input inorganic fertilizer package to fertilize ponds for farmers to produce fish largely for sale.

Farmers produced predator-resistant 6–8 cm fingerlings in small hapas suspended in their ponds. Pond nutritional level was increased in the low-input growout technical recommendation by supplementing readily available buffalo manure with a small amount of urea. While this approach tripled fish yields, it provided only a relatively small increase in the overall on-farm income. Thus, this approach was not very attractive in the presence of alternative livelihood opportunities in Thailand's dynamic economy that has increased the opportunity costs of labor, including that of farmers. The subsequent high-input inorganic fertilizer package for growout tripled yields and was more attractive to farmers who could produce and sell surplus fish. The development of an effective low-cost diet to supplement green, protein-rich water by one participating farmer led to a further doubling of yields that were then close to the limit for semi-intensive culture in static water ponds, thus providing a substantial livelihood option for fish farmers.

Overall, these technology options have provided cost-effective means of increasing the productivity of fish farms and offered feasible ways of improving fish yields by minimizing feed costs through increased reliance on pond fertilization and supplemental feeding rather than on costly commercial feed. However, this experience showed that technology development could not be assessed as promising from its potential yield gains alone. The social and economic dimensions of the potential recipients, clients, or beneficiaries of technology promotion must be closely assessed in order to determine the relevance and significance of the technology options to their livelihoods.

Scaled-down integrated duck-fish culture introduced prior to the AOP failed because it did not fit into the local farming system; it did not take into account market conditions of input supplies and farm outputs. Integrated farming systems, combining livestock and fish farming, do not appear to have relevance for poor farmers in resource-poor Northeastern Thailand, at least until they have gained experience, profited from aquaculture, and gained access to sufficient financial resources to meet the cashflow demands imposed by different crop cycles.

The distance approach for extension has been used pragmatically to overcome the lack of extension personnel. The development of the distance approach has taken into account key requisites for effective communications, including local farmers' culture, language, learning experience, and lifestyle.

A farming systems research and extension approach is required for aquaculture to benefit small-scale farmers in CDR areas. In this approach, farmers are involved in all stages of the research, including the development and dissemination of extension materials. While this approach has proven effective and pro-poor, the participatory processes and the time taken to develop the extension materials may not be readily acceptable to institutions using entrenched top-down approaches. Farming systems research requires a broad-based multidisciplinary approach to capture the social dimensions, development contexts, and operating environment of targeted farmers. Thus, capacity building for the farming systems research and extension approach should be accompanied by institutional assessment and reforms of existing processes to facilitate the development of approaches that can effectively reach small-scale and poor farmers.
Appendixes
### Appendix 1. ADB ASSISTANCE IN AQUACULTURE (as of 31 December 2003)

#### Table A1.1: ADB-Assisted Aquaculture and Fisheries Projects with Major Aquaculture Components

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<th>Country/Loan No.</th>
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--- = not applicable; ADB = Asian Development Bank; ADF = Asian Development Fund; GS = generally successful; LL = largeholder, locally-oriented; LX = largeholder, export-oriented; NE = not explicit; NR = no rating; OCR = ordinary capital resources; PCR = project completion report; PPAR = project performance audit report; PS = partly successful; S = successful; SL = smallholder, locally-oriented; SX = smallholder, export-oriented; U = unsuccessful.

* Project objectives explicitly targeted small-scale aquaculture farmers/fishers and/or the poor.
### Table A1.2: Country-Specific Technical Assistance

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ADB = Asian Development Bank, AO = advisory and operational, AUS = Australia, EEC = European Economic Community, GS = generally successful, JSF = Japan Special Fund, PP = project preparatory, PS = partly successful, TA = technical assistance, TCR = technical assistance completion report, UK = United Kingdom.

* Refers to the funding source under “Others.”

* No rating, unless otherwise specified.

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<td>105.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>SRI-1368</td>
<td>Fisheries Sector</td>
<td>PP</td>
<td>200.00</td>
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<td>SRI-3639</td>
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<td>PP</td>
<td>0.00</td>
<td>800.00</td>
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<td>THA-194</td>
<td>Inland Fisheries Development</td>
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<td>0.00</td>
<td>146.00</td>
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<td>THA-259</td>
<td>Aquaculture Development</td>
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<tr>
<td>THA-558</td>
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<td>150.00</td>
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<td>TUV-1992</td>
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<td>VIE-2382</td>
<td>Coastal Aquaculture Development Study</td>
<td>AO</td>
<td>0.00</td>
<td>600.00</td>
<td>0.00</td>
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<td>VIE-3830</td>
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<td>AO</td>
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Total Cost: 8,435.03 5,621.80 4,205.97 18,262.80

UNDPI = United Nations Development Programme.
Source: Loan, technical assistance, and private sector operations approvals (December 2003).
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<tr>
<th>TA No.</th>
<th>Project Name</th>
<th>TA Type</th>
<th>ADB</th>
<th>JSF</th>
<th>Others</th>
<th>Total</th>
<th>Approval Date</th>
<th>TCR</th>
<th>Rating⁸</th>
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<td>Study</td>
<td>49.00</td>
<td>0.00</td>
<td>0.00</td>
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<td>REG5068</td>
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<td>Training</td>
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<td>220.00</td>
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<td>0.00</td>
<td>220.00</td>
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<td>45.50</td>
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<td>ICLARM for Research on Rice-Fish Farming Systems</td>
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<td>350.00</td>
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<td>162.40</td>
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<td>15 Apr 1984</td>
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<td>Fisheries Sector Development Strategies Study for South Pacific DMCs</td>
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<td>45.00</td>
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<td>REG5279</td>
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<td>979.00</td>
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<td>334.00</td>
<td>0.00</td>
<td>110.00</td>
<td>444.00</td>
<td>18 Jun 1989</td>
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<td>380.00</td>
<td>0.00</td>
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<td>150.00</td>
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<td>1 Jun 1993</td>
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<td>REG5558</td>
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<td>0.00</td>
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<td>1,200.00</td>
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<td>REG5711</td>
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<td>Study</td>
<td>0.00</td>
<td>1,020.00</td>
<td>2,120.00</td>
<td>17 Oct 2000</td>
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<td>REG6136</td>
<td>Eighth Agricultural and Natural Resources Research at International Agricultural Research Centers (World Fish Center: Achieving Greater Food Security and Eliminating Poverty by Dissemination of Improved Carp Species to Fish Farmers)</td>
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<td>0.00</td>
<td>0.00</td>
<td>950.00</td>
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<td><strong>Total Cost</strong></td>
<td></td>
<td>7,048.00</td>
<td>1,650.00</td>
<td>4,476.90</td>
<td><strong>13,174.90</strong></td>
<td></td>
<td></td>
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</tr>
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</table>

ADB = Asian Development Bank, CGIAR = Consultative Group on International Agricultural Research, DMC = developing member country, ICLARM = International Center for Living Aquatic Resources Management, GS = generally successful, HS = highly successful, JSF = Japan Special Fund, PS = partly successful, TA = technical assistance, TCR = technical assistance completion report.

⁸ No rating, unless otherwise specified.

Source: Loan, technical assistance, and private sector operations approvals (December 2003).
Appendix 2. ILLUSTRATIVE FINANCIAL FARM BUDGET OF CARP POLYCulture IN BANGLADESH

1-Hectare Pond (2002 constant prices)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Improved Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Variable  Tk</td>
</tr>
<tr>
<td><strong>Assumptions: 1 Month Preparation, 11 Months Growout</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm Size</td>
<td>ha</td>
<td>1</td>
</tr>
<tr>
<td>Stocking Requirement, Fingerlings (size 5–10 cm)</td>
<td>piece</td>
<td>10,000</td>
</tr>
<tr>
<td>Expected Survival Rate of Fingerlings (size 5–10 cm) to Harvest</td>
<td>%</td>
<td>78</td>
</tr>
<tr>
<td>Expected Average Weight of Fish at Harvest</td>
<td>gram/fish</td>
<td>480</td>
</tr>
<tr>
<td>Expected Yield, Carp Average Survival Rate of 70% for Fingerlings</td>
<td>kg/ha</td>
<td>3,744</td>
</tr>
<tr>
<td>Expected Total Farm Production, Carp Species</td>
<td>kg</td>
<td>3,744</td>
</tr>
<tr>
<td>Farmgate Price, Mixed Carp Species At Pond Site</td>
<td>Tk/ha</td>
<td>50</td>
</tr>
<tr>
<td>Price of Carp Fingerlings (size 5–10 cm)</td>
<td>Tk/piece</td>
<td>2</td>
</tr>
<tr>
<td>Pond Lease Cost</td>
<td>Tk/ha</td>
<td>0</td>
</tr>
<tr>
<td>Lime Application</td>
<td>kg/ha</td>
<td>250</td>
</tr>
<tr>
<td>Price of Lime</td>
<td>Tk/kg</td>
<td>7</td>
</tr>
<tr>
<td>Price of Rotenone</td>
<td>Tk/kg</td>
<td>750</td>
</tr>
<tr>
<td>Urea Application</td>
<td>kg/ha</td>
<td>250</td>
</tr>
<tr>
<td>Price of Urea, On-Site Delivery</td>
<td>Tk/kg</td>
<td>6</td>
</tr>
<tr>
<td>TSP Application</td>
<td>kg/ha</td>
<td>500</td>
</tr>
<tr>
<td>Price of TSP, On-Site Delivery</td>
<td>Tk/kg</td>
<td>12</td>
</tr>
<tr>
<td>Organic Fertilizer (Cow Dung)</td>
<td>kg/ha</td>
<td>3,000</td>
</tr>
<tr>
<td>Price of Cow Dung</td>
<td>Tk/kg</td>
<td>1</td>
</tr>
<tr>
<td>Feed Application, Rice Bran</td>
<td>kg/ha</td>
<td>1,000</td>
</tr>
<tr>
<td>Price of Wheat Bran, On-Site Delivery</td>
<td>Tk/kg</td>
<td>7</td>
</tr>
<tr>
<td>Feed Application, Mustard Oil Cake</td>
<td>kg/ha</td>
<td>800</td>
</tr>
<tr>
<td>Price of Mustard Oil Cake, On-Site Delivery</td>
<td>Tk/ha</td>
<td>10</td>
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</table>

**Revenues**

<table>
<thead>
<tr>
<th>Expected Revenue, Carp Species</th>
<th>Tk</th>
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<tbody>
<tr>
<td>Subtotal</td>
<td>187,200</td>
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</table>

**Operating Expenses**

<table>
<thead>
<tr>
<th>Purchase of Fingerlings (size 5–10 cm)</th>
<th>Tk</th>
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<tbody>
<tr>
<td>Subtotal</td>
<td>20,000</td>
</tr>
<tr>
<td>Pond Lease Cost</td>
<td>25,000</td>
</tr>
<tr>
<td>Pond Preparationa</td>
<td>10,000</td>
</tr>
<tr>
<td>Lime and Rotenoneab</td>
<td>1,975</td>
</tr>
<tr>
<td>Fertilizers (Urea, TSP, and Manure)</td>
<td>10,500</td>
</tr>
<tr>
<td>Supplementary Feed</td>
<td>15,000</td>
</tr>
<tr>
<td>Laborc</td>
<td>11,200</td>
</tr>
<tr>
<td>General Maintenanced</td>
<td>4,000</td>
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<tr>
<td>Subtotal</td>
<td>97,675</td>
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**Net Income Before Interest Payments**

<table>
<thead>
<tr>
<th>Tk</th>
</tr>
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<tbody>
<tr>
<td>89,525</td>
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cm = centimeter; ha = hectare, kg = kilogram, Tk = taka, TSP = triple superphosphate.

a Including pumping costs for ponds that do not have outlets.

b Rotenone is used to eradicate predators in remaining water pockets after pond preparation.

c For 180 person-days of labor at Tk 70/day for pond preparation, maintenance, and harvest.

d Allowance for maintenance of pond structures and equipment.

Source: Special evaluation study survey.
Appendix 3. ILLUSTRATIVE FINANCIAL FARM BUDGETS OF TILAPIA FARMING IN THE PHILIPPINES

Table A3.1: Illustrative Financial Farm Budget for Tilapia Seed Nursery (250-m² pond)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number (per annum)</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso) Per Year</th>
<th>Per Cycle</th>
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<tr>
<td>Number of Crop Cycles Per Year</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
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<tr>
<td>A. Returns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash (sold)</td>
<td>piece</td>
<td>448,875</td>
<td>0.32</td>
<td>143,640</td>
<td>47,880</td>
</tr>
<tr>
<td>Noncash (given away to buyers for mortality allowance)</td>
<td>piece</td>
<td>49,875</td>
<td>0.32</td>
<td>15,960</td>
<td>5,320</td>
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<tr>
<td>Subtotal (A)</td>
<td></td>
<td>498,750</td>
<td>0.32</td>
<td>159,600</td>
<td>53,200</td>
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<tr>
<td>B. Cash Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fry/Fingerlings(^b)</td>
<td>piece</td>
<td>984,000</td>
<td>0.04</td>
<td>39,360</td>
<td>13,120</td>
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<tr>
<td>Feeds(^c)</td>
<td>bag</td>
<td>67</td>
<td>480</td>
<td>32,390</td>
<td>10,797</td>
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<tr>
<td>Fertilizers</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inorganic(^d)</td>
<td>bag</td>
<td>0.2</td>
<td>428</td>
<td>64</td>
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<tr>
<td>Organic(^e)</td>
<td>bag</td>
<td>22</td>
<td>30</td>
<td>660</td>
<td>220</td>
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<td>Pesticide(^f)</td>
<td>bottle</td>
<td>0.1</td>
<td>1,500</td>
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<td>Fuel(^g)</td>
<td>liter</td>
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<td>15</td>
<td>375</td>
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<td>Electricity(^h)</td>
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<td>450</td>
<td>150</td>
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<td>Repairs and Maintenance(^I)</td>
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<td>1,436</td>
<td>479</td>
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<td>Supplies</td>
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<td>Oxygen(^i)</td>
<td>tank</td>
<td>1.5</td>
<td>250</td>
<td>375</td>
<td>125</td>
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<tr>
<td>Plastic Bags(^j)</td>
<td>piece</td>
<td>75</td>
<td>2.5</td>
<td>188</td>
<td>63</td>
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<td>Rubber Bands(^k)</td>
<td>box/pack</td>
<td>3</td>
<td>6</td>
<td>18</td>
<td>6</td>
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<tr>
<td>Record Book/Paper</td>
<td>piece</td>
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<td>75</td>
<td>25</td>
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<td>Marketing and Delivery Expenses(^m)</td>
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<td>2. Fixed</td>
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<td>Salaries and Wages(^n)</td>
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<td>1</td>
<td>2,500</td>
<td>22,500</td>
<td>7,500</td>
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<td>Permit and Licenses(^o)</td>
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<td>Irrigation Fee(^p)</td>
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<td></td>
<td></td>
<td>100</td>
<td>33</td>
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<tr>
<td>Miscellaneous/Food Allowance(^q)</td>
<td>month</td>
<td>9</td>
<td>1,000</td>
<td>9,000</td>
<td>3,000</td>
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<td>Subtotal (B2)</td>
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<td></td>
<td></td>
<td>32,100</td>
<td>10,700</td>
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<td>Subtotal (B)</td>
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<td>110,476</td>
<td>36,825</td>
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<td>C. Noncash Costs</td>
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<tr>
<td>Depreciation(^r)</td>
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<td>1,000</td>
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<td>Imputed Family Labor(^s)</td>
<td>month</td>
<td>9</td>
<td>2,500</td>
<td>22,500</td>
<td>7,500</td>
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<tr>
<td>Subtotal (C)</td>
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<td></td>
<td>23,500</td>
<td>7,833</td>
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<td>D. Total Costs (B+C)</td>
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<td>133,976</td>
<td>44,659</td>
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<td>E. Net Returns</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>After Cash Costs (A–B)</td>
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<td></td>
<td>49,124</td>
<td>16,375</td>
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<td>After Total Costs (A–D)</td>
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<td></td>
<td></td>
<td>25,624</td>
<td>8,541</td>
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</tbody>
</table>

\(^a\) m² = square meter.
\(^b\) Total harvest is 1,995 fingerlings/m²/year; 3 crop cycles/year; water area (250 m²); total farm area (300 m²); fingerling sizes are 17 and 14 (mesh sizes of nets for grading fish seed); average price is P0.32/piece.
\(^c\) Estimated usage is 1 pack/cycle.
\(^d\) Average purchase price of fry/fingerling sizes 38 and 32 is P0.04.
\(^e\) Based on survey results of nurseries in Lake Taal, Batangas.
\(^f\) Commercial fertilizer at P428 per 50 kilograms.
\(^g\) Chicken manure at P30/bag at 2 bags/cycle.
\(^h\) Pesticide application is 1 liter/hectare; 3 times/year at P1,500/bottle.
\(^i\) Fuel (P15/liter, 6 liters/cycle); and oil (0.5 bottle/cycle at P70/bottle).
\(^j\) Assumed at 1% of cash sales.
\(^k\) One load for 2 cycles at P250/load.
\(^l\) Assumed labor cost is equivalent to wages of laborers.
\(^m\) Source: Special evaluation study survey.
\(^n\) Assumed at P50/month for 9 months.
\(^o\) Chicken manure at P30/bag at 2 bags/cycle.
\(^p\) One load for 2 cycles at P250/load.
\(^q\) Assumed at prices applicable to fish cage operation.
\(^r\) Water is virtually free, extracted from the river or lake.
\(^s\) Nursery owner provides P1,000/month for rice and coffee.
\(^t\) Straight line method for utilized capital assets except land.
### Table A3.2: Illustrative Financial Farm Budget for a 10x10 Meter Tilapia Fish Cage

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number (per annum)</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso) Per Year</th>
<th>Total (Peso) Per Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Returns</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash (sold)</td>
<td>kilogram</td>
<td>5,880</td>
<td>50.00</td>
<td>264,600</td>
<td>132,300</td>
</tr>
<tr>
<td>Noncash (given away)</td>
<td>kilogram</td>
<td>60</td>
<td>50.00</td>
<td>3,000</td>
<td>1,500</td>
</tr>
<tr>
<td>(home consumption)</td>
<td>kilogram</td>
<td>60</td>
<td>50.00</td>
<td>3,000</td>
<td>1,500</td>
</tr>
<tr>
<td><strong>Subtotal (A)</strong></td>
<td></td>
<td></td>
<td></td>
<td>270,600</td>
<td>135,300</td>
</tr>
<tr>
<td><strong>B. Cash Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1. Variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fingerlings(^b)</td>
<td>piece</td>
<td>100,000</td>
<td>0.32</td>
<td>32,000</td>
<td>16,000</td>
</tr>
<tr>
<td>Feeds(^c)</td>
<td>bag</td>
<td>360</td>
<td>445</td>
<td>160,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Fuel(^d)</td>
<td>liter</td>
<td>18</td>
<td>15</td>
<td>375</td>
<td>188</td>
</tr>
<tr>
<td>Electricity(^e)</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Repairs and Maintenance(^f)</td>
<td></td>
<td></td>
<td></td>
<td>2,646</td>
<td>1,323</td>
</tr>
<tr>
<td>Supplies</td>
<td>piece</td>
<td></td>
<td></td>
<td>75</td>
<td>38</td>
</tr>
<tr>
<td><strong>Subtotal (B1)</strong></td>
<td></td>
<td></td>
<td></td>
<td>195,196</td>
<td>97,598</td>
</tr>
<tr>
<td><strong>2. Fixed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permit and Licenses(^h)</td>
<td></td>
<td>500</td>
<td></td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>Food Allowance(^i)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal (B2)</strong></td>
<td></td>
<td></td>
<td></td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td><strong>Subtotal (B)</strong></td>
<td></td>
<td></td>
<td></td>
<td>195,696</td>
<td>97,848</td>
</tr>
<tr>
<td><strong>C. Noncash Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation(^j)</td>
<td></td>
<td>7,667</td>
<td></td>
<td>3,834</td>
<td></td>
</tr>
<tr>
<td>Imputed Family Labor(^k)</td>
<td>month</td>
<td>10</td>
<td>2,500</td>
<td>25,000</td>
<td>12,500</td>
</tr>
<tr>
<td><strong>Subtotal (C)</strong></td>
<td></td>
<td></td>
<td></td>
<td>32,667</td>
<td>16,334</td>
</tr>
<tr>
<td><strong>D. Total Costs (B+C)</strong></td>
<td></td>
<td></td>
<td></td>
<td>228,363</td>
<td>114,182</td>
</tr>
<tr>
<td><strong>E. Net Returns</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After Cash Costs (A–B)</td>
<td></td>
<td></td>
<td></td>
<td>74,904</td>
<td>37,452</td>
</tr>
<tr>
<td>After Total Costs (A–D)</td>
<td></td>
<td></td>
<td></td>
<td>42,237</td>
<td>21,119</td>
</tr>
</tbody>
</table>

\(^a\) There are 2 cycles/year with production of 3 metric tons/cycle. Sales discount is 10%; at least 1% each of total production is either given away or consumed at home.

\(^b\) Average price of fingerlings sizes 17 and 14 is P0.32. Stocking rate is 50,000 fingerlings/cycle/cage.

\(^c\) The total number of bags of feeds is based on a feed conversion ratio of 1.5.

\(^d\) Fuel (15/liter, 6 liters/cycle); and oil (0.5 bottle/cycle at P70/bottle).

\(^e\) Estimated at P50/cycle. This is low because almost no electricity is required for fish cages.

\(^f\) Assumed at 1% of cash sales. Estimated from key informant interviews.

\(^g\) Assumed for farm records.

\(^h\) Based on actual expenses at Lake Taal.

\(^i\) No provision for food under the profit sharing arrangements between the caretaker and financier.

\(^j\) Straight line method for utilized capital assets, except land.

\(^k\) Assumed labor cost is equivalent to monthly salary of laborer at Lake Taal.

Source: Special evaluation study survey.
Table A3.3: Illustrative Financial Farm Budget for a 1-Hectare Tilapia Pond

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per Year</td>
<td>Per Cycle</td>
</tr>
<tr>
<td>Number of Crop Cycles Per Year</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**A. Returns**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash sold</td>
<td>kilogram</td>
<td>17,000</td>
<td>45.00</td>
<td>688,500</td>
</tr>
<tr>
<td>Noncash (given away)</td>
<td>kilogram</td>
<td>85</td>
<td>45.00</td>
<td>3,825</td>
</tr>
<tr>
<td>(home consumption)</td>
<td>kilogram</td>
<td>85</td>
<td>45.00</td>
<td>3,825</td>
</tr>
</tbody>
</table>

**Subtotal (A)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per Year</td>
<td>Per Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>696,150</td>
<td>348,075</td>
</tr>
</tbody>
</table>

**B. Cash Costs**

**1. Variable**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeds</td>
<td>bag</td>
<td>674</td>
<td>445.00</td>
<td>300,000</td>
</tr>
<tr>
<td>Fertilizers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inorganic</td>
<td>bag</td>
<td>32</td>
<td>415.00</td>
<td>13,280</td>
</tr>
<tr>
<td>Organic</td>
<td>bag</td>
<td>640</td>
<td>30.00</td>
<td>19,200</td>
</tr>
<tr>
<td>Lime</td>
<td>metric ton</td>
<td>1</td>
<td>2,500.00</td>
<td>2,500</td>
</tr>
<tr>
<td>Pesticide</td>
<td>bottle</td>
<td>1</td>
<td>1,500.00</td>
<td>1,500</td>
</tr>
<tr>
<td>Fuel and Oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>Repairs and Maintenance</td>
<td></td>
<td></td>
<td>6,885</td>
<td>3,443</td>
</tr>
<tr>
<td>Supplies</td>
<td>Record Book/Paper</td>
<td>piece</td>
<td>75</td>
<td>38</td>
</tr>
</tbody>
</table>

**Subtotal (B1)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per Year</td>
<td>Per Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>378,340</td>
<td>189,170</td>
</tr>
</tbody>
</table>

**2. Fixed**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries and Wages</td>
<td></td>
<td>2</td>
<td>3,000.00</td>
<td>60,000</td>
</tr>
<tr>
<td>Permit and Licenses</td>
<td></td>
<td></td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>Irrigation Fee</td>
<td></td>
<td></td>
<td>2</td>
<td>1,500.00</td>
</tr>
<tr>
<td>Miscellaneous/Food Allowance</td>
<td>month</td>
<td>10</td>
<td>1,000.00</td>
<td>10,000</td>
</tr>
</tbody>
</table>

**Subtotal (B2)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per Year</td>
<td>Per Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>73,500</td>
<td>36,750</td>
</tr>
</tbody>
</table>

**Subtotal (B)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per Year</td>
<td>Per Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>451,840</td>
<td>225,920</td>
</tr>
</tbody>
</table>

**C. Noncash Costs**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation</td>
<td></td>
<td></td>
<td>11,934</td>
<td>5,967</td>
</tr>
<tr>
<td>Imputed Family Labor</td>
<td>month</td>
<td>10</td>
<td>3,000.00</td>
<td>30,000</td>
</tr>
</tbody>
</table>

**Subtotal (C)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per Year</td>
<td>Per Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>41,934</td>
<td>20,967</td>
</tr>
</tbody>
</table>

**D. Total Costs (B+C)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per Year</td>
<td>Per Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>493,774</td>
<td>246,887</td>
</tr>
</tbody>
</table>

**E. Net Returns**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Number</th>
<th>Unit Price (Peso)</th>
<th>Total (Peso)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Cash Costs (A–B)</td>
<td></td>
<td></td>
<td>244,310</td>
<td>122,155</td>
</tr>
<tr>
<td>Above Total Costs (A–D)</td>
<td></td>
<td></td>
<td>202,376</td>
<td>101,188</td>
</tr>
</tbody>
</table>

---

1. Total harvest is 8.5 metric tons/cycle; 2 cycles/year assuming 85% survival; the culture is semi-intensive with harvested fish of an average size of 5 pieces/kilogram; sales discount at 10% of total sales volume; at least 1% of harvested fish are given away or consumed at home.
2. Purchase price of fingerlings size 22 is P0.25/piece. Stocking is 50,000/hectare/cycle.
3. Feed expense at P3/piece, based on estimates of the Philippine Bureau of Fisheries and Aquatic Resources.
4. Ammonium sulfate (16-20-0) at 4 bags/month at 50 kilogram/bag.
5. Chicken manure at P30 for each 25 kilogram bag for a total of 80 bags/hectare/month.
6. Applied at 1 metric ton/hectare at P2.50/kilogram.
7. Pesticide use is 1 liter/hectare/year at P1,500/bottle.
8. Fuel (P18/liter, 200 liters/cycle); and oil (3 gallons/cycle at P350/gallon).
10. Assumed at 1% of cash sales.
11. Estimated cost of office supplies for farm records.
12. Wages for two laborers at P3,000/month for 5 months/cycle, including pond preparation.
14. There are two seasons or crop cycles per year.
15. Owner provides an allowance of P1,000/month for rice, coffee, etc.
17. Assumed labor cost is equivalent to wages of laborers.

Source: Special evaluation study survey.