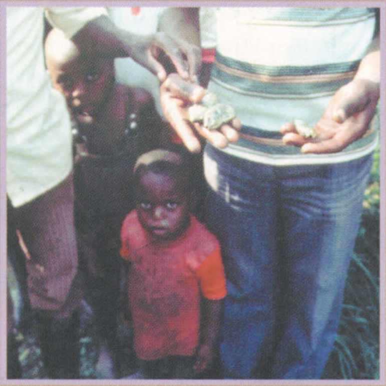
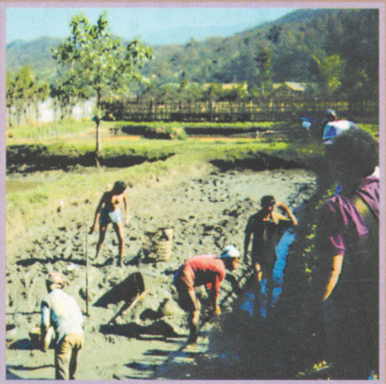
Social, Economic, and Institutional Impacts of Aquacultural Research on Tilapia

The PD/A CRSP in Rwanda, Honduras, the Philippines, and Thailand

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Chapter One
Overview

The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) is a global research network organized to generate basic science that may be used to advance aquacultural development. One of a family of research programs funded by the United States Agency for International Development (USAID), this CRSP focuses on improving the efficiency of aquaculture systems.

The Pond Dynamics/Aquaculture CRSP began work in 1982 in Thailand, and subsequently in the Philippines, Honduras, Rwanda, Indonesia, and Panama. Research continues today in Thailand, the Philippines, Honduras, the U.S. and, until recently, Rwanda. At all the sites, the goal is the same: to identify constraints to aquaculture production, and to design responses that are environmentally and culturally appropriate.

The PD/A CRSP has conducted a Global Experiment for over ten years. The Global Experiment has served as an organizing framework for guiding parallel studies in diverse locales in the tropics. Researchers have conducted a series of standardized research trials at each site, establishing baseline data on physical, chemical, and biological processes as they relate to fish growth. The research network has focused on tilapia (*Oreochromis niloticus*), although some sites have devoted attention to marine shrimp and other locally significant species. This report examines the impact of the network's investigations with tilapia.

Tilapia is an important food fish that has great potential for providing low-cost protein to consumers, as well as income and food security to farm families in rural areas. The fish eats filamentous algae, zooplankton, and phytoplankton because its ecological niche is low on the food chain. Algae blooms in ponds can be fostered by the addition of inorganic fertilizers as well as manures and other sources of organic nutrients. Much of the work of the PD/A CRSP has been directed to specifying optimum ways farmers can fertilize their ponds to increase fish yields *(16)*.

Tilapia also can be grown using commercial feeds to supplement or supplant food from natural productivity. In later years, the PD/A CRSP researchers endeavored to specify the appropriate circumstances for providing additional feed to fish to improve yields, shorten growing periods, or enhance economic returns.

The PD/A CRSP program has identified many of the needed parameters that apply across diverse environments. This report establishes how and to what extent the research findings are reaching institutions serving farmers in PD/A CRSP countries and whether they in turn are extending the findings to farmers. The report develops a profile of aquaculture practices, profitability measures, and producer orientations in four PD/A CRSP countries. To promote the utilization of aquaculture technology it is important to know what types of users are most inclined to make successful and sustained use of the PD/A CRSP production regime. There is a need to clarify the correspondence between the PD/A CRSP paradigm, farmer perspectives, and actual farming system potentials. It has not been established whether the assumed inputs are available, at what cost, and if farmers think that the production regimes fit their farming systems.

To observe the consequences of PD/A CRSP technologies, some definition of what has been developed and made available to farmers is necessary. There is some variability in approach across the PD/A CRSP sites due to institutional interests and the level of aquaculture practice found in each country. This report treats fertilization and feeding practices as central aspects of the PD/A CRSP technology program.

The scientific activities of the PD/A CRSP have been organized under the unifying Global Experiment. A highly diverse set of investigations specify the relative effects of various organic inputs, inorganic fertilizers, feeding strategies, species combinations, water parameters, and other variables on fish production. It is not unreasonable to expect that the main impacts of the PD/A CRSP are transmitted to producers through national institutions, although nongovernmental agencies and private sector firms also are intermediaries for PD/A CRSP research results. The PD/A CRSP should have some connections to the general level of pond-based aquaculture practice because this has been the general focus of the PD/A CRSP across the various sites.

It is also important to understand the interactions among family, farming system, and community as they together shape the choice and continued utilization of technology. Clearly, economic or financial profitability is one signal criterion used by farmers to adopt and continue fish culture *(32,37)*. The interaction between other farm enterprises and household activities also shapes these choices. We remain centrally interested, however, in feeding and fertilization practices as farm-level outcomes or dependent variables to be explained by the PD/A CRSP intervention. The connection between research strategy and finding in relation to actual practice is the central focus of the study. The report provides information that profiles the major points of convergence in the production and marketing of tilapia across the four PD/A CRSP sites.

Important questions pertain to the technologies and production regimes emerging from research that can actually be implemented on farms in the project countries *(6)*. Much of the baseline data commonly found in other agricultural sciences has been lacking in aquaculture *(60,68)*.

SOCIAL SCIENCE AND THE PD/A CRSP

Understanding the circumstances and motivations that shape farm operator decision processes will be a significant step toward designing and maintaining a technology transfer effort that will be sustainable and effective *(17,43)*. There are important commonalities among farmers across the PD/A CRSP sites; there are also important differences in price, market organization, ecology, farming system, and social matrix. Sustainability is a common theme across these diverse disciplinary subject-matter areas.

Sustainability. Sustainability is the ultimate measure of success for a development intervention *(43)*. If people continue to grow fish while being emulated by their neighbors and residents of other communities, aquaculture will have furthered the cause of development and food security *(45)*. Sustainability has environmental, social, and institutional dimensions.

Aquaculture is environmentally sustainable when the water it uses and the pollution it generates do not exceed the carrying capacity of the locale where fish farming is practiced *(8)*. Pullin argues that smaller-scale and less-intensive aquaculture operations, especially those integrated with agriculture, are less likely to pose environmental problems *(53)*.

Aquaculture is socially sustainable when neither its benefits nor its costs are concentrated in one segment of the population. Ideally, fish farming should engender equitable participation in its benefits across a wide spectrum of socioeconomic segments of the community. In reality, not all farmers are inclined or able to build ponds. Other constraints limit participation in aquaculture to those able to make productive use of their time and resources in the activity. Nevertheless, fish farming can augment the array of locally-based opportunities for food production and income generation, and can benefit many residents in different ways.

The social costs of aquaculture are often connected to conflicts linked to the loss of access to resources. Fish farming may accelerate the enclosure of formerly open-access lands or coastal waters. Private fish ponds may divert water from formerly shared uses; effluent from ponds may alter the quality of water for other users. When the expansion of aquaculture limits opportunities or livelihoods for other community residents, social sustainability may be questioned. Regulation of effluent discharge, promulgating access rules for coastal areas, and promoting the orderly allocation of water resources are important roles for the state in moderating the market forces driving the expansion of aquaculture *(4)*.

Conversion of mangrove swamp and other coastal area into ponds is a major issue for shrimp aquaculture *(4)*. The new farms often restrict access to the resource base that would otherwise support a variety of livelihoods associated with small-scale fishing and aquaculture. Similarly, Ahmed et al. conclude that the benefits of improved aquaculture technology will accrue mainly to the owners of small waterbodies whose present socioeconomic circumstances are better than the rest of the rural Bangladesh population *(1)*. They observe that it may be necessary to promote low-cost technologies for aquaculture as well as to provide institutional and policy support to enable poor and landless people to get access to waterbodies and adopt aquaculture.

Aquaculture is institutionally sustainable when the services and subsidies required to build and continue the industry do not exceed the fiscal and organizational capacity of the state. Ultimately, subsidies should cease and state services should become minimally necessary to aquaculture's viability as a widely-practiced farm enterprise. It should be noted that the primary influence of PD/A CRSP activities is exerted through the institutional context of the research sites and the network of students, extensionists, technicians, and host country scientists that collaborate with PD/A CRSP scientists. This report documents the nature and extent of these institutional effects of the research program.

Livelihood activities such as aquaculture are embedded in a structure of social relations; therefore, for the theory and practice of induced development, defining the levels of such embeddedness becomes the critical task. Individuals make decisions in the context of family, household, and village social relations *(46,48,54)*. These considerations shape responses to basic economic incentives and create other motivations for selecting activities and approaches that are often more powerful than price signals. They determine which price mechanisms operate and under what circumstances *(23)*.

Social Knowledge. The systematic use of social knowledge, as a complement to economic and technical knowledge, is indispensable for "putting people first" in development interventions *(12)*. For the PD/A CRSP, farm-level effects have increased in centrality as basic scientific issues have been clarified and the political-administrative paradigm within USAID has shifted toward a concern for the more immediate consequences of development funding.

The work to be done by social scientists that furthers the objectives of the PD/A CRSP and of development should differ substantively in perspective to what is habitual in disciplinary practice *(13,41)*. The canons of method and statistical interpretation remain fundamental ties to sociology, but the focus and level of discourse must be different.

Although the PD/A CRSP is not a village-level development effort, social science research must endeavor to attune the other specialists — technical and economic — to the demands of putting people first. Only in the late state of the PD/A CRSP has social science become recognized as an explicit complement to the research program. As such the work presented here can only document some of the effects and issues that might have been more appropriately considered as an integral part of the Global Experiment.

The PD/A CRSP must be understood as an institutional innovation, a means for fomenting technical change in national aquaculture industries. Although not organized to deliver technology on the village level, it is a mechanism for improving the lot of family farms and the villages they encompass, albeit indirectly, through each nation's institutional network for aquacultural development. Consequently, much of the direct impact of the PD/A CRSP is focused on the organizations and institutions that house PD/A CRSP researchers, their laboratories, and field facilities. The changes instilled by a science and technology project such as the PD/A CRSP are largely felt at the institutional level where individuals are training, procedures put in place, and facilities are planned with expatriate technical assistance. This set of processes will be examined in detail in a subsequent PD/A CRSP social science study.

Impacts. In terms of changes in national aquaculture industries, the impacts of the PD/A CRSP are manifold. A chapter in this report details the institutional context of each nation and portrays the role of the PD/A CRSP in the nation's technical-knowledge system for aquacultural development *(55)*. Many of the advances that take place in an aquaculture industry are facilitated by the formal and informal consulting of PD/A CRSP scientists with private sector firms that grow fish or manufacture and sell inputs to farmers. The researchers' presentations at meetings, visits to laboratories and facilities, and personal communications with industry scientists and managers remain a continuing nexus of impact for the PD/A CRSP.

At the individual farm and village level, we examine the survey reports of fish farmers as to the role that tilapia culture plays in their farms and in their lives. The context or surrounding environment may enhance or inhibit the pursuit of fish farming. Where many farmers are producing fish and it is a commonly traded item in the marketplace — such as in Thailand — fish culture is easily adopted. Inputs are readily available, there is often competition among input suppliers, and providers of specialized services such as fingerling delivery or custom harvesting are available.

Following the sociological dictum "situations defined as real are real in their consequences" we profile fish farmer perceptions of the process of growing tilapia, harvesting the crop, and marketing the fish. We endeavor to specify basic dimensions of farmer perceptions of the effects of the tilapia enterprise on the household. Farmer perspectives on production problems, institutional functioning, and government services also are important forces shaping the acceptability and utilization of PD/A CRSP technology *(11)*.

OUTLINE OF THE REPORT

The report provides a comparative perspective on the social and economic dimensions that interact with biological variables in the conduct of fish culture in the various locales. The report also summarizes major dimensions of variability in the financial incentives presented to producers across the sites.

The objectives of the study are three: first, to profile the farming system, fish production practices, and household circumstances of tilapia farmers in four PD/A CRSP countries; second, to examine the economic incentives and constraints confronting tilapia producers in terms of market signals, input costs, and the relative profitability of various experiment-based tilapia production strategies; and third, to provide an overview of the institutional context of the PD/A CRSP in each country's program of tilapia technology development and transfer.

CHAPTER TWO
SOCIAL AND ECONOMIC FACTORS IN AQUACULTURAL DEVELOPMENT

This chapter presents a framework for considering socioeconomic factors affecting the implementation and sustained pursuit of pond aquaculture. It integrates, compares, and synthesizes what is known about the conditions promoting successful adoption and sustained use of aquaculture technology. It begins with a brief overview of tilapia production technology and production strategies. A typology of producer orientations is developed to anticipate the data analysis that follows in subsequent chapters.

FRAMING CONSTRAINTS FOR FISH CULTURE

Framing constraints are the conditions or circumstances that determine the possibilities and incentives for tilapia production in a particular locale. Material constraints refer to the physical and environmental factors that determine whether the raising of fish is materially possible or feasible. Socioeconomic factors operate after it has been shown that it is feasible to grow fish in a locale; they determine whether the raising of fish is desirable or acceptable as a human activity *(6)*.

Material Constraints. *Soils* affect tilapia culture because they determine the water holding capacity of ponds and the productivity of the aquatic environment. Soil properties are directly related to the nutrients in pond water. Acidity, hardness, and other water quality properties have their origins in the soil environment. *Water* from runoff, groundwater, streams, or impoundments is necessary for fish culture. Individual farms vary in the amount of water they can access and retain. The annual hydrologic regime is a primary factor shaping fish culture.

Water temperature, and various other *water quality parameters* such as salinity and acidity also condition the possibilities of fish culture in a given locale. Tilapia have an optimal temperature range for viability and reproduction; in Rwanda this constraint is a central consideration for researchers and producers. In warmer waters, other parameters may be limiting factors.

Socioeconomic Constraints. Socioeconomic framing constraints include markets, infrastructure, community milieu, household dynamics, and producer orientations. The educational level of producers directly shapes their ability to search for and utilize new technology and to participate in market processes. Lightfoot outlines an extension strategy for understanding the complex connections between households, resource systems, and the larger milieu which shape the possibilities for rural livelihoods *(40)*.

Beyond the pond environment, market incentives, consumer preferences, input availability, and the financial condition of farm households each affects the production strategy appropriate to a locale and a particular set of farmers. Cultural acceptability of fish in general or a particular species affect the prospects for selling or consuming fish once they are produced. Prices affect the incentives for producing fish and the extent to which all segments of a community would be able to purchase fish if availability were increased. The ability to sell or barter fish for cash or other items is a basic consideration determining whether fish will be selected as a farm enterprise and whether subsequent crops will be grown.

To understand the type of technology that tilapia farmers employ and the production strategy they choose, it is important to understand the role of the aquacultural enterprise in the farm household, the infrastructure for marketing and distribution, and the place of tilapia in the dietary regime of the population.

Infrastructure refers to the institutional and organizational mechanisms that allow the conduct of fish culture and the development of an industry. Fingerling supply, disease control services, and feed supply are key components of the infrastructure that supports the development of an aquaculture industry. Research and extension advice also are significant support services that enhance the long term viability of aquaculture. Credit availability and some level of monetary stability also are part of the conditions favoring aquacultural development.

Tendler's study of the institutional history of several small successes in agricultural extension and research portrayed a complex milieu of public agencies, local elites, and strong centralized public sector actors *(65)*. She found that demand-side factors — particularly the presence of organized user groups or representative agencies — played important roles in driving research and extension to do better.

The *community milieu* for fish culture refers to the normative structure of villages with respect to innovations in general and fish culture in particular. The kind of support or criticism farmers receive from their peers and neighbors is one force encouraging or discouraging the adoption of fish culture as a farm enterprise and its continued pursuit. The nature and extent of preexisting internal divisions within a community — and whether aquaculture creates or exacerbates these divisions — can shape the course of fish farming in the locale. Another aspect of the community milieu for fish culture is the level of human predation or the theft of fish and the extent to which such theft is tolerated or supported by community norms*(51)*.

Land tenure and agrarian structure can be broadly defined as the nature and distribution of rights and access to land and water resources *(56)*. Land tenure arrangements shape the incentives and risks for farmers deciding whether to build ponds *(15)*. An important influence on technology adoption, economies of size in access to capital and output markets can bias aquacultural development toward larger, wealthier farms. Small farm sizes or excessive fragmentation of land holdings may constrain adoption of certain "lumpy" inputs such as pumps or tractors. Uncertainty about land title can discourage investment in pond construction and other commitments necessary for fish farming.

Harrison finds that one of the principal constraints faced by nonadopters of aquaculture in Zambia was security of land tenure, a constraint felt most forcefully by women *(30)*. Rothe and his colleagues conclude that tenure security is necessary, but not sufficient for the adoption of productivity-enhancing technology in agriculture *(56)*. As long as constraints on access to input and output markets limit incentives to innovate and invest, tenure security itself does not represent a binding constraint on technology adoption. Because pond construction represents direct capital investment in the land, tenure security may be a larger factor in farmer decisions about this step than it is in decisions about other kinds of productivity enhancing technology.

Household dynamics includes a variety of issues related to decision-making, family roles, the availability of labor, and the set of issues associated with gender. Access to labor for pond construction was a primary barrier to participation in aquaculture for women in Zambia *(30)*. Women were consistently more likely to cite role conflicts or hardships associated with fish culture as an addition to their repertoire of activities *(44)*.

We consider the impacts of a new enterprise on women, the effects of the fish pond on other activities, the disposition of harvests, harvest proceeds, and post-harvest use of fish. Responsibilities and burdens of feeding, monitoring, harvesting, and preparing the fish may not coincide with the nutrition, cash, and other benefits accruing to fish harvests.

Producer orientations represent the perceptions and attitudes of tilapia farmers and others who make decisions about whether and how tilapia will be grown by a household. The way farmers define situations dictates the decisions they make. Molnar et al. conclude that Rwanda farmers undertake fish culture largely as a diversification strategy *(44)*. Many prefer to accept smaller, more reliable yields that offer cash and food security with lower levels of risk and effort.

Producer education and training includes the ability to read, write, and calculate. Less intensive methods of aquaculture can be conducted by non-literate farmers; when fish farming becomes more intensive and market-oriented these skills become increasingly important. The level of education in a population of fish farmers determines the kinds of communication strategies that are necessary to convey technical information for advancing the practice of fish culture *(2,19)*.

OPERATING STRATEGIES

The *operating strategy* undertaken by tilapia operators is the approach farmers take to raising fish; it reflects the effort, technology, attention, and resources devoted to the enterprise. Tilapia culture can be understood in terms of the household's level of investment and the level of dependence on the fish culture enterprise. The following typology uses the two basic dimensions relating to investment and dependence on the tilapia enterprise to portray the operating orientations of tilapia farms. It is used here to summarize the major dimensions of variability in the ways tilapia is grown across national settings. In particular, we are interested in explaining the pattern of technology choices and the trajectory of technology and information needs associated with various operating strategies.

Figure 2.1 shows level of dependence on the aquaculture enterprise and amount of investment in it as determining operating strategy. The pattern of technology choices that a farm operator undertakes can be understood as a function of dependence on the outcomes and investment in the means of production — facilities and equipment — for growing tilapia. This typology will be used to understand the kind of tilapia

		Level of Enterprise Dependence		
		Low	Medium	High
Level of Investment	Low	*Peripheral*	*Marginal*	*Subsistence*
	Medium	*Residual*	*Complement*	*Focused*
	High	*Venture*	*Diversified*	*Specialized*

Figure 2.1. Operating strategy as a function of household dependence on and investment in the enterprise.

production technology employed in various locales and to anticipate trajectories of development if certain barriers were overcome.

Dependence refers to the relative importance of the tilapia-raising activity in contrast to other production activities and the overall wealth of the household. It is reflected in the relative share of family and personal resources devoted to the aquaculture enterprise. Investment refers to the amount of capital and other financial resources deployed in the fish culture operation. Cross-tabulating these two dimensions summarizes the major clusters of farm types characterizing the aquaculture industry in general and tilapia in particular. The central point of comparison is the orientation of the farm operator toward technology adoption.

With one exception to be explained in a subsequent section, we consider intensive production to entail high levels of investment; all other categories are considered to pursue semi-intensive or less aggressive approaches to fish culture. The typology is intended to simplify and summarize a great deal of variability. We acknowledge the existence of counter examples and other logical possibilities, but the classification does summarize a great deal of variability and provides ready insights into the strategies or farming styles undertaken by fish farmers.

Peripheral approaches to fish culture are those where the relative level of investment is low and the level of dependence on fish culture for food or income is low. That is, this segment of the population pursues fish culture as a hobby, pastime, or curiosity. For example, one Dutch project in Jamaica worked with small private backyard ponds often containing less than 50 fish *(51)*. The activity was often undertaken by young people. The nutrition and income benefits of this type of aquaculture are limited at best, although there may be other significant consequences for individual and community development. In Honduras, a retirement-age fruit grower con-structed a series of small concrete tanks to grow tilapia for household consumption, feeding them citrus rinds and other available inputs *(47)*.

Residual tilapia operations utilize tilapia primarily as a means to capture secondary benefits from a large-scale primary activity such as poultry production or food processing. Moderate investment in tilapia production reflects the financial standing of the operator, but low dependence reflects the small size of the tilapia revenue compared to other income sources. The wastes or byproducts of the primary activity are used as an input to aquaculture. Where the level of investment is moderate and enterprise dependence is low, aquaculture will be a residual or secondary activity pursued centrally for the income from the fish as a byproduct of another activity.

When tilapia production is a residual enterprise, few other inputs are applied as the fish are mainly intended to capture unused resources from the primary activity. Such operators are typically interested in producing a fish commodity with undifferentiated quality. Wealthier poultry farmers in Thailand primarily fit this category of the typology. For this type of farm, tilapia is a fortunate byproduct of another line of activity.

Venture farming of tilapia represents fish culture undertaken by nonfarm or farm interests centrally motivated by potential high rates of return or adoption rents associated with a booming business. Such operators are not dependent on the fish enterprise to maintain their livelihoods; instead they are likely to employ a hired manager to oversee day-to-day operations. One such operation observed in Thailand was founded by a construction company owner on the advice of some of his investment-minded friends *(44)*. Located literally in the shadow of one of the largest poultry-producing complexes in Thailand, the farm utilized a semi-intensive approach to producing large quantities of fish for the open market. Tilapia-producing subsidiaries of large feed corporations also would be included in this category.

Marginal farmers are somewhat dependent on the income from tilapia production but operate at a low level of investment. They are likely to use less technology and low intensities of operation. Often constructed as a speculative investment by a local business person or professional, many of the moderate-sized and small tilapia farms in Honduras and some in Rwanda may be thought to be marginal operations. They are moderately dependent but minimally invested in the activity; thus fish culture is most vulnerable to competing uses of their land, labor, and attention *(47)*.

Farming of tilapia can be a *complement* to other farm activities. As such, it represents moderate investment and moderate dependence on the enterprise. Complement strategies differ from residual strategies in the amount of effort applied to tilapia; tilapia receive more management attention and the enterprise is more central to the overall farming system. In this manner, tilapia rounds out the cycle of input use and resource availability on the farm. It is a significant proportion of family income. Family-scale tilapia farms in Thailand most fully represent this category. Such farmers are likely to attend more directly to the technology and management of their fish because of the greater meaning the harvest has for household well-being; they are more dependent on the tilapia income than residual farmers.

As a complement to the overall farm strategy, tilapia are grown primarily for ready cash flow and its low labor requirements. Family-scale farms featuring integrated operations producing pigs, ducks, or rabbits centrally exemplify this category *(52)*. Small and moderate-scale farms in Thailand often culture tilapia in ponds under their chicken houses. Utilizing the chicken waste and feed not consumed by the chickens, farmers grow tilapia to capture the complementary benefits associated with the poultry enterprise. Complement operators may be more receptive to improvements in methods or procedures of tilapia production than in technologies that require high levels of investment or significantly increase operating costs.

Diversified operators have moderate dependence on tilapia growing, but have a high investment in the enterprise. Centrally, these are moderate-size farms that pursue fish culture as a significant part of the activity mix in their farm business. Such operators have a serious interest in new technology and management strategies that reduce risk and optimize return on investment. One dairy farmer in Jamaica was shifting his attention and investment from milk production to include semi-intensive culture of tilapia as a diversification strategy *(51)*.

Subsistence operators have a high dependence on the income and food supply represented by their ponds but have low investment in the enterprise. They may be centrally concerned with the risk reduction represented by the presence of the farm pond. They may be most interested in low-cost, no-cost, no-cash strategies for enhancing the amount and quality of fish produced from their lands. They are likely to be reluctant to implement strategies requiring regular use of purchased inputs. Fish farming in Rwanda may be described as a poverty-reduction strategy for households with little cash, little land, and high risks of crop failure and other adversity.

Focused operators have a high level of dependence on tilapia culture for their livelihoods, but only a moderate level of investment. They may be most interested in ways of optimizing the use of existing inputs or utilizing technologies that have moderate levels of financial risk. Individuals with fish farming as their sole activity are included in this category; many may have off-farm income from their own or a spouse's employment.

A small farm operator with a great deal of expertise could undertake a focused operating strategy that involves intensive production of tilapia. Such an operation would require a high level of managerial ability. Intensively feeding a dense population of fish, possibly by exploiting a spring or other source of flowing water, an individual could utilize his own and family labor to sustain a household through this form of livelihood. Cage culture may offer particular advantages to a focused small farm operator. We observed no such operations, but undoubtedly they exist.

Specialized tilapia farmers have a high level of investment and a high level of dependence on tilapia production. By definition, this category excludes nearly all small-scale or subsistence operations because of the investment requirements. Most United States tilapia producers fall into this category. They are highly motivated to seek information and technology to maximize the benefits of their choices and interests in tilapia. Most PD/A CRSP countries have only a few specialized operators who typically produce for export or specialized internal markets. Some also maintain processing facilities.

Large investor-backed farms engaging primarily in tilapia production for export or specialized markets are the central occupants of this category of the typology. These operators often produce their own fingerlings and frequently seek to supply surrounding farms with excess seed production. Such farms typically have high levels of investment in pumps, facilities, and personnel. They may seek to contract production to neighboring family-owned farms to ensure supply for processing facilities. Such firms may have internal experts and regular contacts with private consultants to manage the level and kind of technology used in reproduction and grow-out.

CONCLUSION

This typology of tilapia farming can be used to understand modes of adaptation and response to changing technology, input costs, and other circumstances shaping the conduct of aquaculture. PD/A CRSP technologies primarily have to do with fertilization and the management of water quality parameters. As such, PD/A CRSP has focused on techniques and approaches most appropriate to low and medium levels of capital investment at all ranges of dependence.

CHAPTER THREE
MODES OF TILAPIA PRODUCTION

This chapter identifies basic dimensions of tilapia production technologies with emphasis on Thailand, Honduras, the Philippines, and Rwanda. The notion of intensity of production is developed and the nature of the production system predominant in each country is examined in terms of the intensity classification. Although this chapter provides a context for interpreting the survey results that follow in a subsequent chapter, readers already familiar with tilapia production technology may simply turn to the findings.

TILAPIA PRODUCTION TECHNOLOGY

Tilapia is cultured in a variety of modes around the world. The kind of technology used is closely linked to the socioeconomic circumstances of the farmer, as the intensity of production often corresponds to the amount of capital investment. Although we focus on inland farming and freshwater tilapia production, use of brackish water to grow tilapia is increasingly important in coastal areas. Brackish water production of tilapia is increasingly important as an alternative or rotational crop for shrimp production where this organism is suffering declining yields due to disease or other problems.

Production of tilapia in freshwater ponds is the central focus of the PD/A CRSP research program. Nevertheless, tilapia also can be grown in cages or pens. Suspended from floats or docks in a body of water, cages may be simple wicker or wooden containers or may be more sophisticated and expensive wire mesh boxes used to confine fish. Pens utilize nets to fence the cultured fish in an enclosed area. Pens are fenced areas in lake, rivers, or ponds where fish are confined for feeding and harvest. Most farm operations, however, utilize open-water ponds.

Cage and pen culture represents an intensive production strategy, typically involving the provision of high quality feed to dense populations of growing fish. Water quality becomes increasingly important as a framing constraint and farm management concern in intensive production systems. In addition, stocking density, type of feed, and whether or not fertilization is used remain additional dimensions shaping the type of tilapia culture undertaken. There are also variations in the species or strain of tilapia employed, whether or not mixed or monosex populations are cultured, and the size of the fingerlings that are stocked.

In most systems, the tilapia fingerlings consume nutrients from algae and plankton growth. The algae bloom is augmented by some form of fertilization. In some cases, tilapia also receive a commercial ration; in the most intensive systems the commercial feed is the only nutrient source. The major possibilities for the culture of tilapia are centrally determined by the kind of water and type of enclosure used to house the fish. PD/A CRSP research has focused on fish grown in open ponds, and not on cage or pen culture.

FISH CULTURE SYSTEMS

Fish culture is often classified by the level or amount of human control over the culture system and the quantity and quality of feeds and fertilizers placed in the system *(16)*. A classification of intensity of control, investment, and risk in fish culture is developed in this section of the report. This classification can be used to understand variability in the practice of fish culture within a nation and between nations. Three levels of fish culture intensity can be identified as follows. The combination of feeding and fertilization can be used to differentiate one major set of divisions in tilapia production strategies. Figure 3.1 shows four major types of production strategies that bear on the development and use of PD/A CRSP technologies. Each type is explained in the subsequent discussion.

Extensive. Systems relying solely on natural productivity to provide nutrients for fish stocked at a low density are termed *extensive*. No nutrients are provided to stimulate, supplement or replace natural foods. Recreational fish ponds are often managed in this manner. In addition, there often is incomplete control over species composition and the number and size of individual fish. Lime may be used to foster algae blooms, but no feed or other nutrients are added. The operator exerts some control over the quantity of water

Input	Feed	No Feed
Fertilizer	*Semi-Intensive*	*Augmentative*
No Fertilizer	*Intensive*	*Extensive*

Figure 3.1. Culture strategies combining feed and fertilizer.

supply, but no control over water quality. Incomplete drainage and harvest typically are normal practices. The PD/A CRSP has used extensive systems or natural productivity as a baseline condition for comparing the relative efficacy of various feeding and fertilization regimes.

Augmentative. When additional nutrients are supplied to the pond to enhance natural productivity, the producer is undertaking an *augmentative* strategy. Fertilization supplements naturally occurring nutrients, enhancing the output of algae and other organisms supported by photosynthesis. The availability of microorganisms for the fish to eat is thus increased, and in some cases manures and other materials provided to the pond may be directly consumed by tilapia. The PD/A CRSP research findings that apply most directly to small-scale and moderate-size farms are augmentative combinations of animal manures, locally available byproducts (slaughter waste, food processing wastes, etc), or other on-farm organic inputs — such as kitchen waste — that are often diverse and irregularly available.

Commercial fertilizers allow higher stocking densities but also represent an out-of-pocket cost, a serious impediment for many developing country farmers. Augmentative strategies most often employ manures and other available farm inputs as nutrient sources for algae blooms. Tilapia also directly consume some of the detritus and other organic matter found in manures and other inputs. One limit to stocking density and the exclusive use of organic materials is the level of biological oxygen demand associated with the decay of these materials. Too much material for a given volume of water can suffocate the live animals, particularly at later growth stages.

Semi-Intensive. Most family farms in the countries examined in this report employ *semi-intensive* strategies; that is, operators fertilize their ponds and they also feed their fish. Pond water is fertilized with fresh vegetation, chemical fertilizers and/or manures to stimulate the growth of natural food organisms. Fish typically are fed a poor quality feed that supplements the natural pond foods. The combination of fertilization and feeding is the central attribute of semi-intensive strategies. Feeding is helpful at the fingerling stage supplementing zooplankton and phytoplankton, the normal food for the young fish. Feeding also is helpful at the later stages of fish growth when the natural productivity of the pond may not be sufficient to allow the crop of larger fish to grow at an optimal rate. Specifying optimal paths of fertilization and feeding is a central aspect of the PD/A Global Experiment.

In semi-intensive strategies, the operator exerts complete control over the quantity of water supply, but little or no control of water quality; drainage and harvest are usually complete. The operator has nearly complete control over species composition, number, and size within species.

Intensive. Modes of production characterized as *intensive* encompass industrial-scale tilapia operations. There is complete control over species composition, number, and size within species ensuring homogenous individuals at harvest. Fish are given a feed that supplies complete nutrition, usually in the form of pellets. Fertilizer is not used because excessive nutrients fuel algae blooms that compete for oxygen and asphyxiate the fish.

The operator exerts complete control over the quantity of water supply. Clear, clean water is vital to the survival of densely-stocked masses of fish that obtain all nutrition from commercially-prepared feeds. Filtration, steady replacement or partial water exchange, aeration, or a combination of these systems are used to maintain water quality; drainage and harvest are complete.

This type of system is centrally used by large-scale producers, although a small-scale farmer with a unique set of resources and capabilities could undertake intensive production. We observed a Honduran farm situated on a small plot of land with a high-quality water source. A graduate of a PD/A CRSP training program, he cultured red and black tilapia strains in a flow-through water system to produce fingerlings for surrounding farms, moderate-size fish for direct marketing, and larger fish featured in the family roadside restaurant *(47)*.

CHARACTERIZING NATIONAL SYSTEMS

The above classification will be used to define tilapia culture systems in Thailand, the Philippines, Honduras and Rwanda.

Rwanda. Species: *Oreochromis niloticus.*

System: Small producers (subsistence farmers) culture mixed-sex tilapia. Most fish harvested are under 200 grams. Fingerlings are produced by government hatcheries, but farmers supply most fingerlings to each other. Tilapia are raised in small ponds (100 to 1,000 square meters) and most farmers have a single pond. No monosex male culture is practiced outside government stations.

Culture: Annual harvest is estimated to be 21 metric tons. Farmers undertake augmentative strategies using manure or compost, but do not normally purchase commercial feeds due to their limited availability. Most farmers limit their efforts to placing vegetation in their ponds; a subset will collect and place manures in their pond. Chemical fertilizers are scarce and expensive.

Supplemental feeding is scarce and restricted to a few wealthy individuals or institutions. No intensive culture is practiced because prepared feeds are not available. Imported netting, woven twine, or baskets are used to capture fish.

Yields: Tilapia yields are low because of the lack of nutrient inputs and the cool climate. Most fish culture is located at 1,400 to 2,000 m elevation and the cool water temperatures at this altitude slow tilapia growth. Yearly yields range from 200 kg/ha in poorly managed ponds to 5,000 kg/ha in well managed ponds.

Markets: Tilapia are consumed at home, sold fresh on the pond bank, or made available in local markets. No tilapia are exported.

Honduras. Species: *Oreochromis niloticus* and hybrid red tilapia are commonly chosen for culture.

System: Small producers (subsistence farmers) culture mixed-sex tilapia. Some Honduran farmers polyculture their mixed-sex tilapia with a predator to control unwanted tilapia offspring.

Tilapia culture is less than 20-years-old in Honduras. Tilapia are raised in earthen ponds. Most farms are small but several large farms (20 to 40 hectares) exist. Conditions are favorable because land and water are abundant and relatively inexpensive. Modern tilapia culture technologies have been rapidly disseminated among farmers.

Presently, more male tilapia are cultured than mixed-sex tilapia. Male tilapia are produced by hybridization and sex reversal. Most tilapia fingerling production comes from government hatcheries. However, the private sector is growing rapidly and will soon be able to supply most tilapia fingerling needs.

Culture: Annual harvest is estimated to be 65 metric tons. Small farms use semi-intensive feeding and fertilization while larger, wealthier farmers are using intensive approaches. Most use chemical fertilizers, manures and agricultural by-products to raise their fish. Fish ponds are rarely integrated with animal husbandry activities. Honduras has only a short history of fish culture. Ponds are uncommon in the countryside and fish culture is not widely practiced. Farmers are not skilled in the art of fish culture. Pelleted fish feeds are available but they are expensive and the quality is suspect. Nets are imported, expensive and not widely available.

Yields: Tilapia yields vary greatly depending on the level of culture employed. Yields can range from 200 to 300 kg/ha/yr in poorly managed family ponds to about 6,000 kg/ha/yr in heavily manured and/or fed ponds. Aeration is still not practiced in Honduras and except for limited water exchange, dissolved oxygen limits the amount of fish harvested.

Markets: Tilapia culture is in its infancy and yearly production is low. Most fish are consumed in the household, sold to restaurants, or sold fresh in local markets. The local market for tilapia is poorly developed; prices and profits tend to be low. Two large farms in the San Pedro region export tilapia to the U. S. and other markets.

Philippines. *Species:* Both *Oreochromis niloticus* and *Oreochromis mossambicus* or their hybrids are widely cultured in fresh and brackish water. The red tilapia hybrid is also cultured.

Culture: Annual harvest is estimated to be 91,200 metric tons. The majority of tilapia culture is mixed-sex production of fish less than 200 grams. Small tilapia are widely accepted in the Philippines. The production of sex-reversed male tilapia is common and will grow rapidly as hatcheries are able to supply more male fingerlings to producers. Tilapia are raised in earthen ponds, cages and rice fields.

The Philippines probably grows more tilapia in cages than any other country in the world. Earthen ponds are typically small, and water area per farm less than 0.5 hectare. However, thousands of hectares of brackish water ponds formerly used to culture milkfish are becoming available as tilapia culture becomes more lucrative. Tilapia are commonly grown in monoculture or stocked with a predator species to check extraneous reproduction in the fish crop.

Semi-intensive feeding and fertilization predominate. Few farmers intensively culture tilapia, but intensive culture will grow rapidly as export markets are captured. The Philippines also has a long history of fish culture and it is an integral part of rural farming activities. Many farmers are skilled in growing fish. Tilapia are commonly raised with chemical fertilizers, fresh manure (integrated with animal husbandry) and supplemental feeds (rice bran and household wastes). Complete pelleted feeds and nets are available in the Philippines.

Yields: Tilapia yields vary greatly depending on the level of culture employed. Yields can range from 200 to 300 kg/ha/yr in rice fields and poorly managed family ponds to over 10,000 kg/ha/yr in heavily manured and/or fed ponds.

Markets: The Philippines may be the largest producer of cultured tilapia in the world and is certainly one of the top two. Most of the tilapia is consumed domestically. Tilapia are cultured to improve family nutrition and economic gain. In addition to the strong internal demand for tilapia, exports are certain to play an important role in the future of Philippine tilapia farming. Taxes, land prices, and other production costs, however, make the Philippines a high-cost producer relative to other exporting countries.

Thailand. *Species*: Predominantly *Oreochromis niloticus*, **but both *Oreochromis mossambicus* and lesser amounts of the red hybrid tilapia are cultured. Tilapia are commonly raised together with other species of fish (polyculture). Tilapia monoculture is common only in the last few years.**

System: The vast majority of tilapia culture in Thailand is still mixed-sex production of fish less than 300 grams. Fish are raised in earthen ponds and rice fields. Ponds range in size from 100 m2 to about 2 hectares. Tilapia farms are small with most farmers having less than 1 hectare of water. A few large tilapia farms exist but even these farms normally have less than 10 hectare of water.

Recently, the production of male tilapia fingerlings by hormone sex reversal has gained popularity among wealthier farmers. Mixed-sex and male tilapia fingerlings are produced by the private sector. Culture of male fish has resulted in the harvest of 400 to 600 gram tilapia.

Culture: Annual harvest is estimated to be 60,000 metric tons. Semi-intensive feeding and fertilization predominate. Some larger farms culturing male fish are intensively farmed. In the poorer rural areas semi-intensive approaches are used. Thailand has a long history of fish culture and it is an accepted farming activity. Many farmers have a working knowledge of fish culture. Most farmers with proper soil type and water will have a fish pond or raise fish in their rice fields.

Tilapia are commonly raised with chemical fertilizers, fresh manure (integrated with animal husbandry) and supplemental feeds (rice bran and household wastes). Feed mills are producing complete pelleted feeds but their use is not widely accepted by tilapia growers. Nets are widely available.

Yields: Tilapia yields vary greatly depending on the level of culture employed. Yields can range from 200 to 300 kg/ha/yr in rice fields and poorly managed family ponds to over 10,000 kg/ha/yr in heavily manured and/or fed ponds.

Markets: Thailand produces a large amount of tilapia and is probably one of the largest producers of cultured tilapia (top 5) in the world. Almost all the tilapia cultured is consumed domestically. Tilapia are cultured to improve family nutrition and economic gain. With the increased interest in all-male tilapia culture, use of export markets has increased.

LIMITS AND NEW DIRECTIONS FOR FISH CULTURE SYSTEMS

PD/A CRSP research has examined the relative merits of feeding and fertilization for tilapia production given variable levels of stocking densities. The diversity of production modes and technology combinations used to produce tilapia reflect not only the high level of adaptability of the species to water and nutrient conditions, but also the fitness of the enterprise among various socioeconomic categories of farmers.

The remainder of this report will be primarily concerned with medium and low-investment systems. Generally, only a handful of high-investment operators are typically found in any PD/A CRSP country. There are none in Rwanda, only two or three in Honduras, more in the Philippines, and scores of high-investment systems in Thailand. Farms in the industrial segment of tilapia producers often serve more as collaborators than recipients of PD/A CRSP technology. Managers in this segment of the industry are interested in the direct results of PD/A CRSP research. On occasion, PD/A CRSP scientists serve as consultants to these firms.

CHAPTER FOUR RESEARCH METHODS

SAMPLE AND DATA COLLECTION

Data were collected from tilapia farmers in four PD/A CRSP countries; Rwanda, Honduras, Thailand, and the Philippines. The following sections detail the procedures employed in each country and the approach used to analyze the data for this report.

Rwanda. Data were obtained from a sample of 121 active Rwanda fish farmers in eight local administrative districts (communes) during the Winter and early Spring of 1992 (Table 4.1). The 141 *communes* (or counties) are the basic units of administration in Rwanda. Several communes were chosen to represent diversity in the nation's regions; others were selected randomly. Interviews were conducted with 115 active fish farmers randomly selected from extension rolls. About 43% of the respondents were women. Figure 4.1 shows a map of Rwanda.

To contact respondents, aquaculture *monitors* (extension representatives) were asked to organize meeting points and times with the farmers and the interviewer. The Rwandan interviewer conducted individual interviews in the native *Kinyarwanda* language using a standardized set of questions and response frameworks. Approximately 60 minutes were spent with each farmer.

An additional 16 active farmers who had not received extension assistance were interviewed. These emulator farmers had independently adopted fish culture as a farm enterprise. They were selected in a two-step process. First, fish farmers in areas not receiving extension assistance were identified through network sampling procedures and local informants *(9)*. General agricultural extension agents then provided information about individuals who had constructed fish ponds. Local residents also made referrals to farmers who had ponds and neighbors provided information about the owners of ponds visible from the roadside.

TABLE 4.1. REGIONS SAMPLED AND NUMBER OF RESPONDENTS, RWANDA, 1992

Rwanda Communes	Number	Percent
Gishamvu	9	7
Karago	17	14
Kayove	14	12
Kigembe	16	15
Ndusu	9	7
Nyamabuye	17	14
Tumba	14	12
Mugambazi	16	19
(Total)	(121)	(100)

Source: Department of Fisheries, 1992 Annual Report

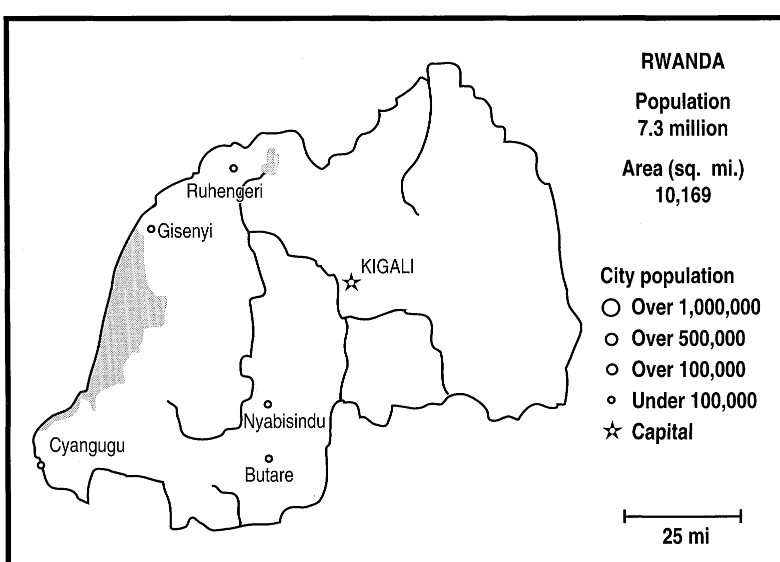

Figure 4.1. Map of Rwanda.

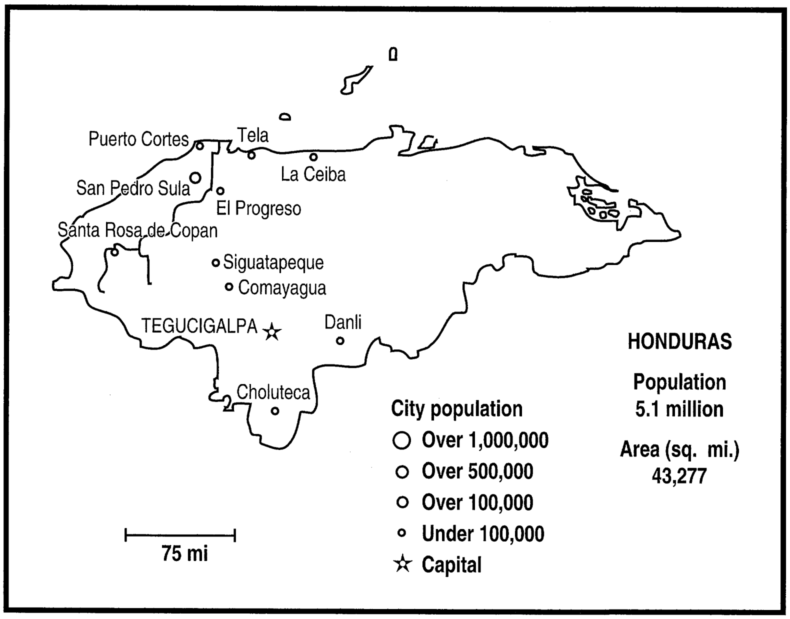

Figure 4.2. Map of Honduras.

The interview schedule used in Rwanda in 1992 was revised and adapted for each of the three PD/A CRSP countries surveyed in 1993-94. Additional specification was obtained for production practices, particularly feeding and fertilization, as these are the central PD/A CRSP technologies examined here.

Honduras. Data were obtained from a sample of 51 active Honduran fish farmers in nine of 15 Honduras departments during the Fall 1993. The survey instrument was translated and all interviews were conducted in Spanish. Tilapia farmers were identified through referrals made by Peace Corps volunteers working in fish culture, Honduran extension personnel, and by farmers identifying neighbors raising tilapia. The departments were chosen to represent the major tilapia production regions in the country. Interviews were conducted with 51 active fish farmers.

TABLE 4.2. REGIONS SAMPLED AND NUMBER OF RESPONDENTS, HONDURAS, 1994

Honduras Departments	Number	Percent
Cortes	9	18
Santa Barbara	3	6
Copan	9	18
Comayagua	9	18
Atlantida	5	10
Colon	4	7
Francisco Morazon	1	2
Olancho	4	7
El Paraiso	5	10
Yoro	2	4
(Total)	(51)	(100)

Figure 4.2 shows a map of Honduras; Table 4.2 details the name of each Department and the number of interviews obtained there.

Philippines. Data were obtained from a sample of Philippine fish farmers in four of 15 provinces on the main island of Luzon during Winter 1994. Tilapia farm operators in Bulacan, Nueva Ecija, Pampanga, and Tarlac provinces were interviewed. The survey was revised and adapted, then translated into the Tagalog language.

Tilapia farmers were identified by sampling lists of farmers purchasing fingerlings at the Freshwater Aquaculture Center at Central Luzon State University in Muñoz. Sample farmers were asked to identify neighbors raising tilapia who also were approached for interviews. Because the sample farmers were purchasing sex-reversed fingerlings at a government station, the sample is likely biased toward more avid adopters of technology. The provinces were chosen to represent the major tilapia production region in the country. Interviews were conducted with 51 active fish farmers. Figure 4.3 shows a map of the country. Table 4.3 lists the sample provinces; these are north of the City of Angeles in Central Luzon.

Thailand. Data were obtained from a sample of 51 active Thai fish farmers in three of 75 Thai provinces during Winter 1994. Tilapia farm operators in Ayutthaya, Pathum Thani, and Nakhom Pathom provinces Central Thailand were interviewed. The survey was revised and adapted, then translated into the Thai language. All interviews were conducted in Thai.

Tilapia farmers were identified through referrals made by Department of Fisheries extension

TABLE 4.3. REGIONS SAMPLED AND NUMBER OF RESPONDENTS, PHILIPPINES, 1994

Philippine Provinces	Number	Percent
Nueva Ecija	9	16
Pampagna	17	30
Bulacan	14	25
Tarloc	16	29
(Total)	(56)	(100)

Source: Department of Fisheries, 1992 Annual Report

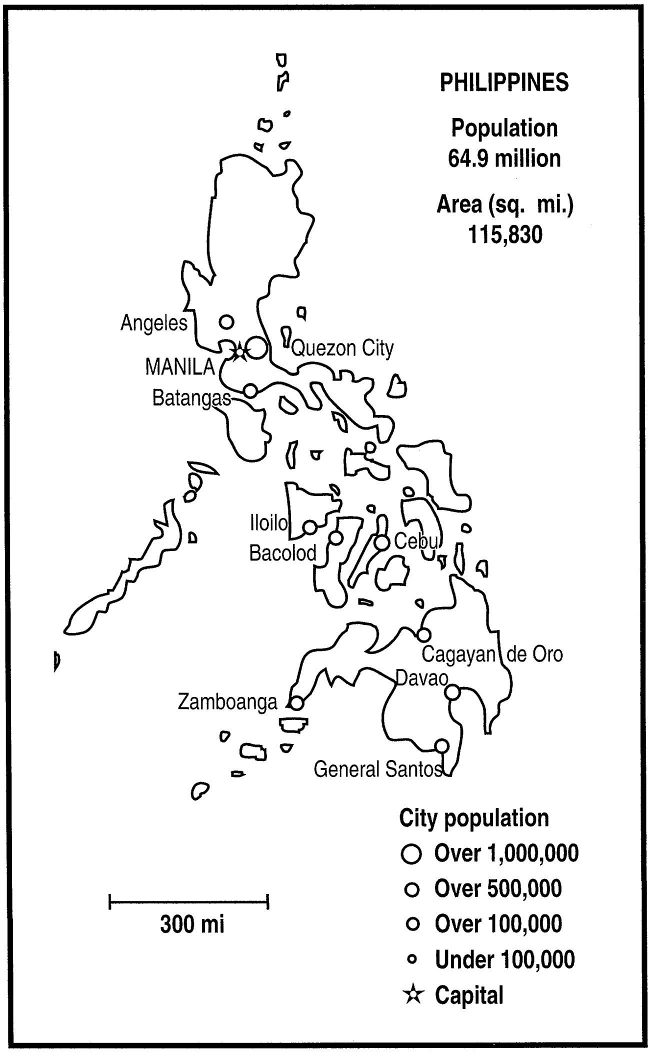

Figure 4.3. Map of The Philippines.

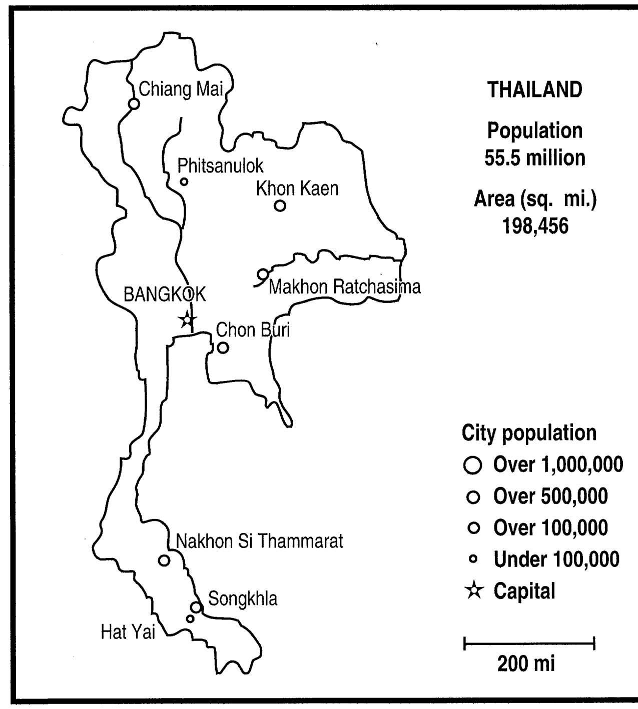

Figure 4.4. Map of Thailand.

personnel, knowledgeable local individuals, and by fish farmers giving identifying neighbors raising tilapia. The provinces were chosen to represent major tilapia production regions in south central Thailand, the major aquaculture region in the country. Interviews were conducted with 51 active fish farmers. Figure 4.4 shows a map of Thailand. Table 4.4 lists the number of respondents interviewed in each location; the sample provinces were in an area directly North of Bangkok.

Representativeness. The previous tables list sampled communes or provinces for each country, but certain cautions are in order. There are limits to the ability of these data to extrapolate to wider populations of fish farmers and other regions of the selected nations.

The 1992 Rwanda sample is more representative than the samples drawn in the other countries. It is nationwide, a larger number of interviews was obtained, and the range of variability in the population of fish farmers is smaller in Rwanda. In Rwanda, the 121 farmers in the sample represent 3.9% of the 3,102 (1,950 group and 1,152 individual) ponds in the country in 1990. Women are 24% of the fish farmers in Rwanda and 43% of the sample *(34)*. Women were oversampled in the 1992 study. Molnar previously examined the Rwanda data in detail, but the aggregate findings are presented here allow comparative analysis across four PD/A CRSP sites *(44)*.

In contrast, the 1993 samples in Thailand and the Philippines are smaller and represent a subset of provinces in one key production area in the country. In Honduras, the sample is drawn from a diverse set of locales across the tilapia producing areas of the country, although the number of cases is similar to the two Asian sites. The sample sizes have restricted capability for statistical estimation of population parameters; they do, however, provide information about practicing fish farmers where none is otherwise available.

Table 4.4. Regions Sampled and Number of Respondents, Thailand, 1994

Thailand Provinces	Number	Percent
Ayutthaya	17	33
Pathum Thani	20	39
Nakorn Prathom	14	28
(Total)	(51)	(100)

ANALYSIS

Financial Analysis. Chapter 6 presents a financial analysis of the CRSP PD/A research, using partial net returns as a profitability indicator. Partial net returns were calculated for various experimental treatments as conducted and reported for each of four CRSP countries. These analyses are based on average 1993-94 tilapia prices found in each country and the quantity of tilapia produced for each experimental regime. Local prices for fish and costs for the production inputs were based on information from CRSP researchers, survey information and the literature.

CRSP PD/A Data Reports for the Philippines, Thailand, Honduras and Rwanda covering Cycles I, II and III of the Global Experiment were used to compare fish yield and profitability of various combinations of feed and fertilizer as applied under wet and dry season conditions. The objective is to specify relationships between input type, costs and relative viability of treatments in each country. Of central interest are the trials with the highest production and those with the highest profitability; they are often not the same. Partial net returns exclude costs for fixed and some variable inputs that are assumed to be similar for all treatments. The approach is further described and justified in Chapter 5.

Survey Data. In each country, the interview schedules were edited to reconcile missing data, ambiguous answers, and exceptional cases. The data were keypunched according to precoded numerical response categories on the printed questionnaire that did not require translation. Opened-ended questions eliciting verbatim comments or explanations were cumulated in a separate process and presented here in tabular form or summarized in the narrative as appropriate.

Chapter 6 presents the data for each country sample tabulated separately to facilitate comparisons across the four sites *(9)*. The objective is to document the nature and circumstances of practicing tilapia farmers who might adopt PD/A CRSP technologies. The data establish the basic community, household, labor, farming system, and marketing environment for the conduct of fish culture at each site.

The survey data also are used in Chapter 7 to portray production systems, technologies, and farmer attitudes toward fish culture as they vary by farm size. Pond area has a close correspondence to subsistence, small-scale and commercial levels of aquaculture production *(32)*. Farm pond area is examined using three categories — small, medium and large — depending on the range reported in the surveys for each country. The *small* pond area grouping is less than or equal to .11, .65, and .96 hectares in Honduras, the Philippines, and Thailand, respectively. The *medium* pond area groupings in Honduras, the Philippines, and Thailand are 0.12 to 0.65, 0.66 to 3.0, and 0.97 to 1.76 hectares, respectively. The *large* pond area groupings is greater than .65, 3.0, and 1.76 hectares in Honduras, the Philippines, and Thailand, respectively.

These categories correspond well with production intensity levels and allow cross-country and intra-country pond area comparisons. Rwanda data is reported in the 'small' pond area category because of its homogeneous low-intensity type of tilapia production, regardless of actual pond area.

CHAPTER FIVE
PARTIAL NET RETURN ANALYSIS OF PD/A CRSP EXPERIMENTAL TRIALS

INTRODUCTION

Although PD/A CRSP research has endeavored to thoroughly specify the production consequences of various combinations of feeding and fertilization strategies, what matters to the farmer is the approach that generates the most income and produces the least risk. While not addressing the topic of risk, this chapter treats the economic implications of experimental tilapia production trials that PD/A CRSP researchers conducted in Honduras, Thailand, the Philippines and Rwanda.

Comparing nutrient input systems is important for understanding farmer incentives for producing tilapia. Better understanding of farmer motivations and incentives may increase the likelihood that researchers will develop and communicate sustainable aquaculture systems. These data also may provide feedback about the efficacy and relevance of PD/A CRSP research.

One of the most critical PD/A CRSP research topics is pond nutrient inputs. Nutrient input results from PD/A CRSP research have been transformed here into partial net returns for comparison to similar production systems being used by farmers in Honduras, Thailand, the Philippines and Rwanda. An abbreviated economic analysis of the PD/A CRSP nutrient experiments provides a context for interpreting the relative profitability of various production strategies in the different countries.

Farmer decisions about nutrient inputs will dictate the possible production intensity levels. Input prices and competition for these inputs further define aquaculture production systems. This study adds to the understanding of what affects tilapia culture choices in these countries. Together, the survey data and PD/A CRSP experimental data begin to establish a profile of profitable tilapia farming systems in these countries.

The chapter places a partial net returns value on PD/A CRSP Cycle I, II and III tilapia nutrient research. Partial net returns reflect the income to a farmer after a specific production cost for the input in question is paid, not considering other variable or fixed costs. Cycles refer to the stage of the PD/A CRSP program that specified parallel or nearly parallel experimental programs across study sites. These comparisons have not been previously made.

Another objective is to examine the relative efficacy of various experimental treatments in terms of production and profitability. A comparison of relative economic incentives for producing tilapia production among the four countries is presented. Comparisons of country-specific production systems reveal similarities and differences in aquacultural development among the study countries.

ECONOMIC ANALYSIS

Microeconomic analysis of aquacultural operations has followed two primary directions — econometric production function analysis and enterprise budget analysis *(3,59)*. Both methods have been adapted to aquaculture from their long-standing use in traditional agriculture *(5,24,33,58)*.[1]

Econometrics. One approach to production economics is through the use of econometrics in the development of production functions that explain output quantities through a linear combination of input variables *(5,33)*. Production functions are regression equations that incorporate input quantities as independent variables to explain the quantity produced *(14,28,49,50,66)*.

The equation coefficients and their significance levels reveal the relative contribution of various factors into the production system. Marginal analysis is conducted on each significant variable. Optimal input levels at given fish selling and input prices can then be determined. As prices change, the optimal levels change and this approach handles this variability well. In this sense, the econometric approach is dynamic while the enterprise budget approach is static. However, the detailed quantitative input data required for the econometric methodology are beyond the scope of the present study.

Enterprise Budgeting. A farm is composed of a bundle of enterprises or money-making activities; each enterprise can be described in terms of expenses and revenues. Enterprise budgets list and quantify items producing income or requiring expenditures for the production of a commodity on a representative farm. Several indicators of economic viability result from this approach; the results also suggest optimal strategies for farmers *(7)*.[2]

Profit can be described as the quantity harvested multiplied by the selling price minus operating costs. Full enterprise budgets include receipts, variable costs, and fixed costs. Fixed costs include payment of loan principal and interest for items such as pond and building construction and land purchases, as well as depreciation and taxes. Net returns are the full enterprise budget's measure of profitability. Partial enterprise budgets charge only variable costs — in this study, costs of the different feed

[1]A third approach not further examined here is the internal rate of return. Primarily used as means for evaluating alternative public sector investments, this result can be obtained by using net present values of long-term receipts and expenses. Taking a longitudinal perspective, the internal rate of return is often used in investment analysis to compare projects in terms of alternate uses of the funds invested as they might be invested over a period of time.

[2]Breakeven prices and quantities are also derived from this analysis and can be useful in determining an enterprises' associated risk. Farm plans can then be developed on the basis of enterprise budgets and assumptions about available resources (land, labor, capital) to optimize profits or minimize costs. Cash flows developed from the farm plans are used in financial planning and loan procurement.

and fertilization treatments. Partial enterprise budgeting analysis is used to evaluate net changes in income from a change in production practice — i.e., the various treatments in an experiment — over the baseline, no-treatment condition.

Enterprise budgeting allows net returns to be calculated and compared across experimental treatments. Price variability is difficult to anticipate; optimized farm plans are only as good as the information included in them. Thus, overall economic stability, specifically for marketing and input/output prices, can dramatically affect the farm plan viability.

The nature of the interview data used here to portray the circumstances on fish farms limits the extent and detail of the analysis, but cross-national and farm size differences can be examined. Others *(10,64)* note that farmer recall of the quantities of various inputs over the production cycle usually is neither thorough nor accurate. However, stocking and harvest quantities do tend to be recalled with greater accuracy. Continuous collection of data over the production cycle is necessary for accurate enterprise budgeting or econometric regression analysis.

In the following financial analysis of the results of PD/A CRSP experimental trials, partial net returns have been used as the profitability indicator. We present partial net returns analyses of the experimental treatments in each of four CRSP countries. *Partial net returns exclude costs for fixed and some variable inputs that are assumed to be similar for all treatments. Thus, these returns are high and do not — are not expected to — mirror actual farm net returns.*

The partial net returns approach does allow a view of the effects of local costs of tilapia fingerling and nutrient inputs on profitability. Only when biologically sound production systems are analyzed in terms of local prices can the actual degree of profitability and sustainability be seen.

Time, recall, and respondent burden considerations constrain obtaining detailed specification of production data in interviews. Additionally, the multi-disciplinary objectives of this study — sociological, biological, and economic — required the survey be manageable in the field, i.e., not too onerous for the respondent in terms of time and mental effort. Thus, a more quantitative production input/output full enterprise budget approach has not been taken in this study. If such an analysis is to be conducted in the future for tilapia farmer systems, then continuous monitoring of the inputs supplied throughout the production cycle must be done.

PD/A CRSP NUTRIENT EXPERIMENTS

PD/A CRSP researchers have experimented with varying nutritional inputs and their effect on tilapia production. Results have allowed specification of the required organic inputs, chemical fertilizers, and commercial feeds for efficient growth. Economic analyses have shown some of these production schemes to be profitable, even though some of the inputs tested are not widely available in some of the countries.[3]

The relative profitability of various approaches represented in on-farm trials has been conducted by Honduras PD/A CRSP researchers *(63)*. Experimental treatments differ in type and quantity of inputs chosen by farmers. Subsistence, small and medium-scale farmers usually use a diverse mixture of inputs as opposed to the limited input combinations used in PD/A CRSP research regimes. In fact, it would be difficult to conduct research paralleling the variety of inputs used by farmers. On-farm tests of PD/A CRSP nutrient regimes have had some difficulty maintaining the integrity of treatment requirements. Farmers sometimes failed to maintain nutrient schedules throughout the production cycle thus making comparisons to field station trials difficult.

Receipts in this analysis are based on average 1993-94 tilapia prices found in each country and the quantity of tilapia produced for each experimental regime. All experiments in Cycles I, II, and III Work Plans stocked one fish per square meter. Local prices for fish and costs for the production inputs were based on information from PD/A CRSP researchers, survey data, and the literature, Table 5.1.

All experimental production data came from the PD/A CRSP Data Reports for the Philippines, Thailand, Honduras and Rwanda covering Cycles I, II and III of the Global Experiment. These volumes may be referenced for specific input quantities (PD/A Collaborative Research Data Reports). The point here is to determine relationships between input type, costs and relative viability of treatments in each country. Of

[3]For Rwanda see (20,34,35); Thailand (22,39,61); Philippines (36); and Honduras (26,63).

central interest are the trials with the highest production and those with the highest profitability; they are often not the same.

Rwanda. PD/A CRSP Cycle I experiments included chemical fertilization — triple superphosphate (TSP) — trials during the dry and wet seasons. This experiment examined the variation in production when very low levels of fertilizer were used. There were no Cycle II experiments. In Rwanda, Cycle III experiments included dried chicken manure treatments during the dry and wet seasons.

In nearly every case, dry season yields exceeded wet season yields. However, seasonal differences were not thought to be the cause of production differences. Researchers contend that these differences were more affected by the newness of the ponds and carryover effects from the first seasonal experiments to the next season's experiments. New ponds built in the clay soils are more "exposed and reactive soils" to input nutrients. Secondly, carryover effects from the wet season experiments conducted in the same individual ponds had residual fertilization effects for the dry season experiments.

Tilapia yields in the Rwanda context are presented in Figure 5.1 and partial net returns are presented in Figure 5.2. The highest yields and partial net returns were obtained using chicken manure during the dry season. The 500 kg/ha/week of chicken manure, dry season, treatment had a partial net return of $1,532 for a 150-day cycle and an annualized production of 2,590 kg/ha.

The comparable treatment during the wet season produced 968 kg/ha/year with a partial net return of $466 for a 150-day cycle. The dry season 250 kg/ha/week and 125 kg/ha/week chicken manure treatments produced 1,917 and 1,244 kg/ha/year, respectively; and partial net returns were $1,170 and $767 per ha per 150 day cycle, respectively. The comparable wet season production yields for the 250 and 125 kg/ha/week of chicken manure input were 669 and 377 kg/ha/year, respectively; partial net returns were $350 and $197 for a 150-day cycle, respectively.

The Cycle I triple superphosphate yields were designed to estimate seasonal differences between wet and dry seasons on fish production as well as biological, chemical and physical conditions. However, pond construction delays did not allow these seasonal determinations, instead two 150 day experiments were conducted to estimate natural production levels. All ponds received 8 kg/ha/week of TSP to decrease wide differences in natural variability. Production yields between the two experiments did not significantly differ and were approximately 646 kg/ha/year — a partial net return of $401 per hectare per 150 day production cycle.

Honduras. PD/A CRSP Cycle I research included TSP trials during the dry and wet seasons. Cycle II trials included chicken manure, cow manure and urea-TSP combinations applied during the dry and wet seasons. Cycle III trials used layer chicken manure at 125, 250, 500, and 1,000 kg/ha/wk rates during the dry and wet seasons.

Tilapia yields in Honduras are presented in Figure 5.3 and partial net returns are presented in Figure 5.4. The highest partial net returns resulted from the use of chicken manure at 1,000 kg/ha/week in the dry and wet seasons. There was no apparent seasonal effect. The 500 kg/ha/wk CM treatment rate similarly shows no seasonal effect. However, the next highest production and partial net return was obtained by the 575 kg/ha/wk CM treatment during the dry season. The same treatment for the wet season had much lower production and returns.

Opposite seasonal differences occurred for the 250 kg/ha/wk CM treatment rate. Treatments using only chemical fertilization, TSP plus urea, had production yields falling between the CM125 and CM250 treatments, Figure 5.3. However, the associated partial net returns were lower than any of the CM treatments, Figure 5.4. When comparing TSP alone with TSP plus urea, the combination increased both production and profitability.

Philippines. PD/A CRSP Cycle I research included TSP trials during the dry and wet seasons. Cycle II trials included (a) no feeding or (b) feeding with supplemental chicken manure or (c) feeding with supplemental inorganic fertilizer (TMP, 16-20-0). Wet season chicken manure fertilization trials were conducted at 125, 250, 500, and 1,000 kg/ha/wk rates. No dry season replication of these treatments occurred.

The following trials and combinations were conducted during the dry and wet seasons: (1) no feed and low chicken manure; (2) no feed and high chicken

TABLE 5.1. PRICES OF TILAPIA AND VARIABLE INPUT COSTS FOR PARTIAL NET RETURN ANALYSIS OF THE PD/A CRSP WORKPLANS I, II, AND III FOR FOUR PD/A CRSP COUNTRIES, 1994.

Country	Tilapia	Fingerlings	Feed	TSP[1]	TMP[2]	Urea	CM[3]
	$/kg	*$each*	*$/kg*	*$/kg*	*$/kg*	*$/kg*	*$/kg*
Rwanda	1.60	0.025	—	0.30	-	-	0.015
Thailand	0.48	0.004	—	0.47	-	0.27	0.010
Honduras	1.33	0.019	—	0.34	-	0.28	0.016
Philippines	1.63	0.005	0.25	0.22	0.22	-	0.010

[1] TSP = triple superphosphate
[2] TMP = triple monophosphate
[3] CM = chicken manure and litter

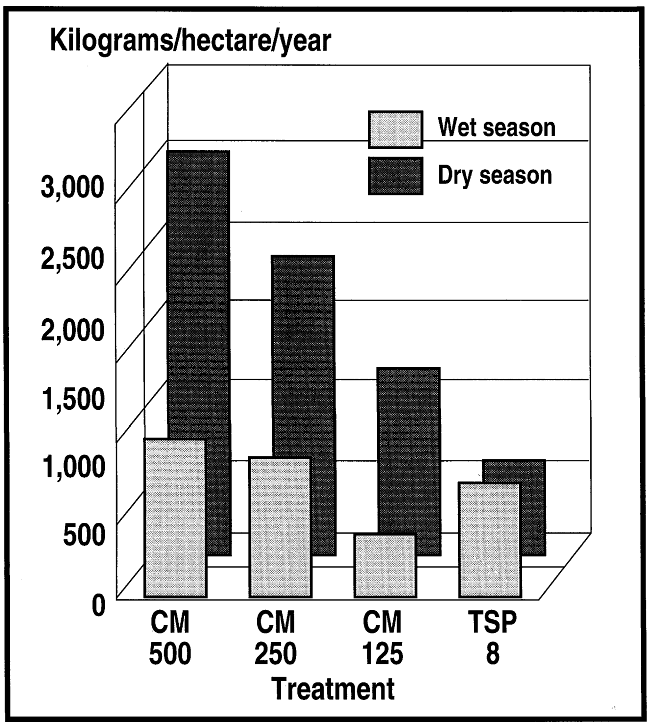

Figure 5.1. Tilapia yields in Rwanda, Cycle I-III work plans. CM=chicken manure and litter; TSP=triple superphosphate; the number that follows is a weekly rate in kilograms per hectare.

manure; (3) no feed, low chicken manure and high TMP; (4) no feed, high chicken manure and high TMP; (5) high feed and low chicken manure; (6) high feed and high chicken manure; or (7) high feed and high chicken manure and high TMP. Tilapia yields in the Philippines are presented in Figures 5.5, 5.7 and 5.9[4] and associated partial net returns in descending order are presented in Figures 5.6, 5.8 and 5.10.

Dry and wet season TSP trials and wet season trials with chicken manure produced good yields, Figure 5.5 and were viable financially, Figure 5.6. Treatments combining chicken manure with TMP were also economically viable in both seasons. However, when feed was provided in addition to chicken manure, negative partial net returns resulted, Figures 5.7 through 5.10.

When triple monophosphate (TMP) was part of a schedule of feed and chicken manure, production soared above all other nutrient regime treatments, Figure 5.9. However, three out of four treatments resulted in negative net returns, Figure 5.10. The negative returns are caused by the high cost of commercial feed which is not balanced by sufficient added income from the additional fish produced.

The two treatments having the greatest returns were the 1,000 kg/ha/week CM (wet season) treatment and the combination treatment of 405 kg/ha/week CM

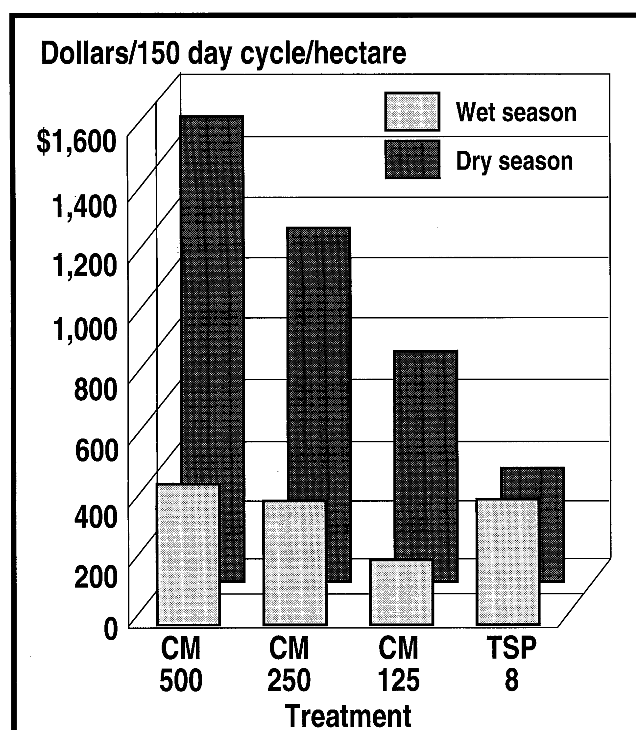

Figure 5.2. Partial net returns for Tilapia production in Rwanda, Cycle I-III work plans. Abbreviations same as in Figure 5.1.

[4]FD represents commercial feed (20% crude protein) inputs as a total input quantity for the 150 day cycle. Chicken manure treatments follow the terms used in the preceding figures, i.e., the quantity of CM applied per week per hectare. The same terms refer to the TMP (16-20-0) in these figures as for the preceding figures, i.e. a weekly rate per hectare. Refer to the PD/A CRSP Data Reports, Cycle I, II, and III for specific details of each treatment.

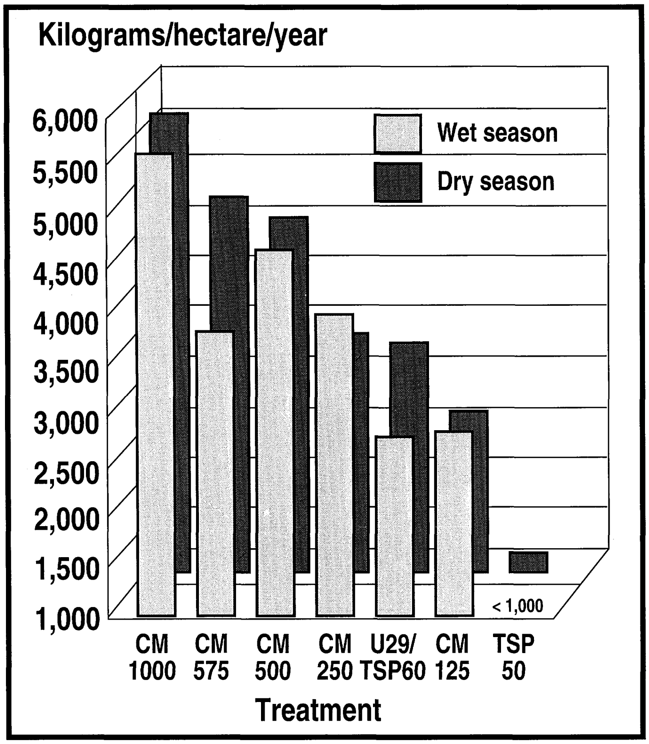

Figure 5.3. Tilapia yields in Honduras, PD/A CRSP Cycle I-III work plans. CM=chicken manure and litter; U = urea; TSP=triple superphosphate; the number that follows is a weekly rate in kilograms per hectare. In the wet season, the actual U29/TSP60 treatment was U31/TSP49.

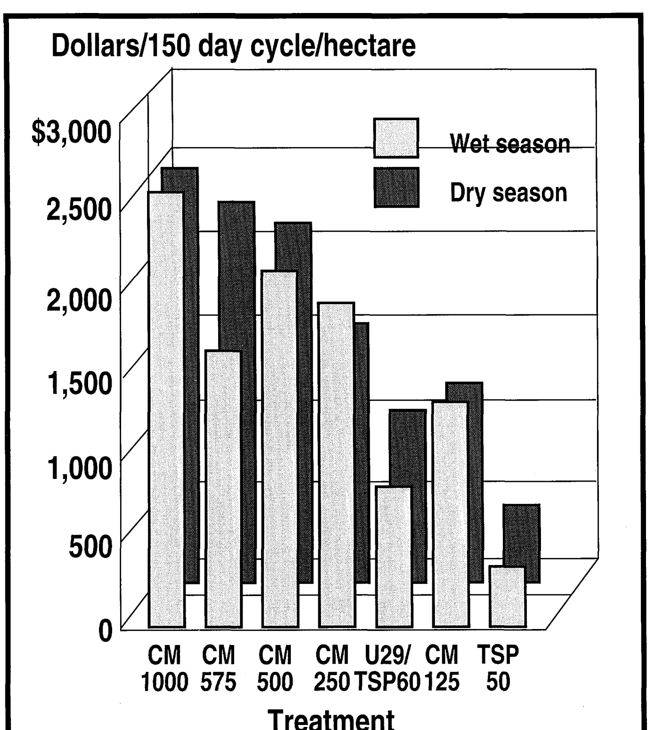

Figure 5.4. Partial net returns for Tilapia yields in Honduras, PD/A CRSP Cycle I-III work plans. Abbreviations, same as in Figure 5.3.

plus 240 kg/ha/week TMP (dry season), Figures 5.6 and 5.10, respectively. In contrast, the highest total yield occurred from three of the treatments using a combination of commercial feed plus chicken manure plus TMP, Figure 5.9.

The highest production resulted from the treatment using the combination of 5,150 kg of feed per cycle plus 278 kg/ha/wk CM plus 50 kg/ha/wk TMP during the wet season. The combined higher cost of these inputs kept the partial net returns lower than the CM125, CM250, CM500 and CM1000 (kg/ha/wk CM) treatments, Figures 5.10 and 5.6.

Thailand. PD/A CRSP Cycle I Thailand experiments used inorganic TSP fertilizer at 8 kg/ha/month during the dry and wet seasons. Cycle II experiments included trials using chicken manure and urea plus TSP during the dry and wet seasons. Cycle III research included chicken manure trials during the dry and wet seasons.

Tilapia yields in Thailand are presented in Figure 5.11 and partial net returns are presented in Figure 5.12. The economically viable enterprises involved only chicken manure (waste and bedding substrate). Production was good for all chicken manure treatments. However, no treatments using TSP alone or with urea were economically viable.

There was a distinct seasonal effect for chicken manure application. Rates used in the dry season had better results than in the wet season for three out of four chicken manure application rates. Chemical fertilizers produced good tilapia yield, Figure 5.11. The low price paid for tilapia in Thailand and relatively higher cost of chemical fertilizers in relation to chicken manure led the partial net returns for the chemical fertilizer treatments to be negative even though production was good.

In general, the regimes using the most chicken manure had the highest production rates, Figure 5.11. Financially, the partial net returns for the 1,000 kg/ha/wk chicken manure treatment were less than those for the 500 kg/ha/wk treatment, Figure 5.12. In this instance, the treatment with the highest production is not the most profitable.

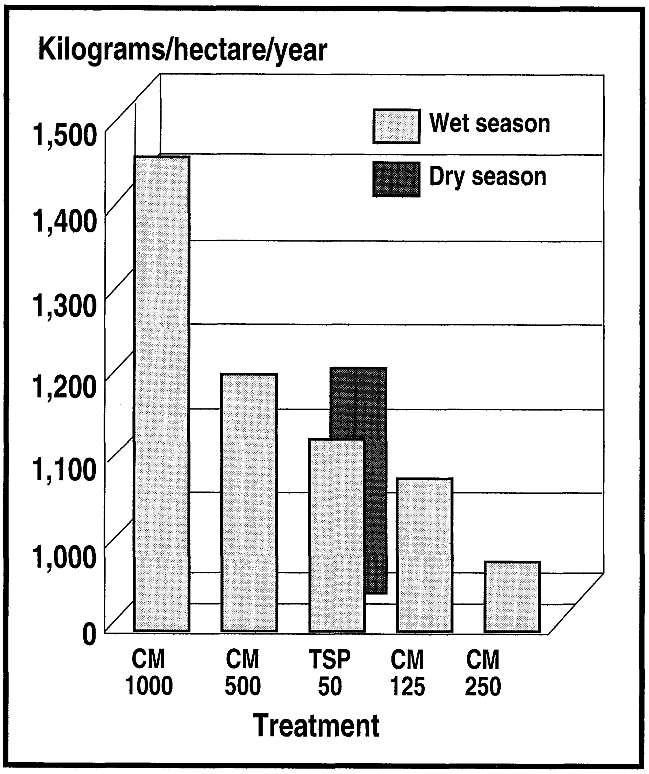

Figure 5.5. Tilapia yields in the Philippines, PD/A CRSP Cycle I and II work plans. CM=chicken litter; U = urea; TSP=triple superphosphate; the number that follows is a weekly rate in kilograms per hectare.

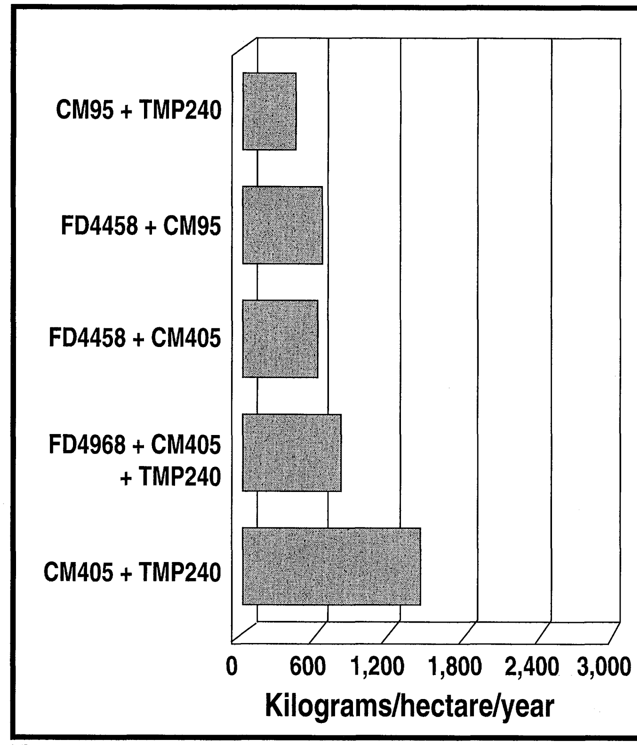

Figure 5.7. Tilapia yields for dry season production in the Philippines, PD/A CRSP Cycle II work plan. CM=chicken litter; U = urea; TMP=triple monophosphate; the number that follows is a weekly rate in kilograms per hectare; FD=commercial feed; the number that follows is the amount applied over the production cycle.

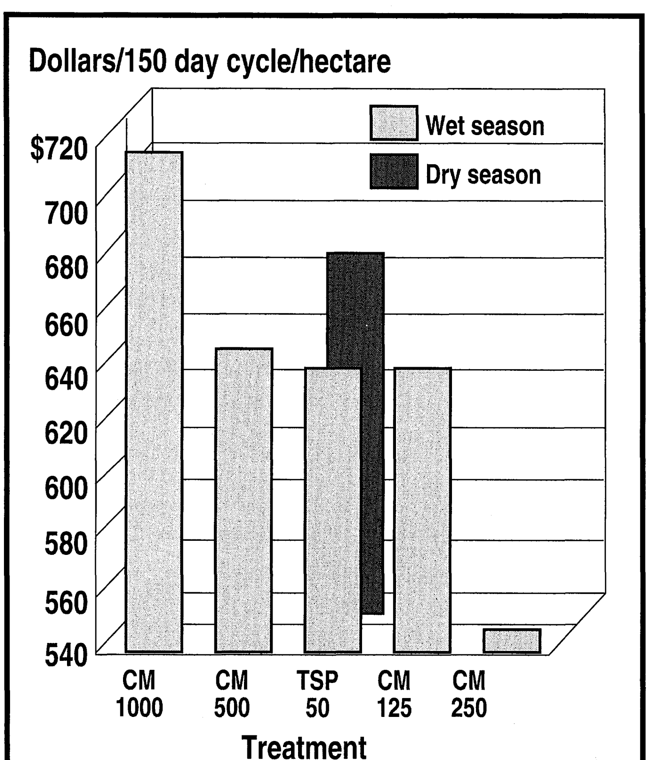

Figure 5.6. Partial net returns for Tilapia yields in the Philippines, PD/A CRSP Cycle I and II work plans. Abbreviations same as in Figure 5.5.

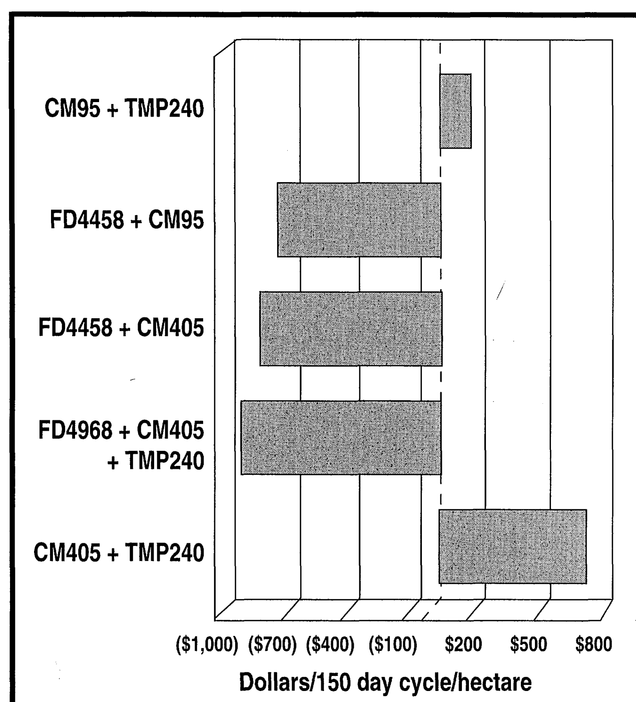

Figure 5.8. Partial net returns for dry season Tilapia yields in the Philippines, PD/A CRSP Cycle II work plan. Abbreviations same as in Figure 5.7.

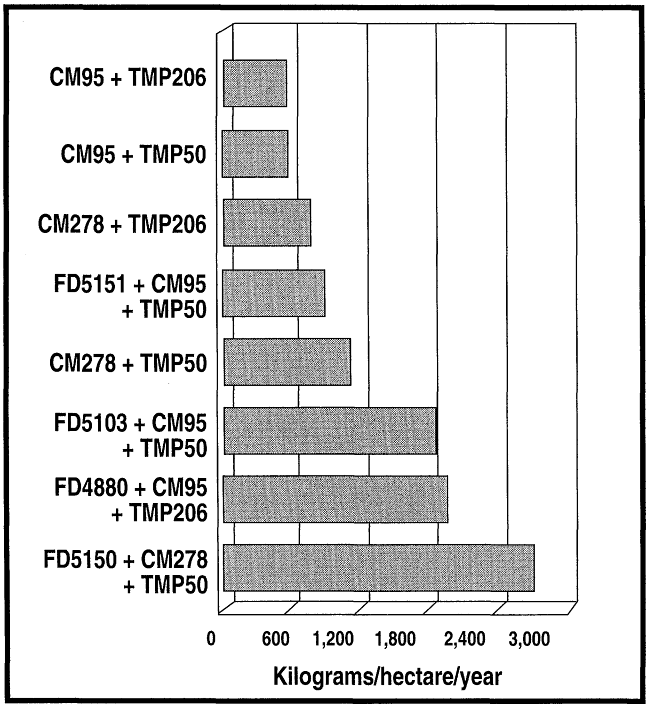

Figure 5.9. Tilapia yields for wet season production in the Philippines, PD/A CRSP Cycle II work plan. CM=chicken manure and litter; U = urea; TMP=triple monophosphate; the number that follows is a weekly rate in kilograms per hectare; FD=commercial feed;the number that follows is the amount applied over the production cycle.

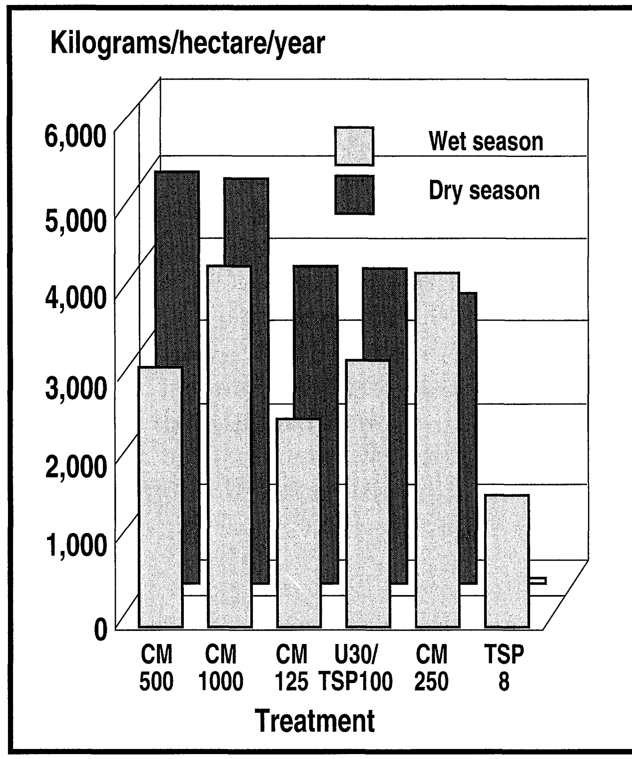

Figure 5.11. Tilapia yields in Thailand, Cycle I-III work plans. CM=chicken manure and litter; U = urea; TSP=triple superphosphate; the number that follows is a weekly rate in kilograms per hectare.

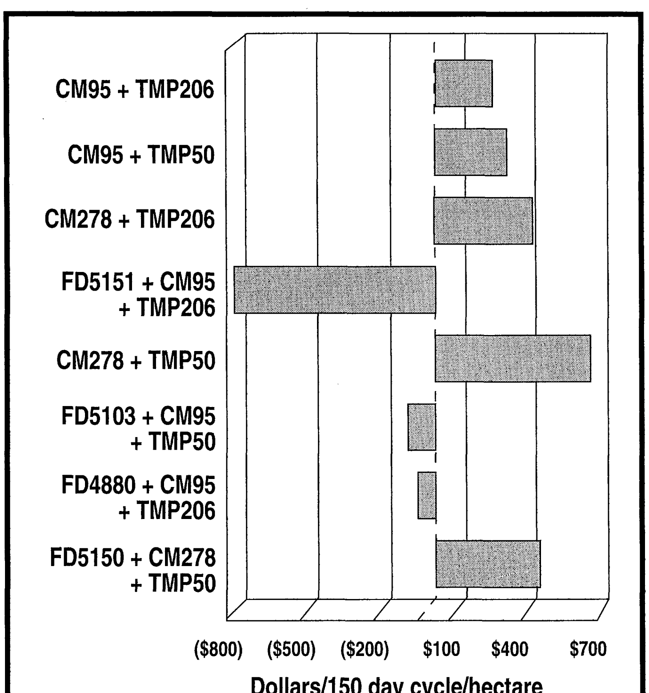

Figure 5.10. Partial net returns for Tilapia yields in wet season production in the Philippines, PD/A CRSP Cycle II work plan. Abbreviations same as in Figure 5.9.

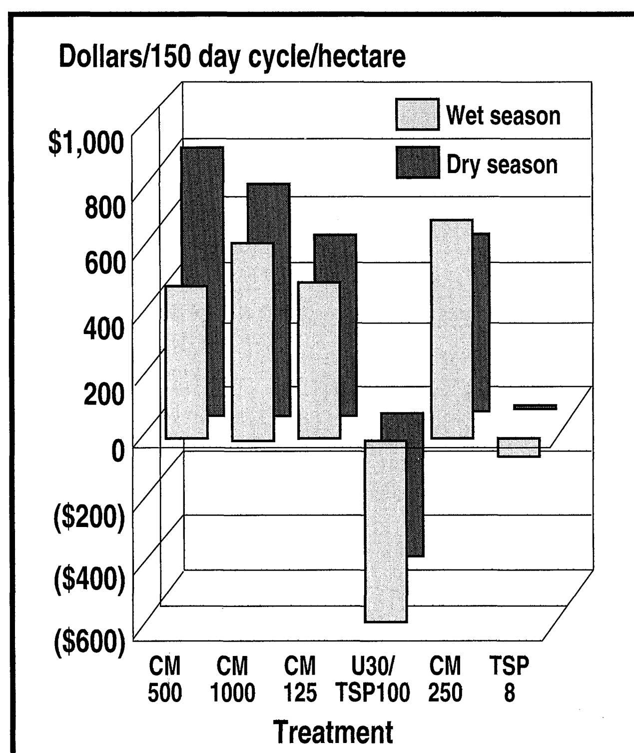

Figure 5.12. Partial Net returns forTilapia yields in Thailand, PD/A CRSP Cycle I-III work plans. Abbreviations same as in Figure 5.11.

CHAPTER SIX
SURVEY RESULTS: PATTERNS OF TECHNOLOGY UTILIZATION

This chapter describes the practices, technical proficiency, and receptivity to the adoption of PD/A CRSP technologies and production regimes among tilapia farmers. The information in this chapter provide a comprehensive profile of the socioeconomic niche for fish farms in each locale. The analysis shows the survey responses for comparable questions across the four PD/A CRSP countries examined in this study. From these data, central patterns of comparison and difference in practice and approach to tilapia production and technology utilization can be discerned.

RESPONDENT CHARACTERISTICS

Respondent characteristics provide some basis for assessing the potential representativeness of the data examined here. Table 6.1 describes the individual and household characteristics of study respondents. Although women make vital contributions to food production and to aquaculture activities, most of the respondents in this study were women. A woman conducted the interviews in Thailand, though men were interviewers in the other sites.

Women comprised about a fourth of the respondents in Rwanda and Thailand, but only about a tenth of the Honduras and Philippine tilapia farmers we contacted. The Rwandan farmers were younger and the Philippine farmers tended to be older than farmers in the other countries. Most farmers were married. A somewhat higher proportion of the Philippine farmers were over age 65.

Nearly all the Rwandan, Honduran, and Philippine households had children under age ten, but only about half the Thai families had young children. Philippine families had the fewest children age ten to 18 and the largest proportion with children over age 18. Rwandans had the largest households, as 65% reported six or more members. About half the respondent households in the other countries were that large.

LANDHOLDING

Table 6.2 profiles the landholding of study respondents. Honduran farms were much more fragmented than the others, as all respondents reported nine or more parcels in their farms. In the other nations, most had relatively consolidated holdings of one to three pieces of land.

About five percent of the Rwandan respondents did not own any land, primarily young people farming in groups formed to use communal lands for the purpose of aquaculture. In the face of burgeoning numbers of young people seeking farm land, local authorities prefer to grant marais land use rights to groups rather than individuals. In Thailand, 19% said they did not own land. Nearly all respondents in Honduras and the Philippines owned some land. These data also reflect on the relative standing of fish farmers in the social structure of each nation and the level of development in each context. Young Thai

TABLE 6.1. RESPONDENT CHARACTERISTICS, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Gender of respondent				
Male	71	86	91	76
Female	29	14	9	24
Age of respondent				
Less than 25	12	8	4	4
25-34	25	24	20	13
35-44	33	25	23	32
45-54	13	27	21	25
55-64	12	12	14	19
65 or older	5	4	18	7
Respondents with children:				
Under age 10	81	98	98	47
Age 10 to 18	71	51	38	45
Over age 18	41	41	57	43
Number of people in household?				
Two or less	1	8	15	6
Three to 5	34	38	40	47
Six or more	65	54	45	47
(Number)	(136)	(51)	(50)	(56)

TABLE 6.2. LAND OWNERSHIP, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Number of pieces of land in your farm?				
1-3 parcels	18	0	93	94
3-9 parcels	63	0	7	4
9 or more	19	100	0	2
How much land owned?				
None	5	0	2	19
Some or all	95	100	98	81
How much land do you rent from others?				
None	43	98	89	56
Some	69	2	11	44
How much land do you rent to others?				
None	92	100	95	85
Some	8	0	5	15
Compared to other farmers, how much land do you have?				
More	10	43	33	26
About the same	15	43	51	42
Less	75	14	16	32
(Number)	(136)	(51)	(50)	(56)

farmers in the study area face rising land prices associated with the growth of the greater Bangkok economy.

Hondurans and Filipinos did not seem to rent much land from others, but in Rwanda two-thirds said they rented land from others. About 44% of Thai farmers rented land in; they also were more likely to rent land out. Only eight percent of the Rwanda farmers said they rented land to others.

Three-quarters of the Rwandan fish farmers felt that they had less land than their neighbors; a third of the Thais felt the same way, compared to 15% in the other countries. About half the Philippine respondents said "about the same as people around here." Hondurans were about equally split between more and the same amount of land ownership. Different segments of the rural populace tend to participate in fish culture in each nation; more Honduran producers tended to be drawn from the rural elite.

FARM ENTERPRISES

The farm enterprises maintained by tilapia farmers are portrayed in Table 6.3. Chickens were the most commonly reported animal enterprises, except in Rwanda. In Rwanda, 83% said they had cattle, nearly as many said they had goats, and about 41% had pigs. Cattle were nearly as popular in Honduras, followed by pigs. In the Philippines, the second most common animal enterprise was "other", reflecting the widespread husbandry of water buffalo. About a third of the farmers in the Philippines reported cattle, goats, pigs, and ducks.

In Thailand, about a third had ducks and pigs. No one single animal enterprise dominated the farming system in the Thai sample. The Thai farmers also were more likely to integrate animal production with

TABLE 6.3. ENTERPRISES ON TILAPIA FARMS, FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
What types of farm animals do you raise?				
Cattle	83	62	32	15
Goats	78	5	32	0
Pigs	41	45	43	31
Chickens	23	69	80	51
Ducks	14	19	32	36
Rabbits	11	5	0	0
Other	19	12	50	8
Do you raise animals with your fish pond?				
No	100	72	60	31
Yes	0	28	40	69
What enterprises give most of cash income?				
Vegetables	0	49	36	9
Rice	0	2	56	36
Bananas	19	2	13	31
Fruit crops	0	2	27	53
Fish	0	30	96	93
Sugar cane	0	4	4	0
Livestock	0	34	25	62
Corn/Maize	10	15	9	0
Other	36	49	9	0
Sorghum	29	0	0	0
Cabbage	10	0	0	0
Sweet Potatoes	83	0	0	0
Beans	10	0	0	0
Taro	16	0	0	0
Cassava	63	0	0	0
Irish Potatoes	12	0	0	0
Sweet Peas	9	0	0	0
(Number)	(136)	(51)	(50)	(56)

TABLE 6.4. POND LOCATION AND WATER SOURCE, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
How many ponds do you have on your land?				
One	84	16	9	39
Two	11	12	20	26
Three or more	5	72	71	35
What is the surface area of the ponds on farm?				
< .25 hectare	—	76	48	34
.25 to 1 hectare	—	20	48	58
> 1 hectare	—	4	4	8
Have you had problems getting enough water?				
No	76	82	66	45
Yes	24	18	34	55
Where are ponds in relation to house?				
Next to house	—	66	36	79
< 1 kilometer	—	12	35	6
1 to 3	—	2	22	9
More than 3	—	20	7	6
Water source for the ponds on this farm?				
Well	—	2	9	0
Spring	—	8	7	0
River or stream	—	18	14	2
Lake - reservoir	—	48	0	2
Irrigation canal	—	14	13	64
Collected runoff	—	0	16	0
Combination	—	10	41	32
Water supply to pond?				
Pumped	0	16	42	96
Gravity flow	100	82	38	2
Combination	0	2	20	2
(Number)	(136)	(51)	(50)	(56)

aquaculture, as more than two-thirds of the Thailand sample reported raising tilapia with some type of animal enterprise. At present, integrated fish-animal production systems are only in the demonstration phase in Rwanda and are less widely adopted in the Philippines.

Fish was the main source of cash income for about 90% of the Philippine and Thai farmers. Sweet potatoes were identified as providing most cash income by more than 80% of the Rwandan farmers, followed by cassava. In Honduras, vegetables and other crops (mainly coffee) provided most farm income.

POND LOCATION AND WATER SOURCE

More than 80% of the Rwandan farmers had but a single pond, as shown in Table 6.4. In contrast, more than 70% of the Philippine and Honduran farmers had more than three or more ponds. In Thailand, slightly more than a third had three or more ponds; a similar proportion had but a single pond. About three-quarters of the Honduran farmers had less than a quarter hectare of ponds; half the Thai farmers had ponds this size; but only a third of the Philippine farmers did.

Most Rwandans obtained water for their ponds from streams or springs. Honduran farmers supplied their ponds from a variety of sources, most frequently identifying lakes or reservoir sources. Thai farmers depended most on irrigation canals, while Philippine farms indicated the least dependence on any single source. All Rwandan ponds used gravity flow, but most Thai farmers had pumps.

More than half the Thai sample reported problems getting enough water to keep ponds full. A third of the Philippine farmers said so, as did a quarter of the Rwandans.

The location of the fish pond relative to the household is significant. Ponds near households are easier to monitor. Family members can attend to the pond as well as give regular surveillance to deter theft. About 79% of the Thai fish ponds were located next to the house, as were two-thirds of the Honduran ponds and a third of the Philippine farms.

In Rwanda, fish ponds are always located in the valley bottoms (marais). These lands are communally owned and individual farmers are given relatively secure use concessions, but no houses are permitted. Consequently, ponds usually are some distance from homesteads built on the nation's mountainous hillsides. In some areas, group or family members take turns guarding harvestable fish at night. Some farmers hire watchmen to protect the ponds and other crops.

FISH FEEDING

Farmers in the four countries fed their tilapia a variety of different items reflecting differences in the intensity of aquaculture practice in each nation, Table 6.5. As discussed earlier, feeding and fertilization represent overlapping activities for the tilapia farmer. In Rwanda, respondents primarily understood questions about feeding in terms of the amount and kind of organic materials they put in their ponds. In the other sites, farmers primarily understood feeding to refer to the use of commercial, purchased feeds.

TABLE 6.5. FEEDING PRACTICES, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Items most often fed?				
Termites	6	0	0	0
Bees wax or larvae	2	0	0	0
Leaves	87	0	0	0
Manure	67	0	0	0
Sorghum beer waste	32	0	0	0
Kitchen waste	0	14	2	12
Fresh vegetation	0	16	6	34
Rice bran	0	14	61	34
Dead animals	0	0	0	8
Slaughter waste	15	4	0	2
Commercial feed	0	41	32	42
Chicken litter	0	0	37	45
Other	8	57	0	2
Grass cuttings	28	0	0	0
Compost	28	0	0	0
Inorganic N	0	8	48	61
Chicken feed	0	0	2	0
Fish feed	0	0	0	0
Use commercial feed?				
Only commercial	—	21	10	7
Mainly commercial	—	10	24	20
Both equally	—	6	2	0
Use no feed	100[1]	63	64	73
Type commercial feed usually purchased?				
None purchased	100[1]	43	25	0
Rice bran	0	14	35	36
Rabbit pellets	0	8	0	0
Chicken feed	0	2	3	2
Fish feed	0	21	33	28
Other	0	12	0	34
(Number)	(136)	(51)	(50)	(56)

[1]Imputed data

Leaves and manure were the most common items in Rwanda. Chicken litter and commercial feed were most frequently mentioned in Honduras. In Thailand, farmers most often utilized rice bran, commercial feed, and chicken litter. A similar pattern was noted in the Philippines, although rice bran was used more often.

Commercial feed was not used in Rwanda; two-thirds of the Hondurans did not use commercial feed; and about half the Philippine respondents did not use commercial feed. Thai farmers were most dependent on commercial inputs to raise their tilapia crops. They also used the most diverse variety of feeds, reflecting the high level of availability of different feed types and a greater willingness to use feeds for other animals for the fish as well.

Honduran and Rwandan farmers were most likely to report inadequacies in feed availability on their farms. About seven percent of the Rwandan farmers said that they never had enough inputs for their ponds.

FERTILIZATION

Table 6.6 shows the use of fertilizer in the four samples. In Rwanda, commercial fertilizer represents a cash outlay that subsistence farmers prefer to avoid and, it generally is not applied to fish ponds. Because commercial fertilizer is not used or recommended for fish ponds, these questions were not asked in Rwanda.

Hondurans typically use cattle and chicken manure as fertilizer for their ponds. Chicken manure is the most frequent pond fertilizer in Thailand and the Philippines. Given the pervasive use of integrated systems in Thailand, ponds were most frequently fertilized with poultry manure in that country. Thai farmers also were more likely to apply lime to their ponds to increase the alkalinity (pH) of the pond and foster primary productivity.

About 73% of the Thai farmers fed their fish several times a day. The greater incidence of integration with poultry and duck production that require multiple daily feedings literally spills over to the tilapia crop. Poultry houses are typically located directly over the fishpond, so feed and manure are nearly continuously deposited into the pond.

Honduran farmers reported a high level of attentiveness to their ponds. About a quarter of the Rwandans fed their fish several times a week or less

TABLE 6.6. FERTILIZATION PRACTICES, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Pond fertilizer used?[1]				
Urea	-	0	14	0
0-46-0	-	0	0	9
18-46-0 (dap)	-	10	2	0
Other N-P-K	-	24	79	49
Chicken manure	-	29	70	53
Cattle manure	-	37	4	6
Compost	-	0	2	25
How often do you fertilize your ponds?				
Several weekly	-	27	0	69
Weekly	-	18	11	10
Several monthly	-	14	19	2
Monthly	-	10	21	0
Less often	-	21	43	4
Never	-	10	6	15
Limed ponds last year?				
No	-	57	95	26
Yes	-	43	5	74
How often visit ponds?				
Several daily	0	39	34	73
Every day	53	37	36	19
Almost every day	2	14	25	0
Several weekly	32	2	5	6
Once a week	13	6	0	0
Several monthly	0	2	0	2
Time usually spent when you visit your pond?				
Hour or less	34	18	4	79
About an hour	48	30	5	11
Two or 3 hours	14	20	16	4
More than 3	5	32	75	6
(Number)	(136)	(51)	(50)	(56)

[1]Multiple responses possible

often. Feeding in the Rwanda case refers primarily to the provision of manure and other inputs, some of which are directly consumed. These items mainly serve as nutrients to foster primary productivity in the ponds.

Rwandan farmers indicated the least attentive approach to fish farming, as only about half said the ponds were visited every day. Philippine farmers spent the most time with their ponds when they visited them; Thai farmers the least.

FINGERLINGS

A fundamental input to aquaculture production is the seed stock or fish that begin the crop cycle. Tilapia is a species that can easily spawn in ponds without farmer assistance, but most producers rely on hatcheries to provide fingerlings of uniform size and characteristics, often only faster-growing males. Spawning other cultured species — such as Asian carps, milkfish, or catfish — require special skills, procedures, or facilities. Fingerling availability is an important consideration in species selection, especially for polyculture systems.

Government hatcheries have generally been effective in supplying tilapia fingerlings in the early stages of aquacultural development. As the aquaculture industry expands, the development of private-sector fingerling producers is crucial. In periods of rapid growth, fingerling needs cannot usually be met by government facilities.

Rwandan farmers are dependent on government hatcheries for the production of fingerlings of known lineage and quality, as no private hatcheries yet exist. Even though no commercial fingerling production has yet developed in the country, fingerling sales are reported between neighboring farmers. Mixed- sex fingerlings from local ponds constitute the primary source of most fish crops in Rwanda. Table 6.7 profiles the fingerling sources used by fish farmers in the other countries. Similarly, few private farm dealers have evolved in Honduras. The private sector provided fingerlings to more than 80% of the Thai farmers and about 37% of the Philippine operators. In each country, most farmers were using the *Oreochromis niloticus* species.

Thai and Philippine farmers tended to densely stock the smallest fingerlings available. Honduran farmers tended to stock somewhat larger fingerlings. All-male tilapia were stocked in each country, although mixed-sex culture was the normal mode of production in Rwanda.

Chemically-induced sex reversal was the most commonly employed method of producing all-male tilapia fingerlings in all the sites. It is notable that 84% of the Thai farmers did not know the method by which all-male tilapia fingerlings were produced.

TABLE 6.7. FINGERLING SOURCES, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Where do you obtain tilapia fingerlings?				
Govt. hatchery	—	57	40	4
Research station	—	18	0	0
Hatchery/station	—	6	0	0
Private dealer	—	2	37	82
From a neighbor	—	2	7	9
From own ponds	—	16	9	9
Type fingerlings used?				
Natural colored	—	63	7	100
Red colored	—	6	0	0
Other (black & red)	—	31	93	0
Tilapia species used?				
Niloticus	—	100	96	100
Mossambicus	—	0	0	0
Aureus	—	0	2	0
Hybrids	—	0	2	0
Stock all-male or mixed-sex tilapia?				
Mixed-sex	100	4	0	0
All-male	0	88	93	100
Both	0	8	7	0
What method produced all-male fingerlings?				
Hybridization	—	2	11	2
Sex reversal	—	76	78	10
Hand-sexing	—	20	11	2
Some combination	—	2	0	2
Don't know	—	0	0	84
(Number)	(136)	(51)	(50)	(56)

STOCKING AND GROW-OUT PRACTICES

Table 6.8 suggests that most farmers are growing but a single crop of tilapia each year in Thailand. In Honduras, almost half reported two or more crops, but in the Philippines two-thirds obtained two crops per year. Although most of these questions were not asked in Rwanda, scarce inputs and cooler water may slow fish growth and lengthen the crop cycle to eight months or more. Warmer water, the stocking of larger fingerlings, or the harvest of a smaller fish may have allowed more than a quarter of the farmers in the Honduras sample to report growing tilapia in less than 180 days.

Polyculture, or raising more than one species of fish in the same pond, was practiced by nearly all the Thai farmers in the study. A third of the Honduran farmers reported stocking other species, but only 11% of the Philippine farmers did so. Although the question was not asked, polyculture generally is not practiced in Rwanda. In Honduras and Thailand, the additional stocked species tended to be a predator fish such as Guapote tigre or snakehead, respectively.

Philippine farmers were least likely to use a predator fish. Although not reflected in the survey data, this practice is not yet in use in Rwanda. The presence of a predator eliminates small fish and reduces the impact of unwanted tilapia reproduction on a crop of fish. The predator species generally is not viewed as another crop or enterprise, given the relatively small number that are stocked. Small tilapia are undesirable because they compete for feed with the market-size part of the crop. Fingerling availability was a problem for 30% of the Philippine respondents, 24% in Rwanda, 22% in Honduras, and a concern for only 4% in Thailand.

WATER MANAGEMENT

Table 6.9 shows how fish farmers use and move water. To maintain the quality of water in farm ponds, farmers often add additional water or use an aerator to provide additional oxygen to the fish. The most immediate symptom that causes farmers to intervene is piping fish [surfacing to draw oxygen-rich water into their mouths], and in extreme cases, dead fish. Some ponds with large populations of intensively-managed large fish also may require additional water to dilute excessive amounts of fish waste.

Exchanging water was the most frequently used water quality management strategy. It was used by all the Thai farmers, more than half the Philippine farmers, and about a quarter of the Honduran farmers. When asked how frequently they exchanged water, about 80% of the Honduran farmers said they never exchange water, suggesting that they understand the procedure but rarely are required to use it, or do not have enough water to do so. About 37% of the Philippine respondents said they never exchange water. We asked farmers to report the presence or absence of various types of equipment on their farms. Honduran farmers were most likely to have a vehicle. Philippine farmers were most likely to have a net, but more Thai farmers had a water pump and a scale.

TABLE 6.8. STOCKING AND GROW-OUT PRACTICES, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
How many crops each year from each pond?				
One	—	54	25	95
Two	—	40	66	5
Three or more	—	6	9	0
How long does tilapia crop grow?				
< 180 days	—	50	94	10
180 to 240 days	—	14	6	6
More than 240	—	36	0	84
Raise other species of fish with tilapia?				
Yes	—	36	11	98
No	—	64	89	2
Stock a predator species?				
No	—	6	71	2
Yes	—	94	29	98
Problems finding fingerlings for restocking?				
No	76	78	70	96
Yes	24	22	30	4
Usual stocking density?				
Less than $1/m^2$	—	13	13	0
$1/m^2$ or more	—	87	87	91
How large are the fingerlings stocked?				
Less than 3 cm.	—	46	70	86
3 to 5 cm.	—	40	16	14
5 to 10 cm.	—	12	5	0
More than 10 cm.	—	2	0	0
Mixed sizes	—	0	9	0
(Number)	(136)	(51)	(50)	(56)

TABLE 6.9. WATER MANAGEMENT STRATEGIES, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Use an aerator or exchange water?				
Exchange water	—	24	59	100
Use an aerator	—	0	0	0
Use both	—	0	0	0
Use neither	—	76	41	0
How often do you exchange water?				
Never exchange	—	80	38	2
Every day	—	8	7	2
Almost every day	—	2	2	2
Several a week	—	4	2	4
Once a week	—	2	4	16
Several a month or as needed	—	4	47	74
What equipment do you have on your farm?				
Truck	—	71	16	56
Harvest net	—	71	84	38
Water test kit	—	4	0	6
Water pump	—	18	75	98
Aerator	—	2	2	0
Oxygen meter	—	2	2	0
Scale	—	90	26	100
Wheel barrow	—	0	0	22
(Number)	(136)	(51)	(50)	(56)

HARVEST PRACTICES

Farm labor for harvesting fish was usually supplied by family members in the Philippines, as shown in Table 6.10. Partial harvesting — taking only the fish necessary for a day's consumption, to fill an order, to provide a certain amount of cash, or to provide a day's worth of fish for the market — was more common in Rwanda, Honduras, and the Philippines. More than two-thirds of the Philippine respondents said they usually partial harvest their ponds.

Some farmers may partial harvest to select only larger fish, to harvest only a quantity that can be marketed with certainty, or to avoid cash outlays for the labor that might otherwise be required for a complete harvest. Thai farmers tended to harvest the fish all at one time. In Honduras and Thailand, harvest labor was typically accomplished by paid workers engaged either by the farmer or the buyer. In Thailand, buyers frequently harvest the fish they purchase from farmers as part of the marketing transaction. Family labor did the work in about a quarter of the Honduras situations.

In Rwanda, around half the ponds are group ponds. Previous work shows that members of the group or their family members supply the labor at harvest time *(44)*. Some private farmers hire laborers or organize neighbors to work for a share of the harvest when it is time to drain the pond. About two-thirds of the Rwandans reported one large harvest, where cooperative labor arrangements usually are made.

In Rwanda, we estimate that about 80% of the harvested tilapia weigh less than 120 grams. Lack of nutrient inputs tend to lengthen the time necessary to grow larger fish.

Farmers tended to harvest larger fish in Honduras, as more than two-thirds reported harvesting fish larger than 250 grams. The Philippine operators had a similar harvest size preference, though a few more harvested smaller fish. In

Table 6.10. Harvest Practices, Tilapia Farms in Four PD/A CRSP Countries, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Did you hire labor to harvest tilapia?				
No, self	—	6	9	0
No, family	—	29	91	8
Yes, laborers	—	65	0	28
Buyer harvested	—	0	0	64
Had trouble getting enough labor to harvest your pond?				
No labor used	—	26	66	9
No, no problems	—	66	28	89
Yes, difficulty	—	8	6	2
Usually partial harvest or have one large harvest?				
Usually partial	36	37	69	6
Partial & a large	0	22	21	17
A single harvest	64	41	10	77
Average size of tilapia harvested?				
Less 120 grams	—	4	13	6
120 to 249 grams	—	18	49	26
250 to 499 grams	—	35	27	33
500 to 749 grams	—	29	11	27
More 750 grams	—	14	0	8
(Number)	(136)	(51)	(50)	(56)

Thailand, however, more than half the sample harvested fish less than 250 grams in size.

MARKETING

Marketing of tilapia at a profitable margin is affected by many factors, most beyond the control of the individual fish producer. Consumer preference for certain fish species, sizes and product forms will determine what sells. Research into existing marketing channels provides a starting point from which to develop alternative outlets.

Tilapia culture has been successful in many places, but markets often have not been properly developed in tandem with increases in supply. While production is low, family and neighbors can consume the product, but as production increases, outlets for new supplies of fish must be more methodically established. Results from this study give a view as to what channels are presently being used by tilapia farmers.

Only a small proportion of each sample reported fish harvested solely for home consumption or barter, i.e., none sold for cash, Table 6.11. Most sold some fish for cash, though a third of the Rwandans said that they sold less than half the harvest for cash. Only 40% of the Rwanda respondents sold for cash. Previous research suggests that much of the fish in Rwanda was used for home consumption or bartered for harvest labor. In Honduras, 80% said they sold more than half for cash. Nearly 100% did so in the Philippines and Thailand.

Middlemen purchased fish from all the Thai farmers, three-fourths of the Philippine farmers, almost half the Hondurans, but nearly none of the Rwandans. Farmers that sold tilapia to restaurants were more frequent in Honduras. Direct marketing was more common in the Philippines, where 30% reported selling fish in the market. The most common marketing method for farmers in all countries was pond bank sales to neighbors and others coming to the ponds at harvest. Word-of-mouth knowledge about prospective harvests or the willingness to partial harvest for immediate sale remain primary means for marketing tilapia for most small and medium size farmers.

MARKETING PROBLEMS

More than two-thirds of the respondents said

Table 6.11. Marketing Practices, Tilapia Farms in Four PD/A CRSP Countries, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Any cash for last harvest?				
No	60	13	2	0
Yes	40	87	98	100
How much sold for cash?				
None for cash	7	6	4	0
Less than half	33	92	20	0
Half for cash	12	2	76	4
More than half	48	0	0	96
Did middleman buy any?				
No	98	51	21	0
Yes, some of it	2	47	23	31
Yes, all of it	0	2	56	69
Sell any to restaurants?				
No	98	71	92	98
Yes, some of it	2	29	8	2
Yes, all of it	0	0	0	0
Sold any in the market?				
No	86	92	70	93
Yes, some of it	13	8	19	5
Yes, all of it	1	0	11	2
Anyone else sold tilapia?				
No	58	18	26	41
Pond bank sales	42	82	74	59
(Number)	(136)	(51)	(50)	(56)

TABLE 6.12. MARKETING PROBLEMS, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Did you have trouble selling your tilapia?				
No	79	82	100	69
Yes	21	18	0	31
Had problems selling at price you want?				
No	77	90	100	44
Yes	23	10	0	56
Even if you cannot get the price wanted, can you usually sell at a lower price?				
No	27	36	76	50
Yes	13	64	24	50
Some people in area do not like to eat tilapia?				
No	66	84	100	85
Yes	72	42	85	96
Larger tilapia would be easier to sell?				
No	28	58	15	4
Yes	72	42	85	96
Sold fingerlings to other farmers?				
No	49	84	74	94
Yes	51	16	26	6
Did you have trouble selling fingerlings?				
No, did not sell	42	84	70	94
Had no problems	31	16	30	4
Yes, problems	27	0	0	2
(Number)	(136)	(51)	(50)	(56)

they had no problem marketing tilapia, Table 6.12. There was concern in Thailand by the farmers that they were not getting the price they wanted. Many also responded that they could not sell their fish even when they lowered their prices. Similar comments were also made by Philippine and Honduran tilapia farmers.

In a study of people practicing aquaculture in Rwanda, Molnar found that fish were considered a recent entry into traditional diets, except in some lake areas *(43)*. No cultural taboos toward eating fish were discovered, although knowledge of fish preparation methods was limited. Consumers exhibited a clear size preference for marketed tilapia. Fish greater than 120 grams sold quickly at $2.00/kg, but fish weighing less than 100 grams would not be purchased, even at reduced prices. However, this size bias changed by region, with consumers in some lake regions accepting smaller fish. A 120-gram fish was attainable in 7 to 9 months by farmers that followed recommended management practices.

Philippine farmers indicated no trouble marketing their fish. Marketing difficulties of some kind were reported by about a third of the Thai respondents, and around 20% of the Honduran and Rwandan respondents. Over half the Thai farmers reported difficulties securing the price they wanted for their tilapia. Honduran farmers were the most confident about being able to sell their tilapia at some price, even if it was not what they originally offered.

Three-quarters of the farmers in the present study felt a larger fish would be easier to sell. In Thailand and the Philippines, almost 100% of the respondents felt larger fish would sell more easily. In Honduras, approximately half the operators with small and medium-sized ponds and 82% of the larger pond operators felt a larger fish would sell more easily.

About a third of the Rwanda sample said that there were many people in their area that did not like tilapia. Around 15% of the Honduras and Thai respondents felt this way, but no Philippine respondent said so. Of the four countries, the Philippines seems to have the highest consumer acceptance of tilapia.

Fingerling sales to other farmers were most common in Rwanda, where more than half the respondents reported such transactions. Private fingerling sales among farmers is an important indicator of sustainability, especially where government services are unreliable or unavailable in much of the country.

Fingerling sales between farmers were least common in Thailand, 6%, largely because a network of private dealers is well-developed there. Dealers are less common in Honduras, but a small segment reported fingerling sales (16%) as did a few more in the Philippines (26%). Rwandan farmers apparently were most actively seeking to sell fingerlings — largely because the mixed-sex production strategy they employed yields many small fish due to unwanted reproduction. About half sold fingerlings, but about half of the fingerling sellers reported problems in making the sales they wanted. None of the respondents in other countries reported problems selling fingerlings.

IMPACTS ON HOUSEHOLDS

Table 6.13 shows a series of questions profiling the impacts of fish culture on households. About 78% of the Philippine farmers thought that there were points in the annual farm cycle when the pond was too much work, 37% in Thailand. Few of the other respondents thought so. Previous work suggests that Rwandan women are much more likely to report these difficulties

TABLE 6.13. FISH POND IMPACTS ON HOUSEHOLDS, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Are there times when the pond is too much work?				
No	98	78	22	63
Yes	2	22	78	37
Does tilapia fit well with other activities of household?				
No	17	36	9	21
Yes	83	64	91	79
Does tilapia pond make it harder to care for other crops?				
No	94	92	100	94
Yes	6	8	0	6
Does having a pond make it harder to take care of family?				
No	95	94	100	91
Yes	5	6	0	9
Does pond make it harder to complete other household work?				
No	94	90	98	92
Yes	6	10	2	8
Does the cash from tilapia make it easier to buy things for your family?				
No	95	27	14	8
Yes	5	73	82	92
(Number)	(136)	(51)	(50)	(56)

but only 64% of the Honduran farmers thought so. They also were slightly more likely to report problems completing household work or taking care of their family.

Few respondents noted problems associated with the tilapia enterprise in taking care of other crops, taking care of the family, or completing other household work. Three-quarters or more of the respondents in the Philippines, Honduras, and Thailand noted the benefits of additional cash for their households as something associated with the tilapia crop. Only 5% of the Rwandans agreed with this statement. The limited amount of cash produced by tilapia in Rwanda is used mainly by men to purchase beer or rent more land.

POND CONFLICTS

Table 6.14 shows respondent experiences with a series of problems sometimes encountered by tilapia farmers. Thai farmers were most likely to note problems over water resources emanating from the tilapia crop (57%), an issue noted by only a few of the other respondents. Philippine operators had few problems with predators eating their fish, but this was an issue for farmers in each of the other countries.

Theft was a concern for 44% of the Honduran farmers, but only 20% or so of the Rwanda and Thailand respondents noted this as an issue; only 11% did so in the Philippines. Thai farmers were most likely to agree that tilapia were easier to steal, though a third of the Honduran respondents thought so as well.

PROSPECTS FOR THE POND

Most respondents thought their fish pond produced enough to be worth the work they put into it, though Rwandans were slightly more skeptical (Table 6.15). A third of the Hondurans questioned the fit of tilapia with the other activities of their farm household. About 60% of the Hondurans thought that tilapia was less profitable than their other activities.

Most respondents thought tilapia was the best use of the land it occupied. Hondurans were more likely to report themselves as planning to build new ponds (39%). In land-short Rwanda only 11% thought so.

Only 54% of the Rwandans were happy with tilapia as a type of fish to grow; they desired a larger, faster growing fish. More than 90% of respondents in the other nations were happy with tilapia as a type of fish to grow.

The perceived profitability of tilapia relative to other farm activities was highest in the Philippines, where 90% thought it was more profitable than other crops. About 78% thought so in Thailand. In Honduras, 23% thought it was more profitable.

Overall Hondurans were least happy with the profitability of tilapia, though Thai farmers were less convinced that tilapia ponds were the best use of the

TABLE 6.14. POND CONFLICTS, TILAPIA FARMS IN FOUR PD/A CRSP COUNTRIES, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Conflicts with others over water for ponds?				
No	—	94	100	43
Yes	—	6	0	57
Birds or other animals eating tilapia from ponds?				
No	31	24	95	4
Yes	69	76	5	96
Problems with people stealing tilapia from your pond?				
No	78	56	89	81
Yes	22	44	11	19
Are tilapia easier to steal than crops?				
No	97	62	80	55
Yes	3	38	20	45
(Number)	(136)	(51)	(50)	(56)

Table 6.15. Prospects for the Fish Pond, Tilapia Farms in Four PD/A CRSP Countries, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Does tilapia produce enough to be worth the work put into it?				
No	28	8	7	10
Yes	72	92	93	90
Is tilapia pond the best use of land it uses on the farm?				
No	11	12	0	24
Yes	89	88	100	76
Are you planning to build more ponds?				
No	89	61	2	71
Yes	11	39	98	29
Generally happy with tilapia as a fish to raise?				
No	46	6	2	6
Yes	54	94	98	94
How profitable is tilapia compared to other activities?				
More profitable	—	23	90	78
About the same	—	17	8	8
Less profitable	—	60	2	14
(Number)	(136)	(51)	(50)	(56)

land. Lowland Thai farmers with irrigation in the far reaches of the Bangkok marketing area have many enterprise choices and marketing opportunities.

TECHNICAL ASSISTANCE

Aquacultural extension services were making frequent contacts with farmers in Rwanda, but not the other nations. In Rwanda, a well-trained cadre of extension personnel were supported by donor funds. Most farmers received regular visits if they wanted them. The Rwandan respondents also were somewhat more likely to report some type of extension contact in the past. Only 10% wanted additional extension help.

A highly professional, relatively well-organized extension and research system is in place in Thailand. Nonetheless, about a third of the Thai respondents indicated that they never have had contact with an extension representative. Budget problems limited on-farm extension work to a small set of individuals supported solely by provincial-level government in the Philippines. Most farmers wanted more extension help.

In Honduras, high inflation has degraded salaries, travel budgets, and morale for extension personnel. These conditions, coupled with high levels of personnel turnover, contributed to the low impact of extension in that country. A third indicated no contact with extension in Honduras. More contacts were noted with Honduran fish stations that supply fingerlings and some technical assistance to farmers. In Honduras, Peace Corps has been very active in fish culture, as has the staff of the Pan-American Agricultural School (Zamorano). Honduras was the only country where Peace Corps contacts were reported. About a third of the Honduran and Thai farmers had no extension contact. Most Thai and Philippine farmers wanted extension help in the future, but farmers in Rwanda and Honduras were not certain.

Farmers were asked about the main things preventing larger harvests. Water quality was the biggest issue in Thailand and the Philippines, referred to simply as "the pond" in Rwanda. Manure and compost availability was the obstacle most frequently cited in Rwanda. Honduran farmers noted "my understanding" as the major obstacle to obtaining larger harvests from their ponds.

Table 6.16. Sources of Technical Assistance, Tilapia Farms in Four PD/A CRSP Countries, 1994

	Rwanda	Honduras	Philippines	Thailand
	Pct.	*Pct.*	*Pct.*	*Pct.*
Last extension contact?				
Never contacted	6	35	22	35
In past months	75	26	46	50
Months to year	6	10	14	4
More than a year	13	29	18	11
Last fish station contact?				
Never contacted	—	4	25	62
In past months	—	38	43	17
Months to year	—	22	14	6
More than a year	—	36	18	15
Peace Crops contact?				
No	—	16	100	100
Yes	—	84	0	0
University staff contact?				
No	—	80	28	75
Yes	—	20	72	25
Want more extension help?				
No	90	0	2	17
Yes	10	100	98	83
Main obstacles to larger harvests?				
The species	45	11	0	0
No inputs	59	9	0	0
Water too cold	9	2	0	0
My understanding	2	36	0	0
Water quality	0	0	95	40
Pond leaks	0	5	0	0
Kind of inputs	0	23	0	0
No extension	0	5	0	0
Other	2	9	5	60
(Number)	(136)	(51)	(50)	(56)

CHAPTER SEVEN SURVEY RESULTS: DIFFERENCES BY FARM SIZE

INTRODUCTION

This chapter elaborates the survey data by portraying production systems, technologies, and farmer perceptions of selected fish culture issues as they vary by farm size. Pond area has a close correspondence to subsistence, small-scale and commercial levels of aquaculture production *(32)*. Distinguishing these production levels are nutrient types, nutrient quantities, water manipulation, and fingerling-related decisions. Social and economic aspects of aquacultural systems determine their sustainability and long term profitability. Therefore, a holistic view of these farmer characterizations are needed and to separate them completely belies their true interconnectedness and interdependence.

From the economic side, producer incentives involve the efficient use of land, labor and capital. From the social side, the size of the farm pond operation reveals much about the farmer's situation and capabilities. This analysis addresses each issue from a small, medium and large pond owners point of view for each study country. Attention is also given to specific variable inputs, output prices, marketing occurrences, and some obstacles to raising tilapia.

Tilapia production technology varies with intensity, market availability of inputs, capital, land and owner's degree of risk aversion. Technological change involves knowledge of aquacultural principles and the desire to increase production efficiency through innovation and adoption of new sustainable technologies. Increasing fish production by improving the quantity and quality of nutrient inputs has many associated implications on management, labor and capital. Additionally, there are social contexts that will affect technology adoption rates.

Farm pond area is examined using three categories — small, medium and large — depending on the range reported in each country. Table 7.1 shows how the cases in each sample were divided into thirds — according to pond area — to obtain small, medium and large pond area categories. The classification boundaries are not the same for each country.

The *small* pond area grouping is less than or equal to 0.11, 0.65, and0 .96 hectares in Honduras, the Philippines, and Thailand, respectively. The *medium* pond area groupings are 0.12 to 0.65, 0.66 to 3.0, and 0.97 to 1.76 hectares, respectively. The *large* pond area groupings are greater than 0.65, 3.0, and 1.76 hectares in Honduras, the Philippines, and Thailand, respectively.

The categories correspond well with production intensity levels and allow cross-country and intra-country pond area comparisons. Rwanda data has been included in the 'small' pond area category because of its homogeneous low-intensity type of tilapia production, regardless of actual pond area.

FARMER PERCEPTIONS OF TILAPIA CULTURE

Regardless of farm size, most fish farmers in Rwanda, Thailand, Philippines and Honduras felt that the tilapia pond was the best use of the land it occupied on their farm, Figure 7.1. This question was intended to elicit the farmer's assessment of the aquaculture enterprise as compared to other possible activities that could take place on the ground the pond occupies. Fewer farmers in the medium and large pond area categories in Thailand felt tilapia production was the

TABLE 7.1. CLASSIFICATION OF TILAPIA FARMS BY POND AREA IN FOUR PD/A CRSP COUNTRIES, 1994.

	Total Farm Pond Area by Country			
Size Category	Rwanda[1]	Honduras	Philippines	Thailand
	Ha.	*Ha.*	*Ha.*	*Ha.*
Small	—	≤ 0.11	≤ 0.65	≤ 0.96
Medium	—	0.12 - 0.65	0.66 - 3.0	0.97 - 1.76
Large	—	>0.65	>3.0	>1.76
Range	0.01 - 0.10	0.08 - 16.32	0.05 - 100.0	0.005 - 15.2

[1] Rwanda data were collected prior to this study and categorization by total pond area was not possible.

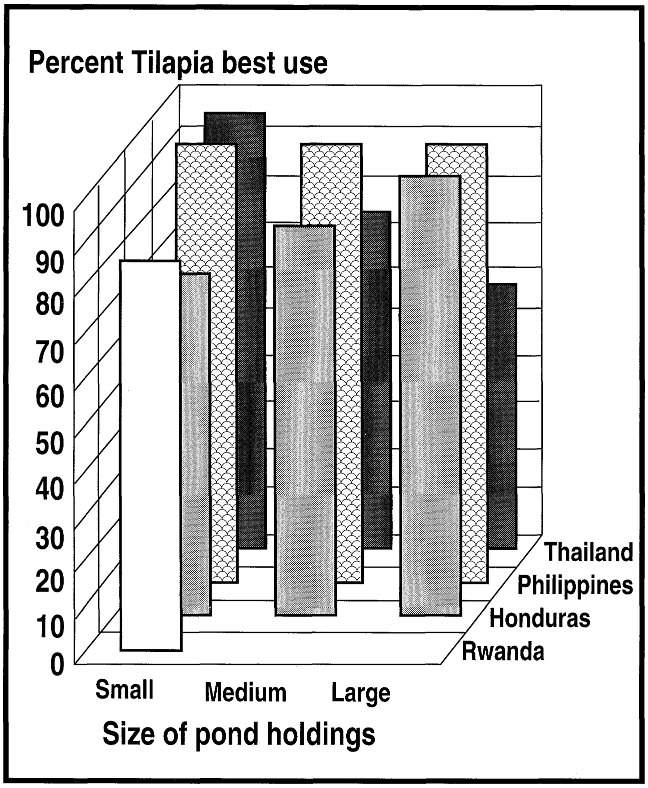

Figure 7.1. Percent agreeing that Tilapia pond is best use of the land it occupies on the farm by pond holding size, and country, Tilapia farmers, 1994-95.

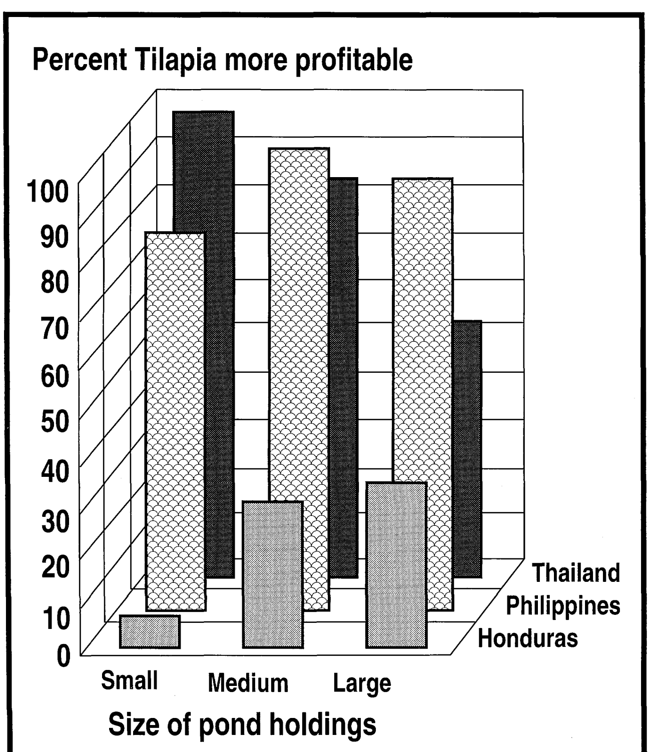

Figure 7.2. Percent indicating that growing Tilapia is more profitable that other farm activities by pond holding size, and country, Tilapia farmers, 1994-95.

best use of their land, although the percentage was still over 60%. As the Thailand respondent's pond area increased, a smaller percentage replied that the pond was the best use of the land occupied. All Philippine owners, regardless of pond category, agreed aquaculture was the best use of the land.

When asked to compare profitability of tilapia farming to other farm activities, the most contradictory patterns were observed in the answers given by farmers in Honduras, Figure 7.2. Only 8% of the small pond owners ranked fish culture as the highest cash producing enterprise while 32% of the medium and 36% of large pond operators ranked the fish as the highest cash-producing enterprise.

Farmers seem to be indicating that aquaculture was less profitable than other farm activities after saying that the pond was the best use of the land on their farm. This seeming incongruity of the two responses may be explained by the location of pond(s) on marginal agricultural land. If this is the case, though aquaculture is not as profitable as other farm activities, it is still a better use of the land because little other agricultural activity could occur on the parcel.

All pond size owners in the Philippines felt very positive about aquaculture in relation to other farm activities, Figure 7.3. In Thailand, small and medium pond size owners shared a similar high degree of enthusiasm about tilapia culture, but only about half the large farm operators in Thailand agreed that tilapia was more profitable than other farm activities.

Appendix I shows the farm enterprises that provide the most cash income. High percentages of Philippine and Thai farmers rank fish culture as the single most positive farm enterprise. These same farmers also tend to have highly diversified operations, often an effective way to reduce agriculture production risks. The diversification of farms decreases as the farm pond area increases, indicating larger degrees of specialization in fish culture, rice production and/or livestock production as size increases.

Labor. The amount of labor required for an aquacultural enterprise varies with the technology employed. The use of animal manures, green manures, and other on-farm by-products often involves a significant labor expenditure for collection, transport and application. Labor used for joint livestock-fish or

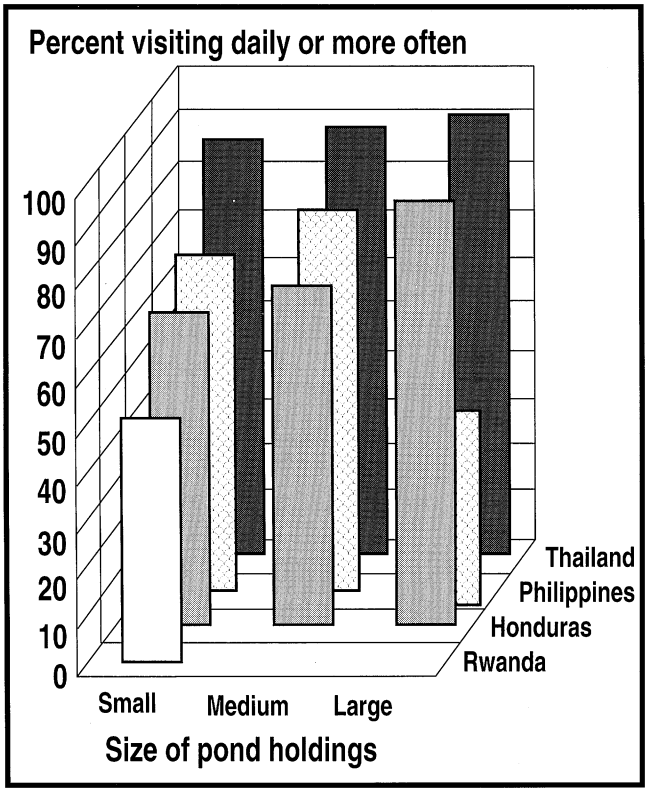

Figure 7.3. Percent visiting ponds daily or more often by pond holding size, and country, Tilapia farmers, 1994-95.

fish-crop activities in integrated systems, such as feeding, weeding, and by-product re-use, increases labor efficiency both overall and for the enterprise.

Labor can be a cash or non-cash cost. Labor activities required in the production cycle are often non-cash costs, i.e., many farms in developing countries use available family labor only or work collectively at certain periods of the year such as at harvest time. The intensity of production and available resources will determine the farmer's need for additional labor. Often farmers who employ laborers are more tied into market economies and exhibit higher degrees of managerial ability that may lead to acceptance of technological innovations more readily than strictly on-farm operators.

The frequency of pond visitation has been used as an indication of good pond management. This linkage assumes most pond visits accomplish some nutrient input for the fish. Nutrient systems using vegetation or animal manures require frequent application of inputs to maintain plankton communities in the ponds. When farmers are providing feed, tilapia respond better to many small feedings versus one large feeding.

If this linkage is indeed true across locations, then, as a whole, Thai farmers manage their ponds better than farmers in the other countries, Figure 7.3. In Honduras, as the pond area increased, more visits were made per day. In Rwanda, and for the large pond owners in the Philippines, only about half the farmers visited the pond at least once a day.

However, visitations alone may not be the only factor promoting good tilapia production. The length of stay may also be relevant. On average, the Philippine farmers spent more than three hours per visit to the ponds. Thai farmers did not fare well as they averaged under an hour per visit.

In Honduras, more time was spent per visit as the pond area increased. Small pond owners spent about an hour per visit, while medium pond owners spent about two hours and large pond owners spent more than three hours per visit. Most Rwanda farmers spent about one hour per visit.

In the Philippines and Honduras, most used a mix of family labor and hired labor. Operation owners, additional family members and hired laborers were employed to help harvest tilapia. Results suggest that as pond area increased more laborers were hired, with less reliance solely on family labor.

The availability of labor to be hired by the fish farmers was a problem only in Thailand, for all size categories. In Honduras, difficulty in obtaining labor increased with pond area. It is not clear if a scarcity of skilled labor or simply few laborers in the pond locale created this problem.

Capital. The number of ponds and pond area were used to reflect capital investment. These analyses are shown in Tables 7.2 and 7.3, along with equipment used in the aquaculture operation, Appendix II.

Information on the total pond area (for each size category), number of ponds per farm and average pond area for the three PD/A CRSP countries are found in Table 7.2. In general, Thailand had fewer ponds per farm than did farmers in the Philippines and Honduras. Also, the average pond area was larger in Thailand than in the other two countries.

Most of the farmers in the small pond area category had two to three ponds in all countries, Table

TABLE 7.2. AVERAGE TOTAL POND SURFACE AREA, AVERAGE NUMBER OF FISH PONDS, AND AVERAGE POND AREA BY SIZE CATEGORY IN HONDURAS, THE PHILIPPINES, AND THAILAND, 1994.

Country and Size Category	Average Total Pond Area	Average Number of Ponds	Average Pond Size
	Ha.	*No.*	*Ha.*
Honduras			
Small	0.05	2.8	0.02
Medium	0.35	3.6	0.10
Large	4.01	12.5	0.32
Philippines			
Small	0.30	2.2	0.14
Medium	1.75	5.5	0.32
Large	12.47	11.0	1.13
Thailand			
Small	0.48	1.6	0.30
Medium	1.43	1.8	0.79
Large	6.09	5.0	1.22

TABLE 7.3. TOTAL OWNED FARM AREA, OWNED AND LEASED POND AREA, AND POND AREA AS PROPORTION OF OWNED LAND IN HONDURAS, THE PHILIPPINES, AND THAILAND, 1994.

Country and size category	Avg. total owned farm area	Avg. pond area owned and leased	Pond area as pct. of owned land
	Ha.	*Ha.*	*Pct.*
Honduras			
Small	128.10	0.05	0.1
Medium	81.09	0.35	0.4
Large	383.74	4.01	1.1
Philippines			
Small	1.63	0.30	18.7
Medium	5.23	1.75	33.4
Large	4.11	12.47	303.7
Thailand			
Small	3.07	0.48	15.7
Medium	4.29	1.43	33.2
Large	3.62	6.09	168.2

7.3. The same was true for medium-sized farm in Thailand. In the Philippines and Honduras, more medium-sized farms had between three and six ponds, and large farms had between 11 and 13 ponds.

Farm size differences in patterns of equipment usage in the aquaculture operation are available in Appendix II. Overall, it seems that Honduran tilapia operations were more capital (equipment) intensive than were the Philippine and Thai operations. However, in the Philippines and Thailand, water pumps were used by most aquaculturists due to the water delivery system available. The relative absence of seine nets on Thai fish farms is understandable because of their preference for one large fish harvest rather than partial harvesting preferred in the Philippines and Honduras, where seine nets were more commonly found. Custom harvesting also is a service generally more available to Thai producers.

The greater use of water pumps by farmers of all sizes in the Philippines and in Thailand than in Honduras is largely because of the topography of the study area. Additionally, the use of water pumps may indicate a greater number of users of the same water system for agriculture than in the Honduran agriculture system. The topography of Thailand is flat and water is pumped to fill and/or drain ponds. The Honduran topography permits gravity filling and draining. Water resources will be discussed at greater length in a following section.

Common to all study countries was the lack of any widespread usage of water quality kits, aeration equipment and dissolved oxygen meters. These items are indicative of capital intensive fish culture operations and higher production intensity, indicating that in these three countries tilapia culture is occurring at less intensive production levels. Another interpretation of the answers to the question regarding equipment would be that these items are not available, their cost is high, or farmers lack knowledge of the use and interpretation of results provided by these instruments. Less-intensive production levels also are less risky for the producer regardless of size.

Land. Ponds are specialized structures whose use is limited to aquaculture. Ponds physically alter the land to a greater degree than do crop, livestock, and poultry activities. (One exception is the modification of rice fields for rice-fish culture). However, ponds can be situated to exploit unique topographic and physical characteristics, as well as making marginal agricultural land productive.

In each country, there was an increasing percentage of land put into ponds as the total farm area increased, Table 7.2. This seems to indicate that smaller land owners were less likely to invest or risk their land in fish culture. This would mean having less land available for other agricultural activities. Smaller farms may depend on non-pond land for subsistence food security while larger farms would have the household food security covered through the larger farm area available or through cash purchases in the market place and could therefore devote more land to other enterprises.

In Honduras, farmers were less likely to put their land into ponds than in the Philippines or in Thailand, as evidenced by the area of ponds as a percent of total farm land owned. Whatever pond area category, Philippine farmers put greater percentages of their land into aquaculture, Table 7.2.

Water. Aquaculture requires that water be available in sufficient quantity year round, or at least for the duration of the production cycle. Dry seasons can be favorable for aquaculture in terms of temperature and photosynthetic activity, but unfavorable in terms of water availability to replace water lost to evaporation and seepage.

Adequate water quality and quantity and control of pond water levels are essential to aquaculture. Because aquaculture tends to require greater quantities of water than other agricultural activities, the cost of water-source development often will be greater than for other agricultural uses. The control of the water resource may not only yield substantial benefits for the aquacultural activity, but also may improve production performance of other crops such as rice and vegetables.

Control of pond water levels is important in water quality maintenance and stock management. Water inlets and outlets must permit the controlled addition and removal of water. Additions of water to ponds are needed to replace seepage and evaporation losses or to improve deteriorated water quality. Ponds are drained to simplify complete harvest of the stocked fish. Proper pond design allows all water to drain from the pond by gravity. Pond water level control structures range from simple to sophisticated.

Tilapia growers in Thailand seem to have the most problems obtaining water, Table 7.4. Further details of water sources by farm size are specified in Appendix III.

About 71% of the Thai small farm operators reported problems getting enough water to keep their ponds filled. The percent of farmers reporting water procurement problems in Rwanda was 24%, while the range for Philippine farmers was 25-50%. In the Philippines, problems obtaining water generally decreased with pond area. In contrast, the number of Honduran farmers having difficulty in getting enough water ranged between 13-24%.

No major farm-size differences were noted in water source. The main water source for Thai tilapia farmers was agricultural irrigation canals. Aquaculture requires more water at certain times of the year, increasing chances for conflict over water with other agricultural water users. Over 70% of the small and large size Thai farmers responded that they had conflicts with other farmers over the use of water for their fish ponds. Few, if any, such conflicts were reported by Filipino and Honduran respondents.

Less irrigation water was used in the Philippines than in Thailand and no irrigation water

TABLE 7.4. WATER AVAILABILITY AND SOURCES FOR AQUACULTURE IN RWANDA, HONDURAS, THE PHILIPPINES, AND THAILAND, 1994.

Country and size category	Farmers having problems getting water[1]	Primary water source
	Pct.	
Rwanda		
Small	24	Stream or Spring
Honduras		
Small	18	Stream or Spring
Medium	24	Stream, Spring or Lake
Large	13	Above Plus Well
Philippines		
Small	50	Combination[2]
Medium	25	Combination[2]
Large	27	Combination[2]
Thailand		
Small	71	Irrigation Canal
Medium	50	Irrigation Canal
Large	41	Irrigation Canal

[1] Response to the question, "Have you had problems getting enough water to keep your pond filled?"
[2] Combination water sources for the Philippines included collected runoff, well, stream, and irrigation canal water.

was used in Honduras, Table 7.4. The main water sources for tilapia farmers in Honduras were either rivers/streams, springs or some combination thereof. The diversity of water sources available to Philippine and Honduran farmers probably reduced potential water use conflicts with other agricultural water users.

Water quality is a serious concern for farmers regardless of size. Insecticide and herbicide residues and accumulations from nearby agricultural operations may adversely affect fish health. Thai tilapia farmers reported poor water quality from pollution as a problem in raising fish. Approximately 33% of the small and medium-size farmers — and 50% of the larger farm operators — reported pollution problems.

Pollution problems stem from the multiple users of the irrigation canal water and the return of waste water to the canals. This is an externality that downstream water users have little control over, and they usually must accept the consequences without any recourse. Conversely, the percentage of Philippine farmers having water pollution problems decreased with increasing pond area; 11% with small pond area, 6% at the medium size, and none of the large farmers.

It is not coincidental that the Thai farmers who are likely to operate at semi-intensive or higher production levels had the most problems with water quality. The higher the production intensity the greater the need for additional water to flush wastes out of the pond. Water quality in Thailand is a serious problem with many water users requiring differing quantities and quality of water. Conversely, farmers in the Philippines and Honduras had fewer water quality problems.

Inputs. Aquacultural production cycle length is dependent on a variety of factors and their interactions. These include; climate, pond area, nutrient input quality and quantity, stocking density, water quality, species choice, size of stocked fingerlings, disease and mortality incidence, and size of fish wanted at harvest *(32)*.

Techniques used to decrease time required to obtain market-size fish are based on the application of the principles of aquaculture. The economics of aquacultural production centers on the variable inputs. Nutrient inputs and fingerlings are the dominant variable cost items. It is the efficient and marginal combination of these inputs and the fish selling price that results in financial gain or loss.

Variable and fixed inputs for aquacultural production systems are similar in nature to those for other animal husbandry operations. Production intensity is determined by the blend, quality and quantity of inputs. Variable input items focused upon in this study include organic nutrients and chemical fertilization, fingerlings and production cycle characteristics. Discussion of variable inputs will focus on what most of the farmers practiced by size category. These production systems will be compared across and within countries.

NUTRIENTS AND FERTILIZATION

Nutrient inputs account for the largest portion of variable production costs and need to be cost effective in the locale of the tilapia producer. Combinations of organic and inorganic fertilizers make practical sense, are already known to both the farmers and the research community, and are profitable. Organic and inorganic nutrient sources can be more economical than commercial feed, but this is relative to the market prices.

Table 7.5 presents an interpolated summary of the results by farm size. More detailed presentation is made in Appendix IV. Nutrient inputs used by fish farmers ranged from kitchen waste and green manures to animal manures and supplemental diets. A variety of available on-farm nutrient sources were used by all size categories, as were purchased formulated diets.

TABLE 7.5. PREDOMINANT SOURCES OF NUTRIENT INPUTS IN THE PHILIPPINES, HONDURAS AND THAILAND, 1994.

Country and size category	Nutrient input source		
	Primary	Secondary	Tertiary
Honduras			
Small	Kitchen wastes	Commercial feed	Fresh vegetation
Medium	Commercial feed	Rice bran	Inorganic N
Large	Commercial feed	Rice bran	Fresh vegetation
Philippines			
Small	Rice bran	Inorganic N	Chicken manure
Medium	Inorganic N	Rice bran	Chicken manure
Large	Commercial feed	Rice bran	Chicken manure
Thailand			
Small	Commercial feed	Fresh vegetation	Kitchen wastes
Medium	Inorganic N	Rice bran	Chicken manure
Large	Rice bran	Inorganic N	Chicken manure

In the Philippines and Honduras, the use of purchased commercial feeds markedly increased with pond area. The opposite was true for the Thai farms, Appendix IV. This may be explained by the increased usage or substitution of chicken manure and inorganic fertilizers by the medium and large Thai farms in lieu of commercial feeds. Chicken manure is understood to be the combination of manure and the substrate used to absorb moisture in the floor of chicken houses — wood shavings, straw, or other materials.

Honduras respondents regularly used chicken manure as a fertilizer. Chicken manure was increasingly used in the Philippines and Thailand as farm size increased. Purchased nutrient inputs included fish feeds, rice bran, rabbit pellets and chicken feed, Appendix V. Fish feed and rice bran were most widely purchased in each country.

Commercial fertilizers were used in each country by all pond area categories, except for the small pond area in Honduras, Appendix IV. Urea was used by all size categories in each country, Appendix V. Triple superphosphate (TSP) and diammonium phosphate (DAP) were used in Thailand, Honduras, and the Philippines, respectively.

Integrated animal and fish systems place animal enclosures next to or over the fish pond allowing wastes to directly enter the fish pond. Poultry, hog and ducks were the primary animals used in integrated systems, Appendix VI. In the Philippines, animal-fish integration was also important with 28 - 57% of all farms using this system. A greater variety of animal manures was used in the Philippines than in Thailand or Honduras. Fresh animal manures were least used in Honduras. Nearly all farmers in Thailand relied on integrated animal-fish systems in their tilapia operations. Thai farmers preferred ducks and poultry in their integrated systems.

FINGERLINGS

Farm size differences in fingerling size, stocking rate, sex ratio and use of predator species in tilapia production are portrayed in Table 7.6. Monosex male tilapia fingerlings were used by most farmers in each country no matter the pond area. The marked advantages to raising all-male tilapia, i.e., faster growth and no reproduction, has lead producers to prefer monosex fingerlings whenever they are available.

All-male tilapia populations used by sampled farmers were produced primarily through androgen sex reversal, Table 7.6. The second most common all-male production methodology was manually determining the sex ("hand sexing") of individual fish via visual observation. There was little use of hybridized tilapia reported. Androgen sex-reversal method of producing all-male tilapia populations requires some instruction, but is easily learned. Androgen-treated feeds are commonly available in Honduras, the Philippines, and Thailand.

Hybridization is difficult because pure fish strains must be kept isolated from contamination with other species and specific mating crosses must be conducted to obtain monosex populations. Hand sexing is not difficult but it is labor-intensive, error-prone, and wastes many female fish.

Stocking density and size of fingerlings are interrelated dimensions. If fingerlings are very small, farmers usually place more into the pond, expecting

TABLE 7.6. TILAPIA FINGERLINGS AND STOCKING PRACTICES IN HONDURAS, THE PHILIPPINES, AND THAILAND, 1994.

Country and size category	Fingerling size	Stocking density	Monosex Method[1]		Predator species[2]
			Primary	Secondary	
	Cm.	*No./m²*			*Pct.*
Honduras					
Small	4.0	3.5	SRT	Manual	88
Medium	3.4	2.5	SRT	Manual	100
Large	4.0	2.0	SRT	Manual	100
Philippines					
Small	2.4	3.3	SRT	None	40
Medium	2.7	4.6	SRT	Manual	15
Large	2.5	5.4	SRT	Manual	31
Thailand					
Small	2.4	8.0	SRT	None	94
Medium	2.3	5.0	SRT	None	100
Large	2.2	9.5	SRT	None	100

[1] SRT — Sex reversal technology refers to the use of the androgen, methyltestosterone, at the fry stage to direct the sex toward maleness; Manual — hand sexing the fingerlings by observing genitalia for maleness.
[2] The predominant predator species used in the Philippines and in Thailand was the snakehead (*Ophicephalus striatus*) and for Honduras it was the 'Guapote tigre' (*Cichlasoma managuense*).

higher mortality rates. Larger fingerlings are stocked at lower rates because mortality is expected to be lower. This generally holds across the study countries, Table 7.6 and Appendix VII.

In the Philippines, stocking rates increased with pond area. Monosex tilapia fingerlings were derived primarily from sex reversal but also through hand sexing. Nearly all farms stocked a predator species to control reproduction. There should not be any reproduction from monosex male populations but stocking a predator fish can be seen as an insurance measure against less than perfect sex-reversal treatments in the hatchery.

In Honduras, the stocking rates were lower than in the Philippines but larger fingerlings were used, Table 7.6. Fifty to 92% of Honduran farmers used monosex male fingerlings obtained from sex-reversal and hand sexing provided the rest. Again predator fish were stocked by almost all farmers. This may be for 'insurance' reasons, but also because the *Cichlasoma spp.* are desired fish to eat.

In Thailand, the stocking rate was much higher than in the Philippines or Honduras. Thai stocking rates were between five to ten fish per m^2, Table 7.6. Fingerling size was in the 3 cm range. Monosex male populations were derived through sex reversal exclusively and predator fish (snakehead) were stocked as insurance by almost all farmers.

The source of fingerlings is often a dilemma for aquaculturists. In many development projects, government hatcheries are established to provide fingerlings to project participants. This system usually deteriorates over time as funds for the project end, or the demand for fingerlings increases faster than the station can expand their operations (32). Ideally, private hatcheries will develop to supply the additional fingerlings required by fish farmers *(52)*.

In Thailand, 90% of the small and 100% of the medium and large pond area farmers relied on private, i.e., non-governmental, hatcheries to provide fingerlings, Figure 7.4. Ten percent of the small, four percent of the medium and 21% of large pond area Thai farmers supplied their own fingerlings.

In the Philippines, 45% of the small, 89% of the medium and 67% of the large pond area farmers relied on non-governmental sources of tilapia fingerlings, Figure 7.4. Production of one's own fingerlings or obtaining fingerlings from a neighbor accounted for 12% of the small pond area farmers, 55% of the medium and 17% of large pond area farmers.

In Honduras, for all farm sizes, well over half the farmers relied on government hatcheries or research stations for their fingerling needs, Figure 7.4 In the short-run, these farmers have access to subsidized tilapia fingerlings. Long-run dependence may curtail expansion. On the other hand, six to 20% of the farmers produced their own fingerlings, which is a promising sign for the future development of tilapia culture.

Interestingly, 10 to 35% of the fingerlings came from research stations, showing their importance in this fledgling industry in Honduras. It also suggest that more effort is devoted to providing producer services at Honduras research stations than to the conduct of research. No such fingerling reliance from research stations was found in Thailand or in the Philippines.

In the Philippines, 22 to 44% of the farmers interviewed had problems obtaining fingerlings during the rainy season. In Honduras, 19 to 25% of the farmers

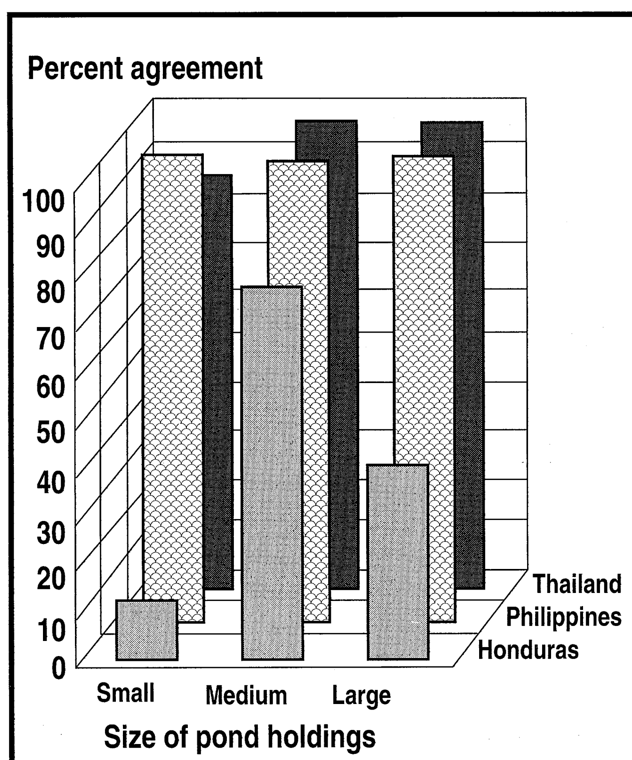

Figure 7.4. Percent obtaining Tilapia fingerlings from nogovernmental sources by pond holding, size, and country, Tilapia farmers, 1994-95.

had similar difficulties in obtaining fingerlings. However, the Thai small and medium-size farms had no problems and only 11% of the large farmers experienced any problems obtaining tilapia. Thailand's private fingerling business seemed to meet farmer demand.

PRODUCTION CYCLE CHARACTERISTICS

Farm size differences in length of the tilapia production cycle, harvesting strategies and size of final product are shown in Table 7.7, Appendix VIII and Appendix IX. The dimension are indicators of production cycle characteristics and market demand. Production cycles were the shortest in the Philippines, ranging from 139 to 149 days. Two crops per year were usually produced. However, the fish produced were smaller than in the other two countries, ranging from 173 to 199 grams.

Producing many small fish is ideal for the farmer, if the consumer will accept a small product, because it is much more efficient to produce large numbers of small fish than it is to produce the same number of larger fish. One large harvest accomplished by draining the pond at the end of the culture period was the most frequently used approach. Honduran farmers had production cycles ranging from 194 to 263 days and one to two crops per year, Table 7.7. The average fish produced ranged from 274 to 570 grams. In this country, partial harvesting along with one large harvest and one harvest only were used.

Thailand had the longest production cycle of the three countries. It ranged from 307 to 358 days, Table 7.7. The longer cycles resulted in larger fish for the small and large farms. Middle-sized farms had intermediate values when culture period and fish size are compared. Less partial harvesting was used in Thailand and one large harvest at the end of the production cycle was preferred, primarily because larger fish bring a better price and are more easily sold.

MARKET CONSTRAINTS

Operators of different size farms have qualitatively different sets of marketing problems due to basic differences in the volume of fish that each is endeavoring to sell. Identifying the market in which the cultured tilapia are to be sold is an essential element in determining production-marketing viability. An understanding of the product characteristics and consumer preferences associated with the selected market is fundamental in developing the appropriate production technology.

Where aquaculture is a new enterprise, there may be no existing marketing infrastructure. Development of marketing infrastructure for aquacultural inputs and outputs will often be as important as soil, water, climate, and nutrients to the economic viability of aquaculture.

Small-scale farmers who consume most of their fish harvest or sell it locally have a lesser need for extensive marketing information. The farmer may be personally acquainted with most of the final consumers of his product. However, as the percent of home consumption of fish decreases and distance to final consumer increases marketing channels become more important. Specific information on consumer and product characteristics will be crucial to expanding markets and maintaining a favorable price.

Sixty percent of the Rwanda farmers did not sell any fish from their last harvest. In the small and medium categories, Honduran respondents kept higher percentages of their harvested fish for home consumption, 20% and 12% respectively, than in the Philippines or Thailand, Appendix X. The percentage of farmers keeping some tilapia for home consumption

TABLE 7.7. TILAPIA PRODUCTION CYCLE INFORMATION BY POND AREA IN HONDURAS, THE PHILIPPINES, AND THAILAND, 1994.

Country size and category	Days to harvest	Crops per year	Average fish size	Harvest strategy[1]
	No.	*No.*	*Grams*	
Honduras				
Small	194	2	274	Single
Medium	263	1	275	Single
Large	235	1	570	Partial
Philippines				
Small	145	2	173	Partial
Medium	149	2	199	Partial
Large	139	2	179	Partial
Thailand				
Small	307	1	328	Single
Medium	346	1	301	Single
Large	358	1	411	Single

[1] Harvesting strategies: Partial — partial; and Single — one large harvest at the end of the cycle. In Appendix VII, another category, Partial + 1 - partial and one large harvest at end of the cycle was not a frequently used strategy and is therefore not mentioned in this table.

decreased as pond area increased indicating that increased pond area was associated with increased entry into the cash market economy.

In the Philippines, small pond operators did not sell all their fish and kept some for home consumption. Medium and large pond owners sold 100% of their harvests. No Thai respondents, at any pond area, kept fish for home consumption; all were sold.

Rwanda farmers sold fish to other buyers — teachers, civil servants, and others making direct purchases; family members also sold fish in the marketplace. Thailand, Philippine and Honduran fish were sold mainly to intermediaries, other buyers, restaurants and by family members in the marketplace, Appendix X.

Between 5 and 19% of the Philippine farmers were able to sell their fish to restaurants and 13 to 47% of the Honduran farmers sold fish to restaurants and only a few Thai farmers sold tilapia to restaurants. The Honduran percentages are much higher than in any other country. Few Thai or Honduran farmers personally sold any fish in the marketplace.

RELATIVE PRICES OF FISH

Prices received for tilapia are related to the final size of the fish, consumer size preference and available market outlets. In this study, the prices for tilapia were lowest in Thailand and comparable in the Philippines and Honduras, Table 7.8.

Consumers in the Philippines paid prices ranging from $0.97 to $2.34 per kilogram of tilapia; one kilogram of fish being equivalent to 5-6 fish. In comparison, the price for fish in Honduras ranged from $0.68 to $1.65 per kilogram of fish; one kilogram of fish being equivalent to three fish. Honduran consumers preferred a larger fish than the consumer in the Philippines.

In Thailand, tilapia prices were much lower than in the Philippines or Honduras. Tilapia prices ranged from $0.12 to $0.99 per kilogram of fish. One kilogram of tilapia is one to three fish. Tilapia in Thailand are ubiquitous and supply is abundant which may account for the low price range. Additionally, the sale of tilapia to middlemen who harvest the fish results in lower prices as the cost of labor to harvest is subtracted from the tilapia purchase price.

Prices received by Honduran tilapia farmers had the most variation. The predominant tilapia size harvested in Honduras was in the 200 to 300 gram range for producers with small and medium-area ponds and greater than 500 grams for larger farms. Some low-intensity, rural farmers had little opportunity for marketing their fish and the prices they obtained were low. On the other hand, large pond farmers produced bigger fish (larger than 500 grams) that tend to command premium prices.

TECHNOLOGICAL CHANGE AND AQUACULTURAL DEVELOPMENT

Economic advantages are found in efficient use of production ideas. From the data available here, some general conclusions about what technologies will be used in the future become clear. Farmers with small, medium and large tilapia ponds in the three PD/A CRSP countries are likely to use all-male tilapia populations. Sex-reversal using androgens was the method of choice.

The use of commercial fish feeds in tilapia culture may be prohibitively expensive in some cases. In rural areas where distribution is difficult, it is not likely that feeds will be used. Additionally, feed mills operating in a monopoly environment may have prices too high for semi-intensive fish farmers. On the other hand, when fish are grown for export and specialty markets, the farm will be able to economically use commercial tilapia feeds.

TABLE 7.8. AVERAGE AND RANGE OF PRICES RECEIVED FOR TILAPIA IN HONDURAS, THE PHILIPPINES, AND THAILAND, 1993-1994

Country and size category	Average price received for tilapia	Range of prices received for tilapia
	$/kg	*$/kg*
Honduras		
Small	1.25	0.68 - 1.94
Medium	1.23	0.84 - 1.94
Large	1.28	0.84 - 1.65
Philippines		
Small	1.70	0.97 - 2.34
Medium	1.86	1.27 - 2.34
Large	1.80	1.50 - 2.06
Thailand		
Small	0.45	0.22 - 0.99
Medium	0.42	0.12 - 0.60
Large	0.51	0.32 - 0.68

Marketing tilapia varied from primarily home consumption to widely distributed markets. Marketing channels for these farmers were not investigated fully. Much more can be done to improve these channels not only for fish distribution but also for production inputs to the farmers.

Dissemination of information about tilapia production systems and innovations is being carried out to varying degrees in the study countries. In Honduras, there was an increasing knowledge of the PD/A CRSP project with an increase in the pond area. Predominantly, there was not much extension visitation to the tilapia farmers interviewed in Honduras. However, there did seem to be a substantial contact between fish farmers and government fish culture extension personnel in the past.

For the small and medium pond area operators, a third had contact with government fish station staff within the last six months, while 67% of the larger pond area operators had contact during this time. About a quarter of all respondents had some contact with Zamorano University that works in fish culture.

All Honduran tilapia respondents agreed they would like more extension involvement. Approximately one quarter of the Honduran respondents felt their understanding of growing tilapia was the main thing that kept them from achieving larger harvests. Another quarter of the respondents felt not enough extension was another reason for low yields.

Twenty to 30% of the Thai respondents had contact with either Asian Institute of Technology or Kaesetsart University staff. Little contact with government fish station staff was reported for the small (10%) and medium (4%) pond area operators, while almost 40% of larger operators reported having contact within the last six months. Eighty to 90% of Thai farmers would like to have future extension assistance.

Most of Philippine respondents had prior contact with Central Luzon State University (CLSU) or Bureau of Fisheries staff. This is not surprising since the farmers were chosen and interviewed by CLSU personnel. More small pond operators had governmental fish station personnel and aquacultural extension visits than did the medium and larger pond operators. Most farmers would like increased extension assistance.

CHAPTER EIGHT
THE INSTITUTIONAL NETWORK FOR TILAPIA TECHNOLOGY IN FOUR PD/A CRSP COUNTRIES

INTRODUCTION

This chapter maps each PD/A CRSP project into the national system of public and private sector actors in each of the four countries. An institution is a cluster of roles that plays some function for society; here the focus is research, extension, and services for tilapia aquaculture. The narrative briefly identifies the historical origins of the PD/A CRSP, the institutional location of the project, the central entities active in tilapia culture in each country, and the connections between the PD/A CRSP to others working with tilapia.

Diagrams summarize the relative position of the PD/A CRSP in each nation relative to other institutional actors. In an incomplete and abstract way, the organizational charts are intended to portray the PD/A CRSP's major relationships to other sources of technology, assistance, and producer services in each nation. The major public agencies, educational institutions, nongovernmental organizations[5], and private sector actors are identified. However, the many kinds and levels of horizontal relationships among institutional and private sector entities are not portrayed.

The narrative outlines the basic functions and programs of the major centers of activity that are connected in various ways to the PD/A CRSP research program in each country. It should be noted that an exhaustive inventory of all tilapia-related projects, agencies, and firms was not possible in the bounds of the present project, particularly in a dynamic and complex environment such as Thailand.

The final section considers the various alternatives to extending research results to individuals, groups, and organizations that might use or further

[5]Nongovernmental organizations are private, nonprofit entities that are not directly funded or controlled by the nation-state. They include international agencies that provide relief and development assistance. They may be international agencies such as CARE or Heifer Project International, or indigenous organizations supported by citizens of a particular country. The latter voluntary associations usually are dedicated to assisting the poor or disadvantaged segments for humanitarian and/or religious reasons.

extend PD/A CRSP outcomes. It discusses some of the central issues pertaining to the way the PD/A CRSP is — and is not — connected to national research systems and the paths of technology and information that extend to the farm level.

RWANDA INSTITUTIONS

Rwanda began experiencing incursions from rebels based in Uganda in 1990. In April 1994, large-scale fighting broke out in the North of the country followed by widespread ethnic slaughters, mass migration, and the fall of the government. All government services and research programs are now suspended pending the formation of a new government. This section describes the institutions that functioned in Rwanda prior to the 1994 problems. What staff, equipment, and facilities remain when order is again established will emanate from the organizations and programs developed over several decades of assistance from USAID, from other donor organizations, and the Rwandan people themselves (42).

PD/A CRSP Technology Transfer Efforts. A number of formal and informal mechanisms were used to transfer PD/A CRSP technology in Rwanda. A predecessor project, the Rwanda National Fish Culture Project (1981-1992) had established an extension program that is described below. At the same time, another USAID project renovated the main station at Kigembe as well a number of satellite stations for fingerling production and distribution that became points of contact between researchers and farmers.

On the extension side, from 1983 to 1988 the PD/A CRSP researcher and her counterpart, Pelagie Nyirahabimana, trained most of the extensionists, creating a well-prepared cadre of individuals to work with farmers. Subsequently, she assumed the PD/A CRSP research position at the University of Rwanda's laboratories and ponds. The Rwasave site is some 14 kilometers from the research and demonstration station at Kigembe. Her 1993 successor, continued the pattern of close working relationships with Kigembe personnel and others working in fish culture in Rwanda.

At Rwasave, field days were held for area farmers and many informal consultations and farm visits were made. Marketing trials helped establish some basic parameters about consumer preferences in the surrounding area. PD/A CRSP personnel often provided consultation about extension training and technology development trials at the Kigembe research station. Unfortunately, budget cuts and an extension reorganization led the nearly 60 specialized aquaculture extension monitors to fall under the supervision of the general agricultural extension organization. Without ties to field staff PD/A CRSP researchers and Kigembe managers had to rely on informal contact and periodic group meetings to convey research results to a dwindling number of monitors.

In sum, PD/A CRSP technology transfer in Rwanda was facilitated by good working relations among the small group of researchers and extension managers working in fish culture. Word-of-mouth remains the primary mechanism for technology transfer in Rwanda. The lapse of support for extension personnel and governmental reorganization increased the PD/A CRSP researchers' distance from fish culture monitors, but the burgeoning interest in fish culture continued to propel growth in the number of ponds and amount of fish produced. Until the ethnic conflicts are resolved, progress in fish culture remains in doubt.

Rwanda Fish Culture Service. This unit of the Ministry of Agriculture, centered at Kigembe, was the collaboration point for a USAID aquaculture project. After the ten years of assistance, a government reorganization shifted supervision of fish culture extension workers to the general extension effort. A number of satellite facilities were then closed or privatized following a longstanding PD/A CRSP staff recommendation. Nonetheless, the Service was permanently established as part of the national program.

Led by Nathanael Hishamunda, the Kigembe station became a national demonstration center for integrated aquaculture. Extension training and farmer training was conducted on a regular basis. Figure 8.1 outlines the major entities involved in aquaculture in Rwanda.

The main station at Kigembe is complemented by a network of more than 10 stations located throughout the country. The main functions intended for the outlying stations were fingerling supply and demonstration of good practice, including integrated animal-aquaculture systems. Consisting of a few ponds, a small building, and concrete holding tanks, the stations often served as a meeting point for farmers and extensionists. Each was staffed by a manager and a few

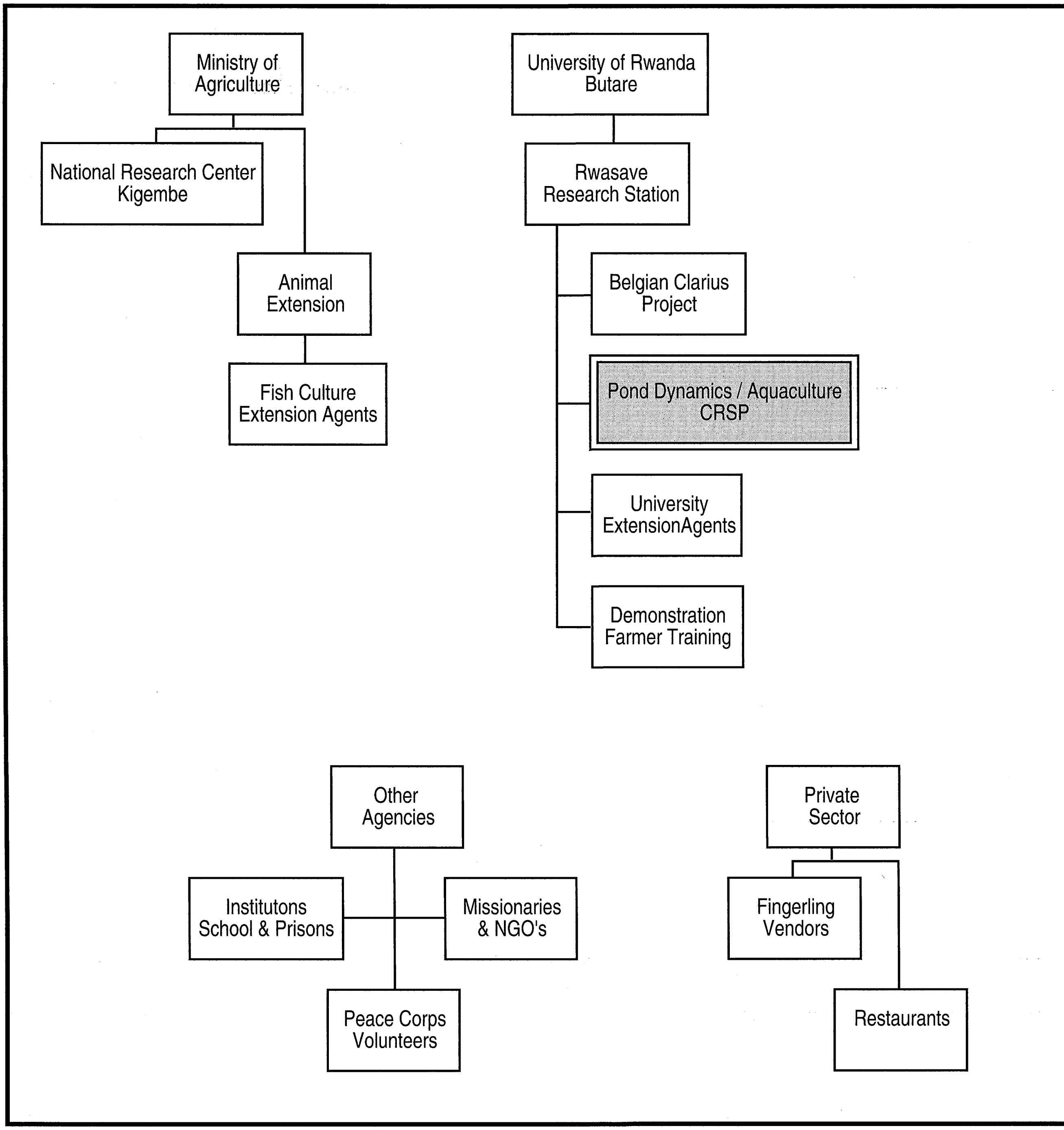

Figure 8.1. Institutional network for Tilapia technology in Rwanda.

laborers. In recent years, some stations were decommissioned or redeployed due to budgetary constraints.

University of Rwanda. The university provides a degree program and other training in aquaculture through the Rwasave station facility adjacent to the Butare campus. The station had been established by the Ministry of Agriculture, but was given to the University for the PD/A CRSP activity. Although a branch of the University is located in Ruhengari, no other institutions or government agencies have aquaculture staff or research programs. The PD/A CRSP project was located at this facility, collaborating with University staff and other scientists associated with a Belgium-supported aquaculture research and development effort.

PD/A CRSP technology informed the conduct of activities in the National Fish Culture Service through established working relationships among staff members at the Rwasave and Kigembe stations. Training programs frequently were joint efforts and many of the extension personnel are graduates of training programs conducted at the two facilities.

Nongovernmental Organizations. As many as 20 nongovernmental organizations (NGOs) — religious missionaries, humanitarian agencies, and other — have some aspect of fish culture as part of their program of activities in Rwanda. There is a great deal of variability in the level and consistency of technical assistance rendered to farmers by the NGOs.

PD/A CRSP staff have proved training seminars, written materials, and various other kinds of informal help to some of these groups. Recent conflicts, large-scale migrations, and other disruptions have shifted the development community's attention to basic issues of safety and survival of human populations. As of this writing, the ethnic unrest characterizing the 1993-96 period has put much of the progress made in fish culture in doubt.

HONDURAS INSTITUTIONS

Honduras has a complex set of governmental, nongovernmental, and private sector actors doing research or providing services for tilapia producers. Multiple segments of the Honduran government have aquacultural programs. PD/A CRSP began work with Ministry of Natural Resources' El Carao National Fish Culture Research Center at Comayagua in 1983.

Since that time, research has been conducted on fish stocking rates, and on the use of inorganic and organic fertilizer, formulated diets, and combinations of fertilizers and formulated diets for production of tilapia. The goal of this work has been to increase fish production and profitability among by small- and medium-scale commercial producers based on a technology that relies heavily on enhancement of natural pond productivity using locally available nutrient inputs.

PD/A CRSP Technology Transfer Efforts.[6] PD/A CRSP research results have been disseminated at local, regional and international scientific meetings, in regular lectures at local vocational-agricultural schools, at technology-transfer days at El Carao, through formulation of pond management plans for producers who buy fingerlings at El Carao, and in scientific publications. Testing of these production systems under on-farm conditions would validate research findings and the PD/A CRSP Pond Management Guidelines, and serve as a teaching tool for extensionists and producers.

Another program of technology transfer, the USAID/Honduras and Ministry of Natural Resources Land Use and Productivity Enhancement (LUPE) program, expressed interest in collaborating with PD/A CRSP in order to promote aquacultural development as part of its overall effort. The LUPE program worked with hillside farmers in the southern and central regions of Honduras to promote watershed conservation and sustainable agriculture. Population pressures on the environment are a serious concern in Honduras *(62)*. Many of the farmers that participated in the LUPE project had few resources such as fertilizers available to them; use of compost as a fish pond nutrient input, as developed in the Rwanda PD/A CRSP, could be tested in these hillside ponds.

In early 1991, the Honduran PD/A CRSP principal investigator, Marco Ivan Rodriguez, developed a program that linked producers in the northern and central regions of Honduras to El Carao. These small- to medium-scale commercial producers were interested in maximizing their profitability by refining their production technology. This group of farmers participated in the field trials of PD/A CRSP production systems developed in Honduras.

Peace Corps/Honduras had an on-going fish culture project, which placed Peace Corps volunteers (PCVs) primarily with MNR. The agency's plan for 1991 to 1998 was to improve the economic and nutritional status of the resource-limited rural population in Honduras through fish culture. Peace Corps managers wanted PCVs, where ever possible, to test PD/A CRSP fish production systems on farms where assistance was provided. Participation in such trials, however, depended solely on farmer interest and resources.

The Honduras PD/A CRSP developed a program to conduct on-farm trials with resource-limited and small- and medium-scale commercial fish farmers in the southern, central and northern regions of Honduras. In April 1991, the PD/A CRSP board approved the project and project implementation began in May 1991.

[6]This section is largely adapted from Teichert-Coddington, Green, Rodriguez, Gomez, and Lopez (1992).

The two components of this project were on-farm trials and short courses in aquaculture for extensionists and farmers that participated in the trials. An initial short course would be given before beginning farm trials. A second seminar would be given upon completion of trials to summarize and discuss trial results. Honduran PD/A CRSP personnel were responsible for identification and selection of small- and medium-scale commercial fish farmers to participate in the on-farm trials managed out of El Carao. Participant farmers were required to have two ponds for use in trials to allow two production systems to be compared.

Each prospective farmer was interviewed prior to selection; upon selection, the farmer and a PD/A CRSP representative would sign a contract that stipulated the responsibilities of each party during the on-farm trials. MNR extension personnel associated with PD/A CRSP would make monthly visits to participant farmers to collect data, water samples and to provide technical assistance as necessary.

In mid-1991 the DIGEPESCA and LUPE directors met to discuss the implementation of on-farm trials of fish culture systems that would be appropriate for LUPE-assisted farmers. Both Directors agreed that such a program would be beneficial. LUPE extension personnel selected by the LUPE project director to implement on-farm trials were responsible for the initial selection of candidate farmers.

Only one pond per farm would be used for trials. Candidate farmers were then interviewed and briefed by Honduran PD/A CRSP personnel as to farmers' responsibilities during the on-farm trials, however, no contract between the farmer and LUPE was signed. LUPE extension personnel did not require participant farmers to sign a contract. However, LUPE extension personnel were responsible for supervising data collection and providing technical assistance to participant farmers. A Honduran PD/A CRSP aquaculture specialist was assigned to accompany participating LUPE extension agents on farm visits at least once a month. During each visit, the PD/A CRSP aquaculture specialist would collect data, water samples and provide technical assistance as necessary. LUPE was responsible for transporting the aquaculture specialist from their Tegucigalpa headquarters to the field sites.

Peace Corps/Honduras was only collaterally involved in testing PD/A CRSP production systems on farm. PCVs were responsible for collecting production data at each of their sites, but they were not obligated to test PD/A CRSP fish production systems. In practice, greatly different situations made it difficult to standardize inputs and management systems.

The results of the on-farm trials with the small- and medium-scale tilapia farmers demonstrated that the PD/A CRSP production systems were more productive than the traditional tilapia production system used in Honduras. The limited enterprise budget analysis indicated that both PD/A CRSP systems resulted in significant income above variable costs, an indicator of the economic viability of the systems. It should be noted that the PD/A CRSP production systems tested in this trial were not developed for subsistence fish farmers, but rather for small-to-medium-scale commercial fish farmers who have the capability to purchase the necessary factors of production. It is this group of fish farmers whom the researchers felt will have the greatest impact on freshwater aquaculture in Honduras.

One PD/A CRSP production system was not included in the trials for subsistence farmers — the green-matter compost system. No farmer felt sufficiently resource-limited to test the compost system that was developed by the Rwanda PD/A CRSP. The researcher observed that there were sufficient nutrient resources available — manure in fields, agricultural by-products, and termite nests, etc. — that farmers did not feel compelled to use compost.

The researchers remarked that any production system is only as good as the farmer who implements such a system. Farmers who complied with the workplan, i.e., were good managers or farmers, obtained consistently high yields that approximated those attained on the experiment station. Non- or variably-compliant farmers obtained proportionally lower yields. This observation applies equally to farmers associated with the on-farm trials.

To develop and implement an on-farm testing program is an ambitious endeavor. The on-farm trials were the first such activity undertaken as part of the Honduras PD/A CRSP, and a few lessons were learned. Participants from all of the sectors active in fish culture in Honduras were sought. As such, the on-farm trial activities were dispersed country-wide. However, this involved interaction with a number of agencies other than the PD/A CRSP host-country counterpart, and effectively limited staff control over the trials.

Cooperating agencies always expressed interest and commitment to the trials, but since the trials, and sometimes aquaculture, were not specific objectives in the agencies' annual workplans, field-level execution of the trials often suffered. It is important that the researchers have direct input into the execution of the field trials to ensure that the protocol is adhered to and that proper, complete data is collected. These shortcomings must be rectified if future on-farm trials are to be conducted in collaboration with other agencies in Honduras.

The trials conducted directly by El Carao and PD/A CRSP personnel also involved farmers located in diverse geographic regions of Honduras. As a result, much time and expense were expended on travel; time spent on travel was time not available to work directly with participant farmers. Future trials should be limited to one to two geographic zones, e.g., the Comayagua Valley, at a time, which would allow greater contact with the farmers of each zone and a more efficient transfer of technology. Subsequent trials would then be conducted in a different geographic zone. Thus the beginnings of a technology transfer program met institutional resource limitations that must be understood before subsequent efforts are undertaken. Figure 8.2 diagrams the network of organizations and agencies working in Honduran aquaculture.

Dirección General de Pesca y Acuicultura (DIGEPESCA). DIGEPESCA is a division of the Ministry of Natural Resources. Although efforts to change traditional practices are underway, the system of political patrimony in Honduras has caused DIGEPESCA to change directors, on the average, at least once a year. Thus continuity of leadership in a central government agency has presented a problem for aquaculture in Honduras.

DIGEPESCA works with many other organizations to promote aquaculture. For example, a seminar concerning the nutrition of aquatic organisms (shrimp and fish) took place in the town of San Lorenzo, department of Choluteca in September 1993. It was organized by DIGEPESCA, but was not widely publicized. Some of DIGEPESCA employees have traveled to Costa Rica, sponsored by FAO, to attend seminars on fish nutrition and processing techniques.

Centro Nacional de Investigación Pisicola. Built in 1980, and located in the department of Comayagua, the El Carao station is the main supplier of fingerlings in the country. El Carao, managed by the Dirección General de Pesca y Acuicultura (DIGEPESCA), produces fingerlings of red tilapia, black tilapia, common carp, grass carp, silver carp, tambaquí and guapote tigre. The PD/A CRSP tilapia research program is based at this station.

El Carao has 41 ponds with an area of 52,300 m^2 of water surface. In 1992 they reported production of about 3 million sex-reversed tilapia fingerlings (nilotica and red). El Carao gave technical assistance to 271 producers from 15 different departments. According to their data they stocked about 338 ponds for a total of 472,000 m^2 of water surface.

During 1992, the staff taught four short courses and produced, together with PD/ACRSP help, a document "Divulgacion del Documento Sobre Enlace Tecnologico". They collaborate with three schools from the area to allow students to do their practical internships at the station. El Carao has ties with the Chinese Mission, USAID, Asociación Nacional de Acuacultores Hondureños (ANDAH), Federación de Productores y Exportadores (FPX) and Federación Hondureña de Inversionistas Agricolas (FHIA).

Estación Pisicola del Instituto Nacional Agrario. The fish station of the National Agrarian Institute (INA), Rio Hondo is located in the community of Santa Barbara, The station was built in 1986 in conjunction with the Tilapia Food Aid Organization, a project involving the Belgian and Honduran governments. This 19,000 m^2 fish station, designed to produced about 500,000 fingerlings per year, has 25 ponds. It also has a wet laboratory with circular tanks for carp reproduction, a building with rooms for offices, board and classes, and a staff of 12 employees.

The Rio Hondo station sells fingerlings at a subsidized price (tilapia nilotica and red tilapia), but INA is not interested in this station and has attempted to privatize it. The Chinese Technical Mission has expressed interest in a joint venture with INA to run this station. Since INA only works with farmer groups, it seemed that the station might be given to the Union Nacional de Campesinos (National Farmers Union), but was instead given to DIGEPESCA.

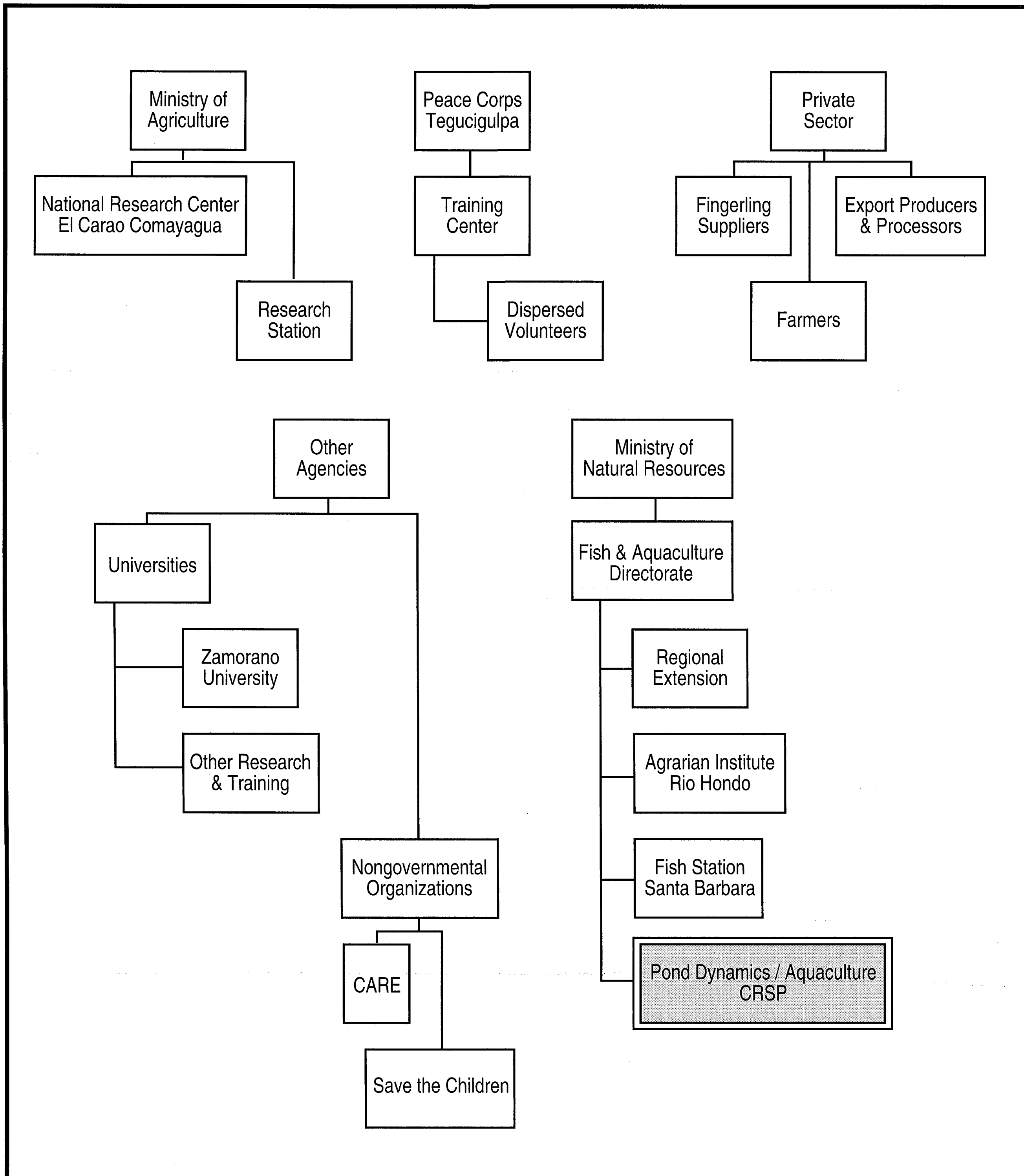

Figure 8.2. Institutional Networks for Tilapia technology in Honduras.

Fish Sub-Station Santa Barbara. A fish station is managed by DIGEPESCA and located in the department of Santa Barbara. It consists of eight small ponds of about 200 m^2 each for a total of 1,800 m^2 of water surface. The species cultured are tilapia nilotica, red tilapia, common and silver carp and tambaquí. They do not reproduce their own fingerlings but receive fingerlings from El Carao fish station to be distributed to fish producers of the area — both stations are managed by DIGEPESCA.

The station is staffed by an Engineer Agronomist, DIGEPESCA's extension agent for the area, and two guard/laborers. The lack of budget, management and facilities makes this station less useful. The Rio Hondo, Santa Barbara fish station is only 15-20 minutes drive from this station and has far more potential; neither one is reported to be functioning well.

Panamerican Agricultural School. Escuela Agricola Panamericana El Zamorano was established in 1942 by Mobile, Alabama banana magnate Sam Zemurray. Since 1987 it has graduated Engineer degrees in Agronomy. The Agronomy degree is a three year degree and the Engineer in Agronomy is a four year degree. Known as Zamorano for the hacienda that previously owned the land, the school has eight Departments; Dr. Daniel Meyer is head of the Biology Department and teaches the course of Aquaculture.

The aquaculture program has worked since 1976 with the main objective of training students in the fundamentals of aquaculture. They attempt to teach students the different levels of aquaculture from extensive to intensive. Many Zamorano graduates are working with the shrimp industry, but just a few work in the tilapia industry.

The Zamorano aquaculture unit has several earthen ponds — not uniform and enough to do research — and eight concrete tanks to do tilapia sex-reversal. They also conduct integrated farming with swine and duck enclosures next to ponds. They annually produce about 100,000 sex-reversed tilapia fingerlings; 60,000 for their own needs and the rest to sell to area farmers. El Zamorano is the only educational institution doing tilapia sex-reversal in Honduras. They supply fingerlings to farmers in the departments of Olancho and Francisco Morazan.

Universidad Nacional Autonoma de Honduras (UNAH). Located in Tegucigalpa, the Universidad Nacional Autonoma de Honduras (UNAH) teaches and conducts limited research in aquaculture through their biology department. They have a staff of five instructors in various ways related to aquaculture. Students take field trips to El Zamorano university, El Carao government station, Rio Hondo government station (Instituto Nacional Agrario, INA), and private shrimp farms. UNAH makes educational exchanges with the Centro Universitario Regional del Litoral Atlantico (CURLA) which is a regional annex of UNAH. The UNAH does not fish ponds or laboratories to teach or to do research in fish culture.

The Universidad Pedagógica Nacional, which is also an autonomous university, is planning to begin teaching some tilapia culture. Teachers of primary and secondary schools will be trained in the basics of fish culture. Teachers can then provide instruction in fish culture in the schools, particularly in rural areas.

Escuela Nacional Agricola. The Escuela Nacional Agricola (ENA) is located in the town of Catacamas, department of Olancho. Managed by the Ministry of Natural Resources (Ministerio de Recursos Naturales) as a semi-autonomous institution, the 250 students school offers a three-year Agronomy degree. A fish culture course is taught for third-year students. Students taking this course must do 20 to 30 hours of theory and 45 to 50 hours of field practice.

ENA fish culture facility has 26 ponds that are used for education, training, and to produce food for their students; they are not used for research. They have the facilities to do tilapia sex-reversal, but it is not being done due to lack of resources. A teacher and a guard/helper are the only two persons involved with the ENA fish program. ENA has ties with the Ministry of Natural Resources, the Japanese Mission, the Canadian International Development Association (CIDA), the European Community (EC) and Partners of the Americas through their Farmer to Farmer program.

The Organización Latino Americana para el Desarrollo de la Pesca (OLDEPESCA — Latin American Organization for Fisheries Development) has a branch for Central America called PRADEPESCA (Proyecto Regional de Apoyo al Desarrollo de la Pesca en Centro America). With EC money they started the construction of a 14 pond research unit in Catacamas; about five minutes drive from the ENA campus.

The Centro Piloto Demostrativo Agricola (Demonstrative Research Unit) "EL Espino" is a collaborative venture between ENA (Ministry of Natural Resource) and PRADEPESCA. The integrated research unit has facilities necessary to do research with swine, poultry, cattle, rice and fish.

With this station ENA will be able to do research, train students, as well as generate and transfer technology. The station was managed by PRADEPESCA during the first year and then by ENA. This research unit should be a very important step in the future of the Honduran fish industry, especially in integrated fish culture.

John F. Kennedy School. Escuela de Agricultura John F. Kennedy is located in the town of San Francisco, department of Atlantida. It belongs to the Ministry of Public Education and graduates Agronomists after three years of studying. At present they have about 100 students although the school has capacity for about 350 students. The 17 fish ponds have 12,200 m^2 of water surface. A severe shortage of operating funds retards the operation of this facility.

Luis Landa School. The Luis Landa School is located in the small valley town of Nacpome, close to Choluteca. It offers a bachelor's degree in fisheries.

United Nations Food and Agricultural Organization. The Food and Agricultural Organization (FAO) has supported the tilapia industry in Honduras since 1985 with the construction of the Santa Barbara station at Rio Hondo. Through FAO, the "Red Nacional de Acuicultura" (National Aquaculture Network) was created in 1992. This network integrates international institutions and the private and public sector of Honduras. This network was in place for about a year but it does not now operate; apparently due to political reasons. At first FAO acted as a promoter and then as facilitator so that the network could be managed by local individuals or organizations.

PHILIPPINE INSTITUTIONS

The institutional system for technology development in the Philippines is characterized by multiple organizations with little national coordination or exchange of materials. The PD/A CRSP is located in the heart of the central tilapia producing region of the country at the leading governmental and university center for aquaculture research. Figure 8.4 profiles the institutional system working in aquaculture in the Philippines.

A small set of powerful industrial firms play a significant role in the expansion of the industry toward export markets, although current tilapia production is almost entirely consumed internally. The national devolution of extension services to provincial governments has virtually eliminated public extension services to farmers. Feed company sales representatives remain the main source of one-to-one farm visits for technical assistance for fish culture in most areas of the country.

PD/A CRSP Technology Transfer Efforts. The PD/A CRSP project has only recently returned to the Philippines after a several year hiatus. It is the only site without an expatriate scientist located in the country. Experienced Philippine scientists in the Freshwater Aquaculture Center (FAC) at Central Luzon State University (CLSU) on Central Luzon Island collaborate with the PD/A CRSP researcher from the University of Hawaii. Periodic visits are made to coordinate activities. Significant institutional resources are located on the CLSU campus; the headquarters for the national aquaculture extension staff, a provincial hatchery and fingerling distribution center, and the Freshwater Aquaculture Center.

PD/A CRSP technology in the Philippines is complemented by two genetics projects located at CLSU. These efforts promise to deliver significant benefits to tilapia farmers. The GMIT project will provide an alternative to conventional sex-reversal seed stock production using super-female broodstock to produce predominantly male fingerlings. PD/A CRSP production strategies complement the efficiency gains and possible marketing advantage of this technology.

The GIFT project has initiated a comprehensive breeding program to identify superior tilapia genetic stock and to disseminate it to hatcheries in the Philippines and other countries. PD/A CRSP production technology also complements the breeding improvements this effort has made.

The proximity to other research projects and outreach activities is a major technology transfer mechanism for the PD/A CRSP. The circumstances encourage the synergism of PD/A CRSP findings with other research work on genetics to directly contribute to an ongoing dialogue with producers, hatcheries, and feed companies over the development of the aquaculture industry in the Philippines.

Large-scale corporate interest in tilapia production is high, given the high relative price for the fish and the broad base of consumer acceptance and regular consumption of tilapia. Feed companies promote tilapia production primarily to increase the demand for feed products.

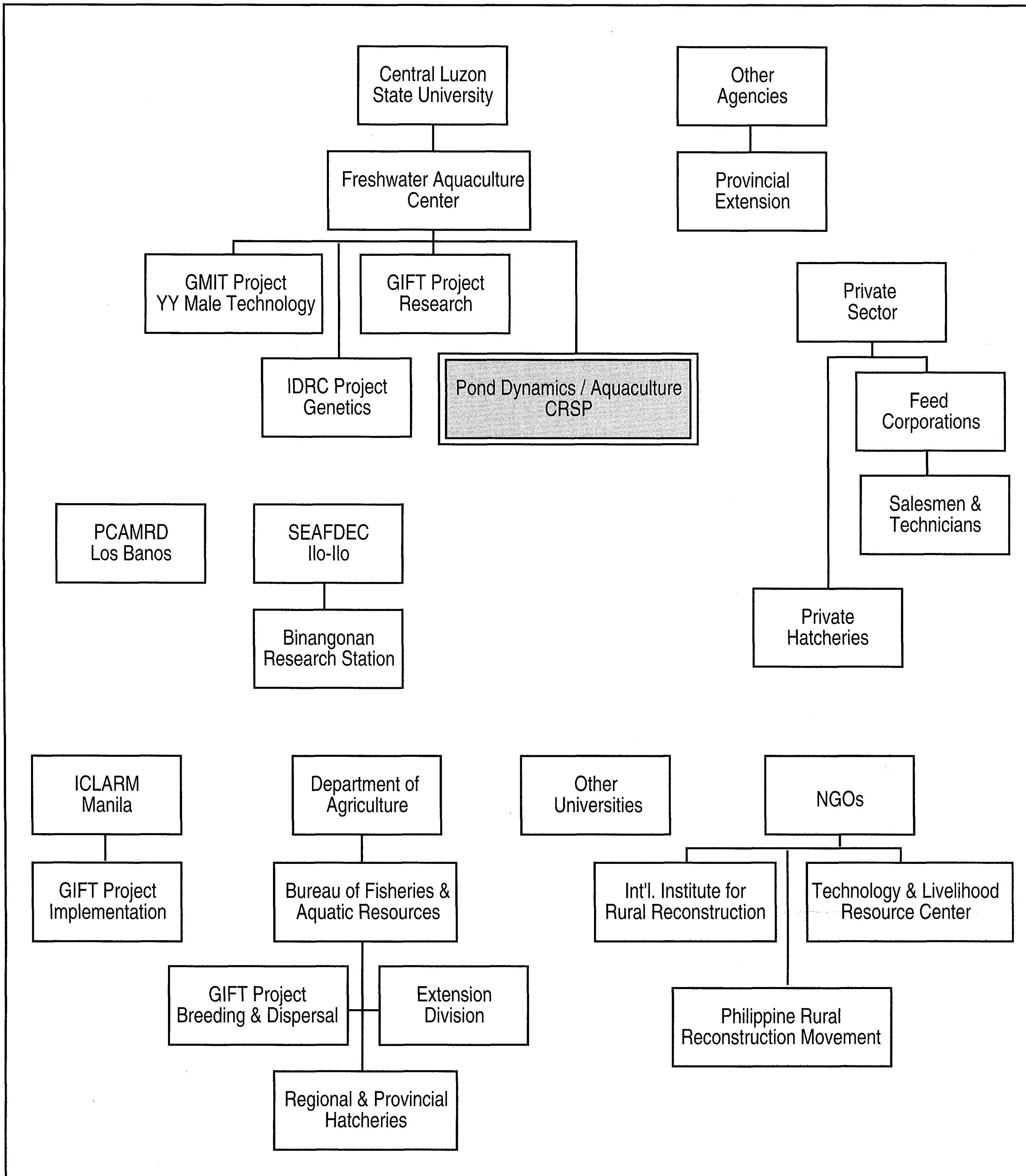

Figure 8.3. Institutional networks for Tilapia technology in the Philippines.

PD/A CRSP research results suggest that full-cycle feeding of tilapia may not be an optimal production strategy; rather that pond fertilization complemented by later stage fish feeding may produce optimum economic benefits for farmers. Unfortunately, the only regular on-farm contacts to tilapia producers are being made by feed company technicians; nearly all printed technical material available to farmers emanates from feed producers.

Freshwater Aquaculture Center. The Freshwater Aquaculture Center (FAC) is a semi-autonomous unit of the university, functionally serving as a research division parallel to the CLSU College of Fisheries. The Dean of the College is presently serving as the director of the Freshwater Aquaculture Center (FAC). The FAC staff have joint appointments to the College, they teach courses, and they direct graduate study. The FAC has a national mandate to conduct freshwater aquaculture research on inland fishes.

In addition to the PD/A CRSP, FAC has collaborative projects with ICLARM and the GIFT project, the International Foundation for Science on waste recycling, International Development Research Center (Canada) on fish genetics, Overseas Development Authority (UK) on fish genetics, and a joint ODA-Thai Government project on fish health. In addition, the Philippine government sponsors projects on catfish reproduction, catfish triploid, and karyotyping.

Bureau of Fisheries and Aquatic Resources (BFAR). A national division of the Philippine Department of Agriculture, BFAR maintains a research unit on the CLSU campus that is supported by ODA and ICLARM funds. In Muñoz, the BFAR-NFFTRC (National Freshwater Fisheries Technology Research Center) is staffed by more than 30 professional staff. Educational programs primarily are directed to fish farmers through the Center and the satellite stations.

The CLSU facility is a national breeding center for freshwater fishes, supplying tilapia fingerlings to area farmers. Satellite stations in each of 13 regions of the Philippines also produce fingerlings and advise farmers. At the CLSU main station, all-day farmer training programs are offered each Wednesday. BFAR is the lead agency for the dissemination of the GIFT fish in the Philippines.

The primary relationship of BFAR to the PD/A CRSP project is one as a consumer of PD/A CRSP research results. The strong informal network connecting BFAR and FAC allows frequent collaboration, sharing of resources, and communication between the units. Most BFAR staff are current or former students of the CLSU College of Fisheries. The units frequently share resource persons for training programs offered at various times by each unit. The GIFT project is the primary formal mechanism of joint effort at the present.

Provincial and Municipal Extension. A recent reorganization of the national extension system has devolved most extension responsibilities to the provincial and municipal level. Many of these individuals formerly worked for the national service. Many have been trained in aquaculture and the various provincial aquaculture programs very much depend on the backgrounds of the extension staff. In Nueva Ecija, the provincial government has established a hatchery on the CLSU campus. The function of this unit is primarily to supply fingerlings to farmers at free or subsidized prices. A BFAR staff member has been seconded to operate this unit for the province. Few other provinces have hatcheries or extension aquaculture programs. These programs have very limited and indirect connections to PD/A CRSP activities.

International Center for Living Aquatic Resource Management (ICLARM). This organization seeks to provide global leadership in aquacultural technology dissemination and development. ICLARM sponsors collaborative research through national institutions and is a major instrument for delivering donor aid for aquaculture in developing countries. Part of the CGIAR system of international agricultural research institutions, ICLARM provides funding and coordination to the tilapia research program in the Philippines in several fundamental ways. Its projects are influential and well-publicized. It also serves as a global clearinghouse for information about tilapia research and demonstration activities.

One central activity is the Genetic Improvement of Farmed Tilapias (GIFT) project. This project endeavors to bring well-documented tilapia germplasm from Africa to Asia where the species are already farmed, for establishing base populations from which genetically improved tilapia strains for farming will be developed. The effort has used eight strains to breed a faster-growing, larger fish.

The GIFT project supports counterpart projects at national institutions; FAC and BFAR in the Philippines. Other efforts supported by ICLARM have to do with information management (FISHBASE) and maintaining an extensive aquaculture library at their Manila headquarters. They have supported previous work on rice-fish culture and served as advisors for projects supported by other donors.

Philippine Council for Aquatic and Marine Research and Development. A unit of the Department of Science and Technology in the Philippine National Government, the Philippine Council for Aquatic and Marine Research and Development (PCAMRD) funds research and training at various institutions. It funds projects throughout the country, including a variety of tilapia research projects at a number of institutions. In recent years, the main topics have been on sex-reversal techniques and brackish water production. The Director, Dr. Raphael Guerroro, is a national leader in the propagation of sex-reversal technologies for tilapia fingerling production. He continues to be an influential figure in the industry.

Southeast Asian Fisheries Development Center. The Southeast Asian Fisheries Development Center (SEAFDEC) is headquartered in Ilo-Ilo in the Visayas Islands. It has one research station that conducts some tilapia research. Located in Binangonan, Rizal Province in the South of Manila, this station primarily focuses on carps, conducting only limited research on tilapia.

University of the Philippines-Los Banos. Individuals pursue aquaculture topics in fulfillment of degree requirements for biological studies in various departments. Several faculty members have tilapia research projects. One project focused on fish pond management in volcanic areas. Another small-scale agriculture project has an aquaculture component focusing on integrated agriculture-aquaculture systems on limited-resource farms.

Regional State Universities. A number of educational institutions throughout the Philippines provide course work, degree programs, practical training, and limited research efforts on tilapia. Most notable are University of the Philippines-Visayas where work and instruction pertaining to brackish water tilapia production is underway. Cagayan State University, Isabela State University, Nueva Viscaya State University, Bicol State University, Pangasinan State University, Mindanao State University, Don Mariano Marcos Memorial State University and others offer course work, some research and practical training in aquaculture, including tilapia. These units might be characterized as indirect consumers of PD/A CRSP technology. They frequently contact FAC staff for research results and publications.

These institutions may utilize PD/A CRSP research findings in teaching, research, and training programs. No systematic network has been established to communicate or link these researchers. Many have common ties to CLSU through education, training, or other experiences. This group of researchers, teachers, and trainers remains a potential audience for the results of PD/A CRSP research.

Nongovernmental Organizations. Nongovernmental Organizations (NGOs) are important conduits of technology and organization to the grassroots in rural areas of the Philippines. A diverse set of these private, nonprofit organizations utilize aquaculture as a component of their portfolio of rural development activities. What is presented here is by no means a comprehensive portrayal of NGO activity in the Philippines nor of the role of this sector in aquacultural development.

One of the more salient actors in this sector with respect to tilapia technology is the International Institute for Rural Reconstruction. Headquartered in Cavite, it has utilized CLSU staff as resources in training programs and promotes tilapia culture among small holders. Its local counterpart the Philippine Rural Reconstruction Movement is located in San Leonardo, Nueva Ecija.

Another NGO is the Technology and Livelihood Resource Center in Manila. It funds local initiatives in aquaculture and other activities and provides training. NGO's represent a relatively untapped audience for PD/A CRSP technologies, largely because their activities are so diverse and fragmented. Systematic communication with this aggregate of entities is difficult, yet they remain a significant mechanism for wholesaling technologies to local communities and producer groups in the Philippines.

Feed Corporations. The animal feed industry has correctly identified tilapia culture as a major new source of demand for their products. In the Philippines, some of the major companies include: San Miguel Corporation, Vitarich, Robina, and others. These firms promote tilapia production through their network of feed stores and technicians prepared to extend a tilapia production regime that emphasizes feeding over fertilization. Some of the firms have established hatcheries to supply fingerlings to their customers. Farmers employing feed company technologies are provided a well-organized recipe for feeding and pond management.

PD/A CRSP technologies in some ways contradict or supplement the approach extended by commercial feed producers. The corporate strategies tend to maximize feed purchases, while discounting the benefits of fertilization and natural algae production in the ponds. They are inclined to emphasize the taste of fed fish, perhaps exaggerating the risks of off-flavor associated with manuring and fertilization. The latter strategies, however, may be economically optimal for many producers even though they are not treated as options in the technology packages extended by the firms. The PD/A CRSP plays an important role as a source of balanced, comprehensive information about the actual benefits of feeding and the identification of economically optimal strategies for generating income and reducing risk in tilapia production.

Private Hatcheries. Local fingerling suppliers provide seedstock for tilapia producers who cannot readily access BFAR supplies. They also present alternatives and some level of competition to the public sector encouraging the forward evolution of quality and availability of seedstock.

Local hatcheries have difficulty establishing producer confidence in the quality and reliability of seed supplies. Hatchery operations can be very profitable, but also can undermine the progress made in tilapia culture when extensive crop failures or other problems result from hatchery misrepresentations. Some farmers prefer private hatcheries because of the proximity and the established personal relationship with the owner that increases their confidence in the transaction.

The private hatchery sector represents a largely untapped audience for PD/A CRSP technology. Private operators represent a diverse and dispersed aggregate with whom systematic communication is difficult. They do represent a set of establishments with regular contacts with large numbers of farmers. They present an opportunity to share production recommendations and fertilization strategies based on PD/A CRSP research directly to the intended target group. Given the devolution of extension responsibilities and control to the provincial government level, PD/A CRSP technology is only indirectly influencing production practices.

THAILAND INSTITUTIONS

Aquaculture is big business in Thailand. Shrimp farming is extensive and the government has a well-organized research and extension system with faculties in nearly every Thai province. Tilapia culture is widely practiced. The institutional system for aquaculture in Thailand is probably one of the strongest in Asia. Widespread indigenous knowledge and experience with aquaculture coupled with a comparatively well-developed public technical system supports a burgeoning aquaculture industry. A large and aggressive private sector complements the pervasive presence of fish culture on Thai farms.

PD/A CRSP Technology Transfer Efforts. In Thailand, the PD/A CRSP has benefitted from its institutional location at the Asian Institute of Technology that supports a formal outreach program that takes research findings to farmers in the region. PD/A CRSP staff have provided seminars and maintain consulting relationships with several large feed companies that themselves maintain field staffs that provide technical information to farmers.

PD/A CRSP technology is transferred to large-scale private sector firms in a number of ways. On main avenue is through direct employment of PD/A CRSP scientists as consultants or as resource persons in corporate-sponsored conferences or training programs. Another is the network of relationships between PD/A scientists and industry personnel.

PD/A CRSP researchers often participate in the thesis research of individuals who take jobs on industrial-scale fish farms or in other positions associated with aquacultural activity. Other donors have supported the Northeast Thailand Project that provides outreach activities in terms of technical assistance and community organization to poor villages in that region.

The stream of research findings from the PD/A CRSP are a significant part of the aggregate research effort at the Asian Institute of Technology. This program makes a signal contribution to the development of aquaculture in Thailand and Southeast Asia. Figure 8.3 diagrams some of the major actors working in aquaculture in Thailand.

Asian Institute of Technology. An international institution devoted exclusively to research and graduate instruction, The Asian Institute of Technology (AIT) is located on the edge of greater Bangkok. An autonomous, international, post-graduate, technological institution, the Institute was recently reorganized into four schools with the Aquaculture Program placed in the School of Environment, Resources, and Development. With 9 doctoral faculty and 20 others with graduate degrees, AIT offers Ph.D. and master's degrees as well as a widely-recognized aquaculture short course training program. In addition to a reservoir, the facilities include

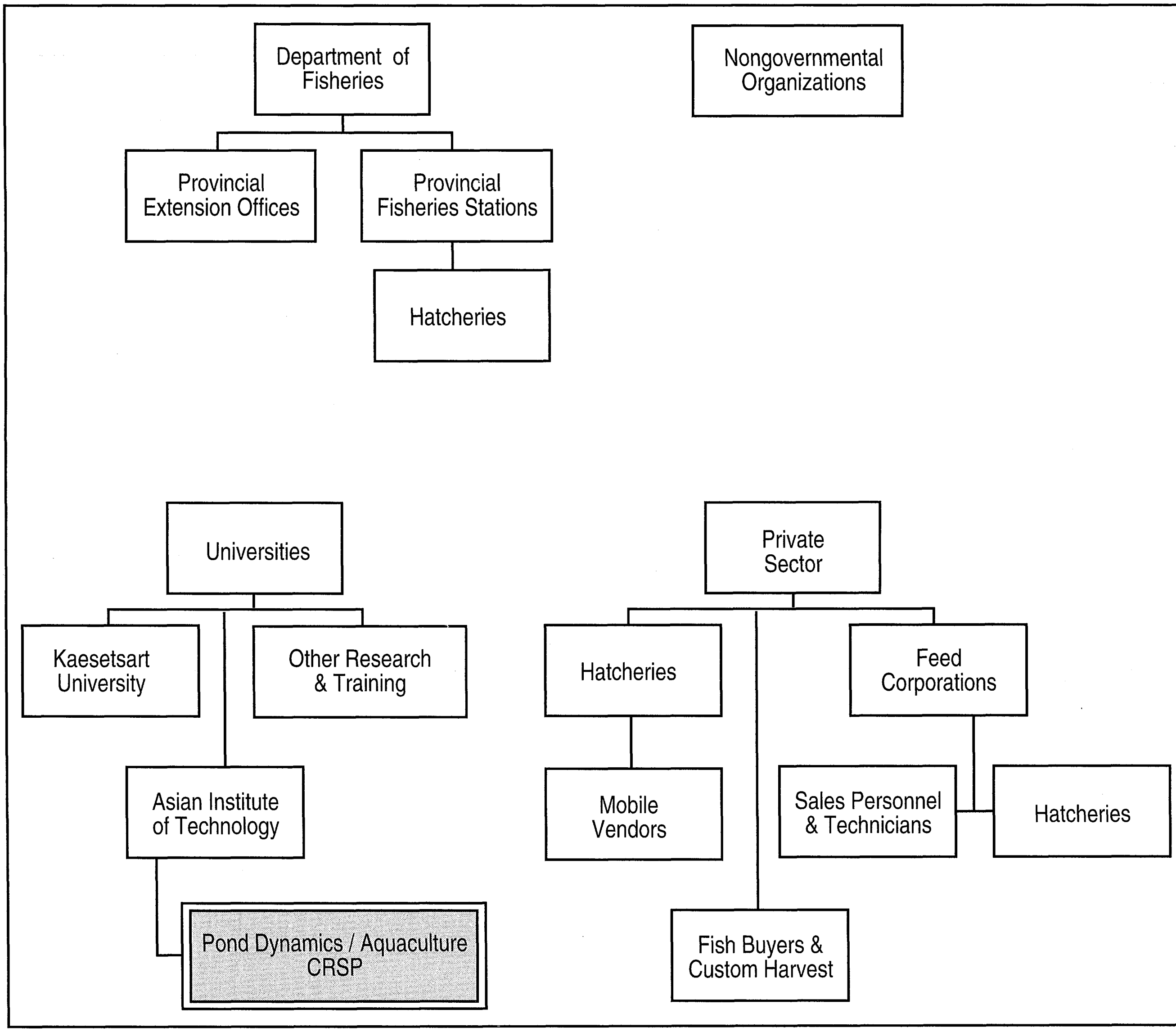

Figure 8.4. Institutional networks for Tilapia technology in Thailand.

about 150 earthen ponds, 120 concrete tanks, two hatcheries, and cropland on a ten hectare site (17).

PD/A CRSP researchers have been located at AIT over the life of the project; additional staff have been supported for shorter periods as budgets and research needs dictated. The PD/A CRSP research in Thailand is complemented by the extensive research program at AIT. Researchers supported by the British Office of Development Assistance (ODA) and other donors identify as well as eliminate possible alternatives to the core pond management principles identified by the PD/A CRSP. For examples, the usefulness of early-stage fertilization in the tilapia crop cycle was clarified here; the low utility of buffalo manure as a pond input was established by AIT research.

Thailand Department of Fisheries. A well-developed and reasonably well-supported research and extension system is in place in Thailand. The Department of Fisheries has strategically placed stations throughout the country. Each province has an extension office; many also have research stations though they are not always co-located with extension. Plans are to link each provincial office to headquarters staff through computer modems, primarily for data transmission.

Tilapia farmers have little or no contact with extension, largely because there are so many fish farmers and apparently little expressed need for extension assistance. Long experience with fish culture and a rich and inventive farming tradition has led Thai farmers to be quite responsive to market-driven technological advance. The widespread development of private sector infrastructure for fingerling production, custom harvesting, and processing also lessens the need for extensive outreach activities, at least in wealthy central Thailand areas.

In Northeast Thailand, soils are poor and poverty is widespread. AIT has utilized donor assistance to mount a project targeting poor farmers with a comprehensive program of assistance featuring aquaculture as a central point of intervention. PD/A CRSP researchers have conducted trials at Department of Fisheries stations, and have participated in staff and farmer training. PD/A CRSP researchers have prepared farmer-friendly printed materials for distribution to farmers by hatchery managers when farmers purchase fingerlings. Though the efforts are largely localized to one location in the central tilapia production region, demonstrable progress has been made in bridging research findings to on-farm practice and the recommendation for practice made by the Department of Fisheries.

Kaesetsart University. Located adjacent to the Bureau of Fisheries in Bangkok, Kaesetsart is the largest source of trained graduates in aquaculture in Thailand. All levels of graduate training take place at this institution. It has received major donor support in fish disease research and other areas of aquaculture. The research program here complements and extends the activities of the PD/A CRSP. Although only 14 kilometers from AIT on a major highway, most PD/A CRSP activity operates through AIT programs.

Other Universities. Thailand is a rich environment for aquacultural education and research; many degree programs and research projects are to be found. A number of regional universities and institutes offer degree programs and training in aquaculture. Several universities have nascent research programs in aquaculture. There are many local training programs and university or college-level courses in aquaculture taught across the nation. The connections to national research and extension institutions are tenuous; similarly the impact of PD/A CRSP technology on these actors is limited at best.

Nongovernmental Organizations. Thailand has a diverse, active, and well-developed cadre of nongovernmental organizations (NGOs) that pursue rural and agricultural development. Many treat aquaculture as one of a portfolio of activities to be selected by local interest and opportunity. Many NGOs have strong relationships with local institutions of higher education, some of which feature aquaculture as a subject-matter. Staff members often become resource persons for these efforts and local promoters of aquaculture.

Some international NGOs feature aquaculture assistance as one option for local development projects. For example, Heifer Project International has utilized aquaculture as one possibility for Hill Tribe villages in Northern Thailand that are seeking alternative uses for marginal lands and additional sources of farm income. The Thai NGO sector is a major constituency for PD/A CRSP research results, publications, and training program assistance.

Private Sector. Several large feed companies produce fish feed and compete with each other for grower business by providing technical assistance featuring feed-based production strategies. These production strategies are often in conflict with PD/A CRSP recommendations that are intended to optimize fish growth and farmer income, and not feed sales.

Some firms also process fish for export using fish from company-operated ponds as well as fish purchased from private farmers. These processing facilities can be important markets for farmers producing sufficient quantities of fish that meet quality standards.

A widespread network of hatcheries provides many alternative fingerling sources for Thai farmers. Hatchery operators are a significant target audience for the results of PD/A CRSP research because of the technology they employ in producing all-male fingerlings and the potential these individuals have to reach tilapia producers.

When tilapia farmers visit hatcheries, they often spend significant amounts of time visiting with other farmers while waiting for their fingerling orders to be filled. Information about production strategies, feeding approaches, pond liming and fertilization, disease monitoring, and other needs can be readily disseminated at this time. In Thailand, some restocking is done on a custom basis or fingerlings are delivered by the hatchery. Some farmers send employees or family members to the hatchery. Consequently, some fish farmers cannot be reached in this way. Nonetheless, the hatchery remains a significant nexus for the transfer of technology.

CHAPTER NINE
CONCLUSION: TILAPIA TECHNOLOGY IN FOUR PD/A CRSP COUNTRIES

This report has provided a socioeconomic profile of tilapia culture in four PD/A CRSP countries. One of the signal contributions of this study is the cross-national comparative data obtained from fish farmers across the globe. A common interview guide and data matrix provide an initial framework for contrasting and understanding the practice of tilapia culture. Similarities in technology and approach to aquaculture also can be counterpoised to the great differences in market receptivity, price, and dietary role of tilapia in each country. The findings illustrate the diversity of institutions, farm situations, and market conditions where tilapia are grown and consumed. Readers of this report should have a more comprehensive grasp of the meaning of tilapia as a livelihood, the institutional structures that provide research and extensions support, and the diverse roles the tilapia enterprise plays in various farming systems.

In particular, the data examined here complement experimental and biological information about how tilapia are grown and used. The findings show how farmers feed their fish, who they sell them to, and what kinds of problems they are experiencing. Farmer attitudes toward tilapia farming and the role of tilapia production within the four PD/A CRSP countries were examined by asking them to compare aquaculture with other farm activities. Operators were consistently favorable in their perceptions of tilapia culture on such dimensions as cash income potential and general attitude toward the enterprise.

Farmer attitudes toward aquaculture also reveal their perception of overall viability of tilapia culture. Such qualitative measurements, in effect, ask farmers to rank the profitability and resource efficiency of each of their farm production activities. Farmers generally felt that tilapia was the best use of the land occupied by the pond.

Results of this study also suggest that tilapia mean different things to different segments of the farm operator population. Clearly the wealth or income level of the grower enters into the amount of capital investment and risk to be undertaken. Off-farm employment and life cycle considerations also play a role in determining the production strategies employed and the kinds of benefits individuals seek from the fish culture enterprise.

IMPACTS OF THE PD/A CRSP

Tilapia growers in each of the countries face vastly different institutional systems supporting tilapia production. The impacts of the PD/A CRSP are muffled by the inherent characteristics of the research process, the nature of institutional functioning in developing countries, and the dynamism of the information environment for aquacultural technologies. No farmers we interviewed had any direct or detailed knowledge of the PD/A CRSP research program or its findings.

The communication process linking experimental pond to farm practice involves several layers of translation and transmission. Many factors interact to affect the nature and extent of impact PD/A CRSP scientists and research programs have on national aquacultural institutions and farm practice.

Experimental findings are at base experimental; that is, they reflect controlled conditions and careful measurement of a focused set of factors. Farm conditions reflect variable physical and management situations that often mitigate the impact of effects identified by repeated experimental trial. Experimental findings must be cumulated from many studies and modified in certain ways to generate a robust field recommendation. In essence, an internal process of recognition and acceptance must take place within national research and extension systems before the findings become farm-level practice. Typically, greater the deviation from conventional understanding, the slower the process of internal diffusion. Other factors also intervene.

In Thailand, an extensive and well-trained network of Department of Fisheries research stations and extension offices is augmented by a broad set of colleges and universities that provide baccalaureate and post-graduate training in aquaculture. An aggressive private sector supports a wider network of producer services in Thailand. Firms supplying feeds, fingerlings, and custom harvesting and marketing are the most well-developed here. Several large feed companies and many small processing and fingerling supply firms provides most tilapia farmers in the greater Bangkok area with ready access to inputs and markets.

Large feed companies also promote tilapia culture in the Philippines, though an extensive network of private fingerling suppliers has yet to develop there. Nor is the network of producer services as well developed as in Thailand. Nonetheless, the Philippines has several university programs in aquaculture, but not the extensive network of research and extension offices found in Thailand. Central government support for most kinds of extension work has been withdrawn. A few large feed companies are beginning a serious promotion program for tilapia production, albeit in a self-interested manner that emphasizes the use of purchased feed (their products) and neglects pond fertilization.

Tilapia farmers in central Luzon have a variety of publicly supported fingerling producers, while private sector seed suppliers are beginning to increase in number in other parts of the country. The high relative price for tilapia in the Philippines presents a happy situation for tilapia producers as long as the fish remains a popular and affordable item in the market place.

Honduras faces fundamental difficulties with an underdeveloped marketing system and an uneven set of consumer preferences for tilapia. The public sector in Honduras is under great financial stress and is widely lacking in public confidence over its ability to deliver services and provide assistance in an effective and reliable manner. Coupled with inadequate operating funds, the agencies serving aquaculture have high levels of staff turnover. These conditions limit the technical support that can be given to farmers.

The financial difficulties of the Honduran government constrain the budgetary resources available for aquaculture. Frequent reorganizations and limited operating funds weaken the efforts of the regional aquaculture offices, exacerbating widespread distrust and skepticism about governmental services. One large private university has been a consistent source of training and fingerling supply for producers in central Honduras. Public universities provide some graduates and research support, but shrinking budgets greatly limit the programs that can be offered.

In Rwanda, ethnic conflicts have swept aside much of the progress made in aquaculture over the last two decades. Assuming peace and public confidence can be restored in the short term, the need and potential for aquaculture success is clearly present. The University of Rwanda has facilities and programs to provide trained aquaculture graduates. The government's limited ability to make a financial commitment to aquaculture makes the likelihood of any broad initiative for extension to be low. In contrast, farmer interest and enthusiasm for aquaculture is high. The data in this study and in previous reports show that new farmers are adopting the enterprise without extension prompting and some farmers provide fingerlings to their neighbors. Although the practice of aquaculture in Rwanda has been at a low level of technical proficiency, the need is much greater in this country than the others and the rate of change in the status of fish culture has been much faster.

Farmers were asked about the main things preventing larger harvests. Honduran farmers noted "my understanding" as the major obstacle to obtaining larger harvests from their ponds. Water quality was the biggest issue in Thailand and the Philippines, an issue referred to simply as "the pond" in Rwanda. Manure and compost availability was the obstacle most frequently cited in Rwanda. These findings underscore the significant contribution of PD/A CRSP research activities toward the demystification of the pond as a growth environment for fish. Productivity advances for the majority of family farm operators will stem from basic understandings of the pond system that will diminish the risk of crop loss and enhance yields from a given set of resources. Many of the basic parameters of fish culture have been established in useable form; the translation and dissemination of these principles remains a daunting task.

PD/A CRSP RELATIONSHIPS TO GOVERNMENT AND INDUSTRY

Aquaculture succeeded in Rwanda because its diffusion was properly supported during an extended period of peace in the countryside. The technology was appropriate to the setting and it met critical needs for cash income, nutrition, food security, and enterprise diversity. A widespread network of hatchery stations provided fingerlings and demonstrated good aquaculture practice. A well-trained and motivated cadre of extensionists made visits to farmers. Producers found ready markets for their fish among their friends and neighbors, as well in organized markets in towns and urban centers. The PD/A CRSP provided sound science and organizational guidance to an extension network that provided an extended period of support to individuals and groups beginning the practice of fish culture. The ethnic unrest that troubles Rwanda, and much of Africa, in the 1990s presents obstacles to aquacultural development.

In Honduras, the PD/A CRSP effort was well-positioned to contribute to the development of national institutions, but the location was far from the North Coast areas where a large-scale tilapia industry is established. A solid research program and a wide network of interpersonal and interorganizational contacts multiplied the impact of the research program. High personnel turnover and weak institutions muffled the impact of PD/A CRSP technology on the farm level, though the success of key alumni of PD/A CRSP training programs keep the promise of fish culture alive among farmers.

The Philippine PD/A CRSP contributed to baseline research on tilapia production issues, but the impacts of the PD/A CRSP program in this country are largely overshadowed by the efforts of ICLARM and the British Overseas Development Agency (ODA) that have had a sustained presence of personnel in the country and much larger budgets for conducting research. PD/A CRSP efforts have been extensively leveraged by the extensive network of United States - trained personnel and their interest in the PD/A CRSP program. PD/A CRSP ties to large-scale tilapia production are weak or nonexistent in the Philippines. Nonetheless the project has been a beneficial influence on the national research program conducted in the nation's main tilapia production area.

The Thailand PD/A CRSP was best positioned to conduct high-quality, world class research. The Asian Institute of Technology provided a supportive, if expensive, environment for the conduct of experiments and data analysis. The presence of other aquaculture researchers and a small cadre of aquaculture social scientists augmented the impact of the PD/A CRSP program by providing ties to other projects in other parts of the country. Other projects provided baseline social data about tilapia producers and access to technology transfer mechanisms otherwise unavailable to the PD/A CRSP. The extensive network of industry contacts maintained by PD/A CRSP researchers also multiplied the influence of PD/A CRSP research efforts on the burgeoning Thai aquaculture industry.

TECHNOLOGY TRANSFER

When we refer to PD/A CRSP technologies, we are primarily considering experimentally-based information about feeding and fertilization. The PD/A CRSP has done extensive work in each nation detailing optimum paths to tilapia production using the predator species, growing conditions, and input materials found in each setting. The technology transfer process is at core a series of communication steps that relay new findings and perspectives to technical representatives in government research and extension systems, as well as to hatchery managers and others in commercial sector roles that feature regular contact with tilapia growers.

It is intended that the framework developed in this study be sufficiently general to be applied at all PD/A CRSP sites, yet sufficiently flexible to allow the inclusion of site-specific variables and other considerations. We endeavored to obtain basic production, marketing, labor, input supply, and farming system information from potential adopters of PD/A CRSP-related technologies. Based on primary data from farmer interviews, secondary data from PD/A CRSP researchers, and other sources, we are led to a number of basic observations about the transfer of PD/A CRSP findings to national institutions and to individual farm operators.

The primary impacts of the PD/A CRSP project are channeled through interpersonal processes. PD/A CRSP scientists interact with station personnel, sharing insights and perspective on the technology of aquaculture. These influences are then retransmitted to farmers and others who have contacts with station personnel, particularly if the station personnel have training or leadership roles. Through interpersonal contacts, PD/A CRSP scientists impart a holistic understanding of pond dynamics and fish behavior that is difficult to obtain through the printed word or other formal means.

PD/A CRSP scientists have had direct impacts on farm practice through the various training sessions that research stations have sponsored over the years. The production recipes conveyed directly to farmers in these programs often have had dramatic impact in the operations of receptive individuals with the ingenuity and motivation to realize the promise of the enterprise. The effect of personal relationships between farmers and PD/A CRSP scientists should not be underestimated. In turn these individuals influence their neighbors by example and interaction over the proper practice of fish culture.

Another communication channel for PD/A CRSP findings is through written publications. Journal articles and meeting presentations convey research results to the scientific community. Reprints may circulate among some institutional participants in the host country, but rarely do they reach the farm level. Findings of this sort require two sorts of transformation on two levels; one, accumulation and reconstitution to become user-robust recommendations, and two, translation to the spoken language of the user. On both fronts we observe an opportunity to improve the impact of the PD/A CRSP.

Applied research reports translated into the local language are not extensively found in the PD/A CRSP corpus. Although a number of sporadic and situational efforts have been made to produce illustrated handbooks or pamphlets in the local language, the legacy is not extensive. Most research reports have been issued solely in English, most often without national language executive summaries or abstracts. These translated preambles are important for non-native English speakers because the translation provides context and meaning for the more detailed findings presented in the document it precedes.

Video cassette recorders are becoming a pervasive part of life in each PD/A CRSP country. Unlike some international projects, the PD/A CRSP has yet to develop video presentations of its findings and research program that could be used in meetings with technical staffs and progressive farmers in each of the countries. These videos could be prepared in English with separate voice and music tracks for ready rerecording of narrative into local languages and possible use in other countries.

We observe an opportunity for PD/A CRSP support of a host-country national at each site to serve a training and communication function for fish farmers. There has been very indirect and limited impacts of PD/A CRSP research findings on farm level practice. The primary effects of the PD/A CRSP experimental program have been on national systems through interaction with national scientists, program managers, and extension personnel.

It is understandable that one or two scientists responsible to an annual work plan and experimental program have little time or resources to expend on applied publications or extensive direct participation in staff or farmer training. However, these are the fundamental mechanisms for extending PD/A CRSP results to the farm level and realizing the socioeconomic benefits of fish culture to individuals, families, rural communities and the national economy.

FINANCIAL ANALYSIS

One objective of this study was to determine the costs and returns associated with alternative production regimes specified by the PD/A CRSP workplan to establish a baseline profile of financial profitability per system per country.

In Honduras, previous research has established a model for integrating economic and financial information in assessing the viability of different ways of growing tilapia. Using economic information on nutrient-input tilapia production regimes provided by PD/A CRSP researchers, an examination of the various strategies was made. The PD/A CRSP research shows that fertilization could profitably supplant feeding for a significant part of the tilapia's growth cycle.

The relevant data for each site's experimental regime was concatenated into a comparable analytic framework. Comparisons and analysis of production relationships and adopter incentive structures were made. Economic viability was assessed with published PD/A CRSP experimental results and recent data about input costs. These data show the relative profitability of various combinations of feeds, fertilizers, and production systems.

Econometric analysis of production inputs and outputs can help determine economically optimal production paths to maximum profit. The partial net returns from many PD/A CRSP experiments showed that the greatest production was not necessarily associated with the highest return. These ideas about the production and profitability relationship need to be furthered through incorporation of economic data collection on PD/A CRSP field trials.

A system of collecting quantitative input data at the farm-level using PD/A CRSP technologies is needed to learn optimal efficiency levels. Input information on stocking rates and amount harvested is usually possible without problem. However, systematic monitoring of nutrient and fertilizer inputs by farmers has proven very difficult to accomplish, but must be collected for future econometric analysis of production.

Some stocking rates in the survey results were higher than those used in the PD/A CRSP experiments. In more recent PD/A CRSP workplans than are analyzed here, stocking densities have been increased to two and three fish per m^2. Further increases in stocking rates need to be conducted to find optimal tilapia stocking rates for farmers. Again, given sufficient data, production function models can be developed that can identify economically viable stocking rates.

The survey results show that most farmers use a diverse combination of vegetative inputs, manures and livestock feeds. Concentration on one input with supplementation from one of the other categories is the norm. Farmers seem to organize their tilapia enterprise around an existing resource or under-utilized input. The tilapia enterprise is most often valued as a complement to an existing farm activity (such as poultry), especially among small- and medium-scale operators.

PD/A CRSP research has tested the use of low, high and combined levels of feed and fertilizer (organic and inorganic) inputs and could play a leading role in tilapia farming development by getting this information out to farmers. Field tests and data collection, as described above, could further clarify the profitability and risk of these technologies to farmers.

Where PD/A CRSP activities have the opportunity to influence host country governmental assistance to aquaculture, efforts should emphasize infrastructure development. Poorly organized fish product markets and input distribution systems often hinder aquaculture development. As markets for tilapia expand, production and support services will also expand. Development of private sector marketing services for both production inputs and fish outputs will be needed for sustained aquacultural development.

FINGERLING PRODUCTION

Fingerling production is often the most profitable, but also the most risky and complex, phase of aquacultural production. The development of private sector fingerling suppliers is a primary step toward sustainable aquacultural development. If the public-sector is used as an initial aquaculture catalyst, government efforts could initiate the supply of fingerlings, but should not continue to supply seed stock at subsidized prices.

Although primarily an issue in Honduras, government hatcheries need to gradually increase fingerling prices to cover all production costs. More efficient private fingerling producers can then develop in a competitive market. This action will increase competition and stimulate private-sector fingerling production. Nonetheless, government stations have an important role in maintaining and improving broodstock, conducting applied research, and coordinating information exchange in the absence of effective extension programs.

We observe a need for better understanding of private sector hatchery operations and their role in aquaculture development and technology transfer. In all four countries, the purchase of fingerlings is a significant opportunity for contact with producers. When government stations are the main source of seed stock for fish farmers, fingerling sales approximate field days or organized events that present opportunities to communicate with assembled groups of fish farmers. In Thailand, however, the private sector infrastructure for fingerling production has matured to the point that many dispersed fingerling suppliers have regular contacts with local sets of farmers.

The fingerling suppliers themselves then become an important target group for extension because of their regular, direct interactions with farmers. Private hatchery managers often provide informal advisory and diagnostic services to their customers, if only to maintain the reputation of their seed stock against competing sources. In Rwanda, similar (albeit less formal) processes were at work. Fingerling sales by farmers to their neighbors also were mechanisms for transmitting basic information and instruction to new producers.

Information distribution is the one support service that may be difficult for the private sector to provide effectively to small-scale producers. Large-scale private firms have effectively transferred production inputs and information to contract farmers. However, contract farming has been likened to agricultural serfdom, where the farmers are not well-paid, make few production decisions, and control resides in the hands of a few large companies. Vertical integration may not be the best developmental path to encourage, although it may be the most rapid route to high levels of fish production.

Finally, aquacultural development will be more sustainable if fish production technologies have low economic risks to the farmer. Baseline PD/A CRSP and farmer fish production data need to be analyzed for risk levels and strategies developed to lower such risks. Economic indicators can be useful in helping researchers to fine-tune technologies to improve the likelihood of farmer acceptance and long term sustainability.

REPRISE: IMPACTS OF THE PD/A CRSP

One common pattern across the four PD/A CRSP sites considered here is the upstream nature of the PD/A CRSP contribution to technology transfer. Although farmer trials have been conducted at one time or another in each site, these efforts largely have been singular or specialized events and not part of a systematic program. In none of the countries do farmers now have a regular pattern of contact with a private or governmental technology transfer agent. What limited efforts are underway tend to have only sporadic and indirect communication ties to PD/A CRSP researchers and host institutions.

Farmers rely heavily on word-of-mouth and a melange of information sources and experiences most of which have little connection to the PD/A CRSP. In a small nation like Rwanda with little institutional or private-sector development in aquaculture, the PD/A is a central and influential actor in the advance of aquaculture. In a more-developed, dynamic, and institutionally rich context such as Thailand, the PD/A CRSP is but one of many sources of research, technology, and practical assistance.

Most of the farm-level impact of PD/A CRSP activities is second order; that is, PD/A CRSP research information is absorbed, integrated with other messages, and retransmitted by private firms and national institutions. The messages are received by innovator farmers, private managers, hatchery personnel, trainers, consultants, and others who will use the information to make decisions about growing fish. The messages also affect what these individuals tell others who want to or already are raising tilapia.

The most immediate impacts of PD/A CRSP activities are manifested primarily in the training experiences of degree candidates at institutions of higher learning such as the Asian Institute of Technology, University of Rwanda, Zamorano University, or Central Luzon State University. PD/A CRSP personnel serve as thesis advisors or consultants for faculty and students conducting aquacultural research or have other ties with these institutions. The insights, paradigms, organizing frameworks, and scientific technique communicated during these activities represents a major technology transfer impact of the PD/A CRSP.

In each country, PD/A CRSP researchers have direct contacts with extension or outreach staff working in fish culture. The collegial relationships, information exchanges, mutual assistance, and other forms of mutual influence also are a means for furthering the influence of PD/A CRSP research. In a manner that is often diffuse and subtle, but occasionally direct and focused, PD/A CRSP research operations and research findings contribute to the information milieu surrounding each nation's aquaculture industry.

Extension programs and the training of extension personnel are only indirectly influenced by the PD/A CRSP. In the Philippines, village-level extension in aquaculture does not exist. It is at best highly variable in the other nations. Even in Thailand, with the largest and best-developed network of personnel and facilities devoted to fish culture, PD/A CRSP ties to extensionists are infrequent and weak.

The many institutional actors working in aquaculture perhaps should be considered the primary audience for a global research project such as the PD/A CRSP. Although some level of direct farmer contact and training is necessary for keeping PD/A CRSP scientists in touch with the direct experiences and problems of fish farmers, the impacts and influence of the PD/A CRSP may be greater if institutions and industry are understood to be the primary consumers of PD/A CRSP outcomes.

Thus, seminars for nongovernmental organizations (NGOs) that maintain extensive and long-term relationships with villages and small-scale farmers may be a more effective mechanism for reaching this constituency than direct intervention by the PD/A CRSP. As long as small- and medium-scale farmers remains a central target segment for PD/A CRSP research impacts, the development of a continuing network of contacts with representatives of these groups will be a significant objective for the PD/A CRSP. The NGOs may be more effective at stimulating interest and reaching small-scale farmers than governmental organizations or the limited and sporadic activities of PD/A CRSP personnel (38).

To gain greater leverage for PD/A CRSP activities, a number of strategies might be consciously highlighted for PD/A CRSP scientists. These include; instructing NGO trainers, encouraging NGOs to adopt aquaculture as part of their repertoire of assistance activities, and helping national institutions organize seminars and training programs for NGOs. These and other means may be used for wholesaling PD/A CRSP technology to actors closer to village life who will be there when PD/A CRSP is not.

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APPENDICES

APPENDIX TABLE I. FARM ENTERPRISES PROVIDING MOST CASH INCOME BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994.[1]

Farm enterprise		Honduras			Philippines			Thailand		
	All	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Vegetables	32	71	39	33	60	35	7	18	-	13
Rice	34	—	8	—	80	50	33	71	38	6
Bananas	16	—	8	—	15	20	—	47	19	31
Fruit crops	28	—	—	7	20	50	7	77	31	50
Fish	73	12	46	40	80	85	100	100	100	94
Sugar cane	3	6	—	—	—	10	—	—	—	—
Livestock	40	41	15	40	25	30	20	71	75	44
Corn	8	24	8	13	15	10	—	—	—	—
Other	3	—	—	—	15	10	—	—	—	—
(Responses)	(357)	(26)	(16)	(20)	(62)	(60)	(25)	(65)	(42)	(38)
(Cases)	(151)	(17)	(13)	(15)	(20)	(20)	(15)	(17)	(16)	(16)

[1] Column percentages will be greater than 100 because of multiple responses given by each respondent.

APPENDIX TABLE II. CAPITAL EQUIPMENT PRESENT BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994.

Equipment item		Honduras			Philippines			Thailand		
	All	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Truck	47	77	53	80	5	15	33	53	69	47
Seine net	65	71	59	80	75	95	87	18	38	59
Water quality kit	3	—	6	7	—	—	—	—	—	18
Water pump	64	18	24	13	55	75	100	100	94	100
Aerator	1	—	—	—	—	—	7	—	—	—
D.O. meter	1	—	—	7	—	—	—	—	—	—
Weighing scale	87	82	77	87	75	85	87	100	100	100
Wheel barrow	62	100	94	80	25	25	27	53	75	88
(Responses)	(513)	(59)	(53)	(53)	(47)	(59)	(51)	(55)	(60)	(70)
(Cases)	(156)	(17)	(17)	(15)	(20)	(20)	(15)	(17)	(16)	(17)

APPENDIX TABLE III. WATER AVAILABILITY AND SOURCES FOR AQUACULTURE BY SIZE OF POND AREA, PHILIPPINES, HONDURAS AND THAILAND, 1994

Country and pond size category	Problems getting water[1]	Primary water source					
		Irrigation canal	Combination[2] stream	River or runoff	Spring	Collected	Well
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Philippines							
Small	50	10	20	5	5	35	25
Medium	25	20	45	15	10	10	0
Large	27	0	63	25	6	0	0
Honduras							
Small	18	0	18	47	29	0	0
Medium	24	0	6	56	13	0	6
Large	13	0	7	40	13	0	13
Thailand							
Small	71	88	6	0	0	6	0
Medium	50	44	50	6	0	0	0
Large	41	53	47	0	0	0	0

[1] Response to the question, "Have you had problems getting enough water to keep your pond filled?"
[2] Combination water sources for the Philippines included collected runoff, well stream and irrigation canal water.

APPENDIX TABLE IV. MAIN SOURCES OF NUTRIENT INPUT BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994

Nutrient source	All	Honduras			Philippines			Thailand		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pctg.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Kitchen wastes	5	32	6	—	—	3	—	19	5	5
Vegetation	10	26	6	16	3	3	3	19	12	12
Rice bran	24	11	19	16	42	30	27	14	24	26
Dead animals	1	—	—	—	—	—	—	—	2	7
Slaughter wastes	1	5	6	—	—	—	—	5	—	—
Commercial feed	21	26	44	62	6	16	30	35	12	9
Chicken litter	16	—	—	—	18	19	23	—	17	21
Inorganic fertilizer	22	—	19	8	30	30	17	8	29	21
(Responses)	(278)	(19)	(16)	(13)	(33)	(37)	(30)	(37)	(42)	(43)
(Cases)	(136)	(11)	(11)	(11)	(18)	(20)	(16)	(24)	(16)	(16)

APPENDIX TABLE V. TYPES OF COMMERCIAL FEEDS AND FERTILIZER PURCHASED BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994[1]

Nutrient source	All	Honduras			Phiippines			Thailand		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Feeds:										
Rice bran	25	6	18	20	30	20	25	18	50	41
Rabbit feed	3	6	12	7	—	—	6	—	—	—
Chicken feed	3	6	6	7	—	5	—	—	—	6
Fish feed	28	29	12	33	20	25	50	47	31	12
Fertilizers:										
Urea	21	29	53	40	15	5	25	6	19	6
0-46-0	3	—	—	—	—	—	—	6	19	6
18-46-0	4	—	18	13	—	—	6	—	—	—
Chicken manure	52	24	47	20	70	70	69	47	44	71
Cattle manure	15	47	24	40	—	—	13	6	6	6
Compost	9	—	—	—	5	—	—	6	31	41
Other fertilizer	52	41	24	7	85	80	69	35	69	53
(Responses)										
Feeds	(942)	(102)	(102)	(90)	(120)	(120)	(120)	(102)	(96)	(102)
Fertilizers	(1256)	(136)	(136)	(120)	(160)	(160)	(128)	(136)	(128)	(136)
(Cases)										
Feeds	(157)	(17)	(17)	(15)	(20)	(20)	(16)	(17)	(16)	(17)
Fertilizers	(157)	(17)	(17)	(15)	(20)	(20)	(16)	(17)	(16)	(17)

[1] Column percentages will be greater than 100 because of multiple responses given by each respondent.

APPENDIX TABLE VI. TYPE OF ANIMALS RAISED WITH FISH BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994[1]

Animal	All	Honduras			Philippines			Thailand		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Animal-tilapia integration	45	29	35	13	38	28	57	65	80	63
Cows	37	69	39	82	35	32	27	15	—	33
Goats	14	6	—	9	25	32	40	—	—	—
Hogs	40	63	54	18	60	37	27	46	17	25
Chickens	68	81	69	55	90	79	67	62	42	50
Ducks	29	19	15	27	25	32	40	31	50	33
Rabbits	2	6	8	—	—	—	—	—	—	—
Other	26	13	15	9	45	53	53	15	8	—
(Responses)	(288)	(41)	(26)	(22)	(56)	(50)	(38)	(22)	(14)	(17)
(Cases)	(133)	(16)	(13)	(11)	(20)	(19)	(15)	(13)	(12)	(12)

[1] Column percentages will be greater than 100 because of multiple responses given by each respondent.

APPENDIX TABLE VII. STOCKING DENSITY BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994

Stocking density	All	Honduras			Philippines			Thailand		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
No./m²	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1.1 or less	12	23	—	18	25	6	8	7	7	1
1.1 - 1.5	6	15	7	27	—	6	8	—	—	—
1.6 - 2.0	14	8	57	27	13	6	8	—	13	—
2.1 - 3.0	16	39	7	27	19	11	17	—	7	11
3.1 - 4.0	15	—	29	—	13	30	8	13	20	11
4.1 - 5.0	11	—	—	—	13	18	17	13	34	—
5.1 - 6.0	4	—	—	—	6	—	—	13	7	6
6.1 - 7.0	4	—	—	—	6	6	—	7	7	6
7.1 - 8.0	8	—	—	—	6	—	17	27	7	11
8.1 - 9.0	—	—	—	—	—	—	—	—	—	—
9.1 - 10.0	5	8	—	—	—	6	8	—	—	18
> 10.0	9	8	—	—	—	6	8	20	7	24
(Number)	(157)	(13)	(14)	(11)	(16)	(17)	(12)	(15)	(15)	(17)

APPENDIX TABLE VIII. PRODUCTION CYCLE LENGTH, CROPS PER YEAR, AVERAGE HARVEST WEIGHT AND HARVEST STRATEGY BY SIZE OF POND AREA, PHILIPPINES, HONDURAS AND THAILAND, 1994

Country & Pond Size Category	Days in cycle	Tilapia crops/year			Average size harvested	Harvesting strategy[1]		
		One	Two	Three		Partial	Partial+1	Single
	No.	*Pct.*	*Pct.*	*Pct.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*
Honduras								
Small	194	41	53	6	274	24	35	41
Medium	263	67	27	7	275	33	13	53
Large	235	53	40	7	570	47	20	33
Philippines								
Small	145	39	61	0	173	80	13	7
Medium	149	21	68	11	199	74	16	11
Large	139	13	69	19	179	50	36	14
Thailand								
Small	307	83	17	0	328	0	13	87
Medium	346	100	0	0	301	0	15	85
Large	358	100	0	0	411	12	24	65

[1] Harvesting strategies include: Partial — partial harvesting; Partial+1 — partial harvesting and one large harvest at end of the cycle; Single — one large harvest at the end of the cycle and NO partial harvesting

APPENDIX TABLE IX. WEIGHT CLASS OF INDIVIDUAL FISH HARVESTED BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994

Size of harvested fish	All	Honduras			Philippines			Thailand		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Gm.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
< 100	6	13	—	—	11	11	25	—	—	—
100 - 200	30	31	32	—	56	58	50	14	—	6
201 - 300	31	25	38	27	33	16	19	29	64	18
301 - 400	16	6	13	27	—	16	—	14	29	41
401 - 500	11	19	13	13	—	—	6	21	7	18
501 - 600	1	—	6	—	—	—	—	—	—	—
601 - 700	2	6	—	7	—	—	—	—	—	6
701 - 800	1	—	—	—	—	—	—	7	—	6
801 - 900	1	—	—	7	—	—	—	—	—	6
901 - 1000	0	—	—	—	—	—	—	—	—	—
> 1000	3	—	—	20	—	—	—	—	—	—
(Number)	(147)	(16)	(16)	(15)	(18)	(19)	(16)	(14)	(14)	(17)

APPENDIX TABLE X. DISPOSITION OF TILAPIA HARVEST BY SIZE OF POND AREA, HONDURAS, PHILIPPINES AND THAILAND, 1994[1]

Item	All	Honduras			Philippines			Thailand		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Sold tilapia last harvest	87	80	88	100	94	100	100	100	100	100
Sold to:										
Middlemen	69	19	50	80	55	84	100	93	93	93
Restaurants	13	13	31	47	—	5	19	7	—	—
Marketplace	14	13	—	13	39	32	19	7	—	—
Other buyers	70	88	75	87	89	63	69	79	50	50
(Number)	(11)	(15)	(16)	(15)	(18)	(19)	(16)	(14)	(14)	(15)

[1] Column percentages will be greater than 100 because of multiple responses given by each respondent.


Left to right: Aquaculture facility at PanAmerican Agricultural School, Zamorano, Honduras; fish harvest at Rwasave Research Facility, University of Rwanda; Rwanda fish farmer with sociologist Alphonse Rubagumya; Philippine fish harvest.



Top: Aquaculture Research Station, Comayagua, Honduras; center: Freshwater Aquaculture Center at Central Luzon State University, the Philippines; bottom: Asian Institute of Technology Aquacultural Research Facilities, Thailand.