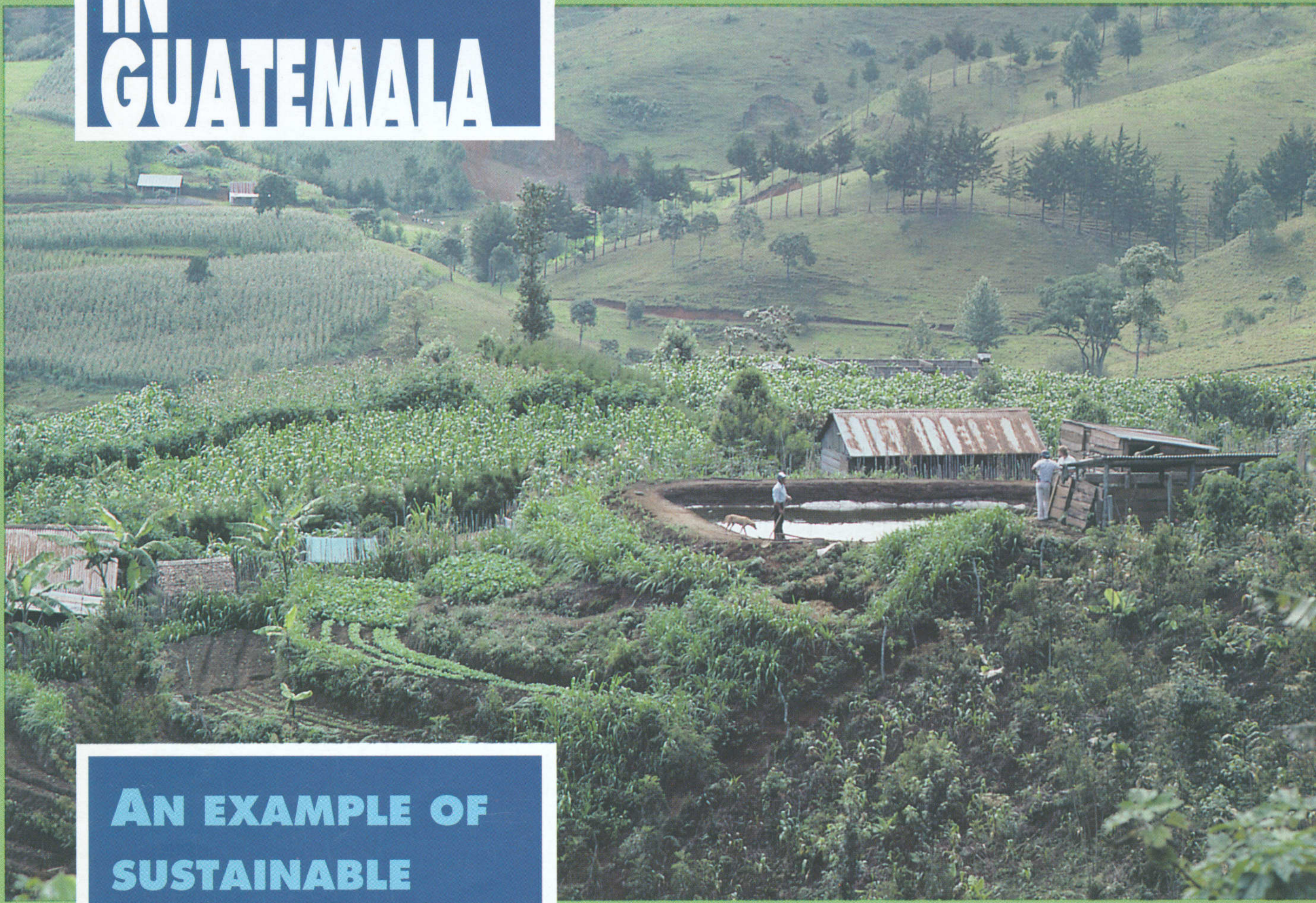
FAMILY-SCALE FISH FARMING IN GUATEMALA

Report of a Project Funded by:
DIGESEPE - Guatemalan Ministry of Agriculture
CARE - Guatemala
United States Peace Corps
United States Agency for International Development
International Center for Aquaculture
and Aquatic Environments
Alabama Agricultural Experiment Station
Auburn University
Research and Development Series No. 37
August, 1992



AN EXAMPLE OF SUSTAINABLE AQUACULTURAL DEVELOPMENT THROUGH NATIONAL AND INTERNATIONAL COLLABORATION

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ACKNOWLEDGMENTS

The following persons are acknowledged for their contribution to this project and report: Carmen Gonzales-Artiles, an M.S. graduate from Auburn University, who studied the sociological impact of the CARE Integrated Aquaculture Project in rural Guatemala; Jose Alvizurez, Associate Peace Corps Director in Guatemala, who provided continuity and leadership to the Peace Corps fish culture activities throughout the entire program; and Corinne Seltz, Project Manager of the CARE Family Fish Pond Project, the first phase of the aquaculture program, and planner of the follow-on project.

FAMILY-SCALE FISH FARMING IN GUATEMALA:

AN EXAMPLE OF SUSTAINABLE AQUACULTURAL DEVELOPMENT THROUGH NATIONAL AND INTERNATIONAL COLLABORATION

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INTRODUCTION

PROBLEM

Development agencies often find that rural families most in need of improving their living conditions are the most difficult to help. Small land holdings, low educational levels, and limited capital make farmers unable or reluctant to adopt new agricultural practices, such as fish farming in Latin America. Relative isolation of farms and limited mobility of extensionists further hinder development by reducing contact time with rural families. These combined constraints can lead to discouragement and withdrawal or redirection of donor support before rural families have become self-sufficient.

Research and experience have shown that low-input aquaculture can be an appropriate activity for small-scale farmers. However, many efforts to establish small-scale fish farming in Africa, Latin America, and the Caribbean have not documented long-term successes. Some projects may have been attempted under inappropriate conditions. Others were technically and economically feasible, but developed slowly and achieved limited success because of the above mentioned constraints. The effectiveness of most development efforts in small-scale aquaculture remain controversial. Although part of the controversy revolves around the definition of social and economic success, the controversy is largely rooted in the scarcity of data on the impact on participating families.

Field staff who implement projects aimed at the most disadvantaged of these rural farmers most often strive for social rather than economic impact. They are strongly motivated to improve living conditions for these farmers, and are less driven to show verifiable, numerical proof of the benefits. Many argue that effort expended in data collection and analysis can be more productively channeled into field activities. Unfortunately, when benefits to farmers are not convincingly documented, planners and politicians, who must make difficult decisions about distribution of scarce resources, may prematurely withdraw support.

PURPOSE AND INTENDED AUDIENCE

The purpose of this publication is to document the development of a successful small-scale aquaculture project in Guatemala that was funded by the U.S. Agency for International Development and collaboratively implemented by the General Directorate for Animal Husbandry (DIGESEPE) of the Guatemalan Ministry of Agriculture, the Cooperative for American Relief Everywhere (CARE), and the U.S. Peace Corps.

This report is intended primarily for planners who make decisions about the support to and organizational strategy for family-scale fish farming projects. It is assumed these individuals are experienced in international development but may lack technical expertise in aquaculture. Technical and economic data, included primarily to substantiate conclusions, will also be useful to implementers and managers of aquacultural projects in Guatemala and other countries with similar conditions.

SOURCES OF INFORMATION

Technical, economic, and social analyses were made possible by a detailed database maintained by CARE-Guatemala on project activities and accomplishments from 1986 to 1989. Additional information was compiled from the Final Project Report and Project Implementation Analyses by CARE-Guatemala and from field trials, demonstrations, extension reports, field visits, external evaluations, and official documents from the Government of Guatemala and various international agencies.

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Financial Support

All participating agencies contributed to the financial support of the aquacultural project. Salaries and support of field staff were financed by DIGESEPE and Peace Corps through their respective Governments. CARE provided unilateral support and matching for a grant from the United States Agency for International Development (USAID). Participation of Auburn University, through short-term technical assistance and publication of this report, was supported by three USAID-funded programs: Water Harvesting/Aquaculture Project, a Cooperative Agreement, and Program Support Grant.

BACKGROUND

The Country

In the *Popol Vuh*, the Mayan Bible, the perfect man was made of corn. In Guatemala corn still retains much of its religious importance and is the basic food for rural families. Historic ties to the land remain strong among Guatemalans. Agriculture continues to be the economic foundation of the country, generating 25 percent of gross domestic product and 70 percent of all exports.

Approximately 70 percent of the 8.2 million Guatemalans live in rural communities. However, 80 percent of all farms occupy only 8 percent of the agricultural land. Land holdings for the average small-scale producer is 0.9 hectare. In contrast, large-scale agricultural land holdings average 195 hectares.

Insufficient agricultural production faced by most rural families is reflected in their low income and nutritional status. Guatemala has the highest rates of malnutrition and infant mortality in all Central America. The Central American Nutrition Institute (INCAP) reported in 1987 that 57 percent of children under 5 years of age were underweight, and 84 percent exhibited growth stunting from chronic malnutrition. Early childhood deaths in rural areas were estimated at 150 to 170 per 1,000 . INCAP also estimated that 84 percent of the rural population lacked resources to acquire basic foods required to sustain good nutritional health.

In the Western Hemisphere, only Haiti and Bolivia have higher rates of illiteracy than Guatemala. In 1980 46 percent of the rural adult population was illiterate. The average rural child received 3 years of formal education, and of these only 20 percent advanced beyond the sixth grade.

Aquacultural Program

Many national, international, and private development agencies give high priority to improvement of nutrition and income in rural Guatemala. The first initiative for aquacultural development in Guatemala began in 1960 with the construction of four fisheries stations with support from the Food and Agricultural Organization of the United Nations (FAO). Heavy equipment was also used to construct fish ponds on medium- and large-scale farms. Unfortunately, few resources were subsequently available for management of the fisheries stations and for on-farm technical assistance. Most of these ponds were abandoned or became unproductive.

The first aquacultural extension program directed to small-scale farmers was initiated in 1978 by the U.S. Peace Corps when seven fisheries volunteers began an extension program in the central highlands. Political instability forced a temporary withdrawal of Volunteers from that region 2 years later.

In 1980, the Penny Foundation, a private organization, assisted the Peace Corps aquaculture program in the Verapaz regions by providing 2 years of salary support to four local Promoters who served as counterparts for the Peace Corps Volunteers.

CARE, a private voluntary organization, became involved in Guatemalan aquaculture in 1982 with financial support from the U.S. Agency for International Development (USAID). These two international organizations initiated a collaborative venture with the General Directorate for Animal Husbandry (DIGESEPE), a recently organized division within the Guatemalan Ministry of Agriculture with responsibility for fisheries and aquaculture extension. The venture was implemented in two separate projects: the *Family Fish Ponds Program* (1982-86) with a budget of $343,000 from USAID and the *Integrated Aquaculture and Extension Program* (1986-89) with a budget of $610,000 from USAID, CARE-New York, and DIGESEPE. In addition, Peace Corps provided 73 Volunteers, and DIGESEPE contributed salaries for its 32 promoters and 7 part-time supervisors, as well as logistical and administrative support during this period.

The goal of the collaborative undertaking was to establish aquaculture as a viable agricultural activity that would enable rural families to improve nutrition and income. Farmers dug fish ponds on marginal land, and subsequently harvested fish for home consumption and sale to neighbors. During the second project, integrated aquaculture was introduced. Livestock were raised over or near the fish pond so the water was fertilized with manure at reduced labor and cost. Water and nutrient-rich pond muds made small-scale vegetable production more feasible, and garden by-products were an additional source of nutrients for the fish pond.

Target Group

The target group for the joint aquacultural programs was subsistence farmers with less than 2 hectares of land and annual income of no more than US $925, Photo 1. Traditional agricultural crops included corn, beans, and occasionally vegetables. Most families had a few free-ranging chickens and a pig or two. These animals were occasionally consumed by the family on special occasions, but their principal use was as a reserve for unexpected expenses.

Average per capita fish consumption in Guatemala was 1 kg. The pre-project level among the target group

Photo 1. Average land holdings of participating families was less than one hectare dedicated to a mix of several agricultural activities. Relative isolation and financial constraints required that most pond fertilizers and feeds be obtained from on-farm sources. Fish ponds played an important role in farm integration and more efficient utilization of resources.

was only 0.5 kg. In the regions populated by indigenous communities 78 percent of the people ate fish once every 5 months and 22 percent never ate fish before they had a pond.

Most participant families lived in houses consisting of mud walls, thatched or tin roofs, and dirt floors. Women and children walked for long distances, sometimes up to a half day, to gather firewood for cooking. Many families had portable radios for entertainment and news, but newspapers and magazines were less common. Illiteracy ranged from 82 percent among indigenous families in the central highlands to 56 percent among the mixed-race inhabitants called *ladinos.*

Geographic and Climatic Conditions

The fish culture program covered three geographical regions, encompassing diverse ecosystems and socio-economic categories:

The *Alta and Baja Verapaz* regions are variable in elevation, topography, and ethnicity. The lower region, about 1,000 m above sea level, is a flat and fertile plain with annual rainfall of 1,000 mm, average annual temperature of 21°C, and is mainly inhabited by ladinos. The higher region, inhabited by indigenous families, is situated at cooler and more rainy elevations above 1,300 m, where average maximum and minimum temperatures are 18° and 13°C, respectively, and the principal agricultural commodities are corn and beans.

The flat *Pacific and Atlantic Coastal* regions are below 800 m where average temperature is 24°C. Rainfall is high (3,200 mm) along the Atlantic side and lower (1,700 mm) on the Pacific coastal plains. These regions are occupied mainly by ladinos engaged in production of corn, sorghum, cattle, rice, and sugar cane.

The geography and climate of the *Eastern Region and Jalapa* are also highly variable, ranging in elevation from 210 to 1,760 m above sea level. Rainfall averages from 700 to 1600 mm, and temperature ranges from 18° to 30°C. Traditional agricultural commodities include corn, melons cashews, and fruits. Indigenous families generally inhabit higher elevations, while ladinos reside mainly in lower, warmer areas, figure 1.

Variability in ethnicity, education, climate, and resources made implementation of the program complex. What was appropriate for one community was often inadequate for another. The challenge was to develop a local aquacultural extension capability that functioned efficiently within this diversity.

ORGANIZATIONAL STRUCTURE

Implementing and Supporting Agencies

Both phases of the joint development effort were implemented by three agencies: CARE-Guatemala, U.S. Peace Corps, and DIGESEPE of the Guatemalan Ministry of Agriculture. Technical backstopping was provided to CARE by the International Center for Aquaculture at Auburn University. The organizational relationship among the three implementing agencies was occassionally modified in response to changing conditions and a clearer understanding of the relative effectiveness of different management strategies. The organizational chart in effect since 1987 is shown in figure 2.

CARE-Guatemala

The role of CARE during the first phase of the aquaculture program was primarily administrative. The Family Fish Pond Project (1982-86) was managed as one of several projects in the portfolio of a CARE staff member. In the second phase, entitled Integrated Aquaculture Project (1986-89), a host country national with undergraduate training in animal husbandry and advanced degree training in aquaculture was employed as project manager. She coordinated activities in the central office, maintained close contact with field personnel, provided technical insights on pond management practices, and supervised support staff.

During the first year of phase two, a CARE training coordinator prepared instructional aids, and organized the centralized training for all extensionists and farmers. These activities were subsequently decentralized and became the responsibility of three regional coordinators. They supported DIGESEPE supervisors and assisted extensionists in non-formal training in accordance with regional differences in socio-economic conditions and interests of the farmers.

U.S. Peace Corps

Peace Corps Volunteers were the first aquaculture extension agents in a community. They were responsible for generating interest in fish farming, for evaluating sites for pond construction, for overseeing pond construction, for providing technical assistance to farmers, and, most importantly, for assisting in the selection and training of a host country counterpart. As communities matured in fish farming, the volunteers gave more emphasis to assisting the local extensionist rather than to first-line contact with prospective farmers.

The Peace Corps program began with seven volun-

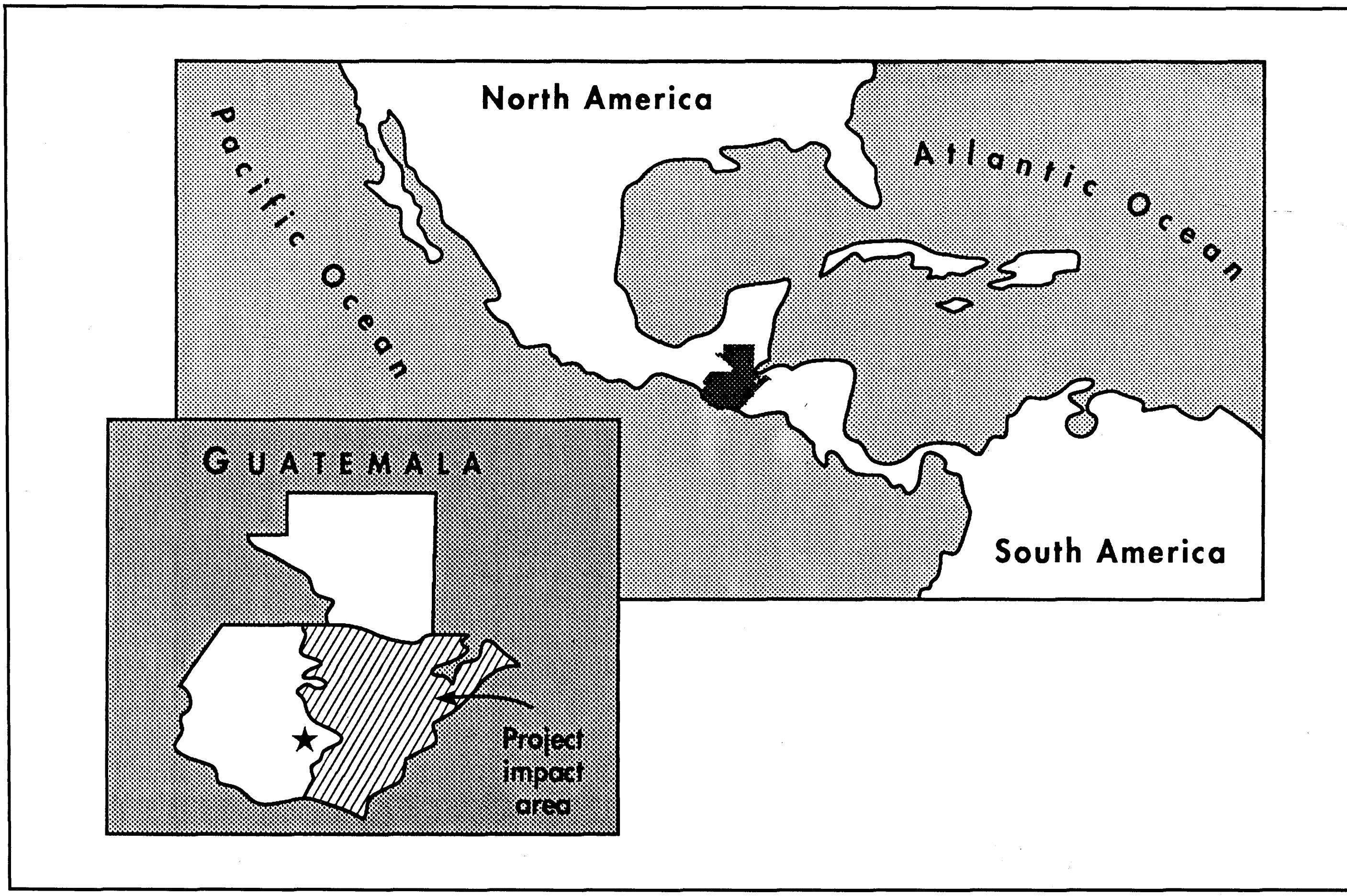

FIG. 1. Map of project area.

teers in 1982, and gradually expanded to 27 volunteers in later stages. A host country Associate Peace Corps Director provided leadership and continuity throughout the entire project.

DIGESEPE

DIGESEPE within the Guatemala Ministry of Agriculture has nationwide responsibilities for animal husbandry, including fish culture. Its program is

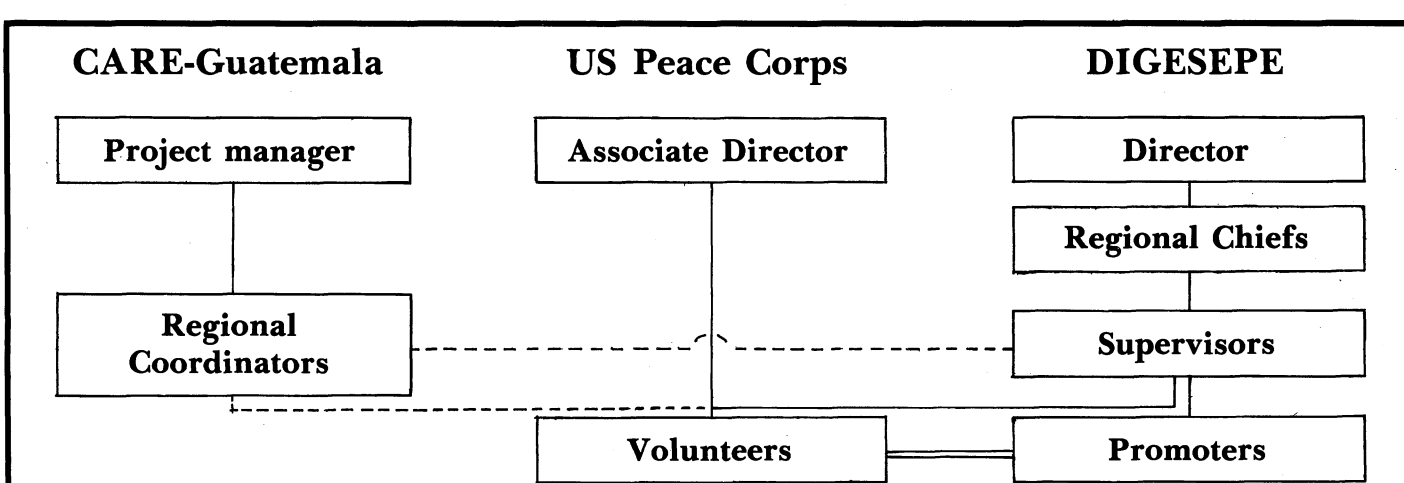

FIG. 2. Organizational relationships among the three agencies implementing the family-scale fish culture program in Guatemala.

managed at regional and subregional levels. Direct field supervision of Peace Corps Volunteers and their counterpart "promoters" was accomplished by supervisors at the subregional level.

Salary support was provided by CARE during 1986 and 1987 and then assumed by DIGESEPE. DIGESEPE also provided logistical and technical support to the project. Six national fish culture stations, four regional mini-stations, and nine small-animal centers were enhanced to provide fingerling fish and livestock to farmers. DIGESEPE technical staff also provided training in the husbandry of poultry, swine, and rabbits.

MANAGEMENT AND SUPERVISION

Project management was initially centralized, but significant differences in customs, socioeconomic conditions, and stage of aquacultural development in different communities motivated a regional approach in 1987. A national council, with representation from the three implementing agencies, and annual seminars with all field staff maintained a unified focus. However, routine planning, problem solving and training were addressed at monthly regional meetings.

The project had both national and regional management components. A national level council included the DIGESEPE Director and Regional Chiefs, the Associate Peace Corps Director, and the CARE Project Manager. At monthly council meetings, topics discussed included selection of new target communities, placement of Peace Corps Volunteers, hiring of additional Peace Corps counterpart promoters, vehicle allocation, training requirements, and strategies for field supervision.

Beginning in 1987, annual seminars were attended by all management and field staff. At these seminars, strategies were evaluated and goals were set for the upcoming year. They offered a valuable opportunity to motivate personnel, consolidate attitudes and enforce the roles and responsibilities of all staff members. However, most routine planning and coordination were conducted at the regional level. Monthly meetings were attended by all field personnel within a region and by the CARE Project Manager and the Regional Coordinator. The primary focus at regional meetings was on information exchange, progress and problems, and supplemental training.

The project was organized to include monthly visits by DIGESEPE supervisors to promoters and Peace Corps Volunteers in their sites primarily for administrative and logistic support. The effectiveness of this approach was highly variable, depending on the longevity of a supervisor in the region, his technical background, and the perceived importance of fish culture in a specific region.

MONITORING AND EVALUATION

An evaluation of project impact was facilitated by a detailed data base maintained by CARE-Guatemala based on monthly reports submitted by Peace Corps Volunteers and DIGESEPE extensionists. General records on pond construction and management were kept for all participating families, and more detailed records on nutrient inputs and fish production were maintained for subsamples of farmers to accurately monitor technical and economic results of different pond management practices.

During the early years of the aquaculture program, progress was recorded on the basis of community accomplishments, but starting in 1987 project personnel began maintaining data on individual ponds. Auburn University assisted in identifying critical parameters and designing an appropriate database. CARE-Guatemala then assumed responsibility for data entry and management. Parameters monitored on all ponds were:

- Pond construction (method, size, cost)
- Fingerling stocking (species, source, stocking rate)
- Pond management (primarily nutrient inputs)
- Integrated activities (animal husbandry, gardening)
- Pond harvesting (weight and use of harvested fish)
- Extension activities (visits to farmers, training courses, and demonstrations).

More detailed records would have been impractical for every pond due to time constraints and priorities of many farmers and extensionists. Complete production statistics on every pond became even more difficult as farmers became more independent, thus reducing their need for frequent contact with the extension agent.

The most practical approach to monitoring was a two-tier system:

1. General records (pond construction, management practices, harvesting schedule, training activities, site visits, etc.) were kept on all project participants, while more detailed production statistics were maintained on selected ponds. The primary criterion for selection was willingness of the farmer to keep detailed records. A special effort was made to include several ponds in each of the major pond management strategies. These records were used to more reliably quantify nutrient inputs and productivity of different management schemes. To accomplish this, a special calendar containing drawings of principal fish farming activities had to be developed for illiterate farmers.

2. Field records were forwarded by extensionists to CARE Project Manager where they were maintained in a computerized record keeping system to generate status reports. This centralized database furnished the majority of the quantitative information included in this report.

At the request of CARE, the International Center for Aquaculture and Aquatic Environments at Auburn University performed the final assessment of the first phase of the project and the intermediate and final technical evaluations of the second phase. Recommendations were submitted for mid-project adjustments and appropriate follow-on activities. One of the final recommendations was that the well documented results of this project be disseminated to a wider audience in the development community.

OVERVIEW OF PROJECT IMPACT

The impact of fish farming on rural families must be evaluated in the context of pre-project conditions. Before the project began there was minimal fish consumption, scarce financial resources, and limited land holdings. Pre-project per capita annual fish consumption was less than 0.5 kg. Average total annual income per family was approximately $700, and the average land holding was 0.9 hectare per household. The most common fish farming operation was a single 100- to 200-m^2 pond owned and operated by one family.

FISH PRODUCTION

From 1982, through 1989 more than 1,200 private fish ponds were built or renovated in the project target region. The total water surface area was 27 hectares. Ponds were hand-dug by participating families, primarily by men and their sons. Construction of a 120-m^2 median size pond required $6 cash for drain structures and 23 person-days of labor.

Most ponds were stocked with tilapia, common carp, and snails. A source of tilapia fingerlings was required only for initial stocking, as this fish readily spawns in ponds. Fish production was necessarily labor-intensive due to the physical isolation and economic status of these families. Women and children performed most of the feeding, fertilizing, and marketing tasks, providing approximately half of the total labor requirements for pond operation. The most common nutrients added to ponds were animal manures, low value agricultural by-products, and feeds produced on-farm. During the first phase of the project, all nutrient inputs were manually added to ponds by owners, but by 1989, 15 percent of the ponds were integrated to include animals, usually poultry, in enclosures suspended over the ponds.

By 1989, the project included more than 1,200 private fish ponds with a total surface area of 27 hectares. Average annual fish production ranged from 3,800 kg per hectare in non-integrated ponds receiving low cost nutrients to 6,100 kg per hectare in fish-poultry integrated ponds. Research data from other countries suggest most ponds in the Guatemala project were well managed and productive.

Total fish production was estimated at 90 to 100 metric tons per year in 1989. Pond construction statistics during the final 2 years of the project indicate family scale fish farming was growing at an annual rate of 15 percent.

By the end of the project, annual fish production from 950 monitored ponds was 83 metric tons. Production statistics were unavailable for an additional 250 ponds. Total fish production from small-scale, family-operated ponds was conservatively estimated at 90 to 100 metric tons per year, with a market value of approximately $150,000. The value of the fish produced was less than the annual implementation costs of the program, but, in view of the continuing future benefits to existing farmers and the current rate of expansion of fish farming, the investment of supporting and implementing agencies was deemed to be amply justified.

IMPACT ON FAMILY NUTRITION

An independent survey of 62 participating families revealed that for more than 50 percent of participating families, the most compelling reason for fish farming was to improve their diet. An additional 30 percent of the families thought income generation was an equally motivating factor. Only 5 percent did not include home consumption of fish as at least one of the important considerations, Photo 2.

Annual fish production from a typical pond was 48 kg, of which 20 kg were sold, 23 kg were consumed by the producer family, and the remaining 5 kg were used to restock the pond or were donated to neighbors. Average per capita annual consumption of fish among participating families thereby increased from pre-project levels of 0.5 kg to 3.3 kg by 1989.

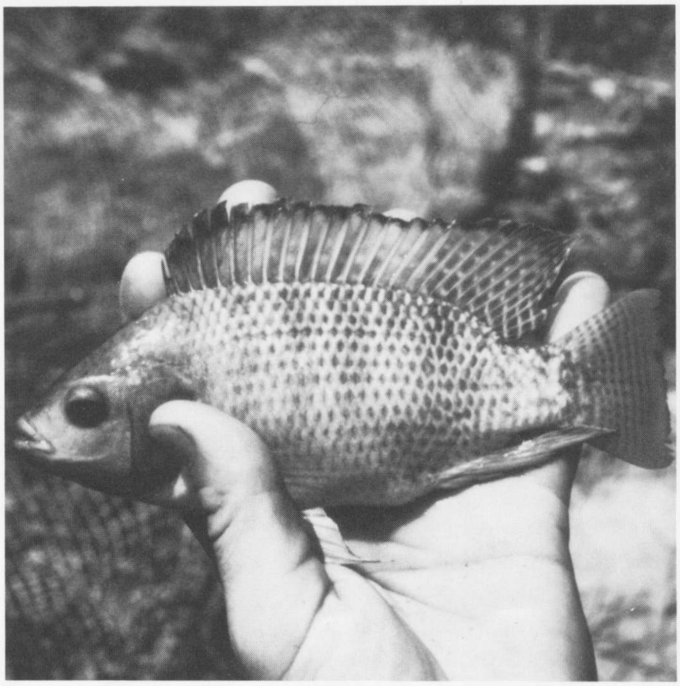

Photo 2. Rural fish farmers considered home consumption as the primary motivating factor for fish ponds. Fish of all sizes were consumed, but most families considered 15-cm tilapia as a preferred portion size for each family member.

An appreciation of the nutritional impact of increased fish consumption requires further analysis. Protein requirements for humans depend mainly on age and weight, as well as on the quality of the protein. Assuming high quality protein, such as fish, and an average weight of 40 kg per family member, annual protein requirements are 7,300 g per person. Prior to this project, the diet of the average rural Guatemalan contained just over half the recommended quantity of protein. Consequently, an average seven-member fish farming family increased their dietary protein 13 percent by eating slightly less than half the fish harvested from their pond. Many nutritionally disadvantaged and isolated families consumed nearly all fish harvested. Under those circumstances, seven-member families with average fish production increased their dietary protein 28 percent.

Improved nutrition was the primary motivating factor for most of the 8,000 participant family members. Average fish production from a median size 120-m^2 pond was sufficient to increase dietary protein intake of a typical seven-member family by 28 percent. High quality fish protein further enhanced the nutritional status of rural families by supplementing deficiencies of low quality protein in their traditional diets.

By the end of the project, 7 tons of fish were donated annually by the participating families to relatives and neighbors. The distribution and nutritional impact on these secondary beneficiaries was not determined.

Impact on Family Income

Family nutrition was the primary motivator for most fish farmers, but income generation was important to many. The final harvest of fish from drained ponds generally exceeded demands of even the most avid fish-consuming families. Consequently, a high percentage of fish were sold at pond bank or in local markets. As pond management improved and marketing channels were established, there was a gradual trend toward increased commercialization. In 1986, only 36 percent of the fish crop was marketed, while in 1989, 46 percent was sold. Market value ranged from $1.20 to $2.00 per kg, but in 1988-89, the most common selling price was $1.62 per kg. Average cash cost to produce the marketed fish was $0.50 per kg, producing an average net annual income from fish sales of $28 per pond. These profits seem modest by many standards, but the financial impact on many rural Guatemalan families was significant.

The average annual income of participating families was $698, of which $384 was earned on the farm. The sale of 42 percent of the fish crop therefore increased total family income by 4 percent and on-farm income by 7 percent. That income was equal to wages that would have been earned from 19 person-days of rural labor, while labor investment for that fraction of the fish crop was less than 6 person-days. Income generation for farmers who chose to sell all or most of the crop was proportionally higher.

On an average farm, the fish pond occupied only 2 percent of the farmer's land, but the market value of all fish harvested increased on-farm net income by 18 percent. Expressed in terms of employment potential, a typical pond required 0.7 person-month of labor annually, but net cash value of the fish crop was equivalent to approximately 2 months of wages as a rural laborer. The labor required to manage and harvest the pond displaced few outside employment opportunities since at least half of the labor was provided by women and children who have less off-farm employment potential.

STRATEGY FOR AQUACULTURAL EXTENSION

An effective extension service was particularly important for aquacultural development in Guatemala. The concept of animal husbandry was not new, but fish were thought to be wild creatures, needing no special care. Investing scarce resources to tend and feed fish required a radical change in thinking for most subsistence farmers. The strategy chosen to extend aquaculture to families lacking capital was one of the most influential factors in the success of the program.

Widespread adoption of aquaculture compatible with physical, economic, and cultural conditions was contingent upon a competent extension service. The project focused on training Peace Corps Volunteers and DIGESEPE promotors to extend aquacultural-agricultural techniques to participating farmers.

Training and Support of Peace Corps Volunteers

Peace Corps Volunteers are American men and women who volunteer to work overseas for 2 years. Volunteers destined for aquacultural assignments typically do not have college degrees in aquaculture. After medical and administrative screening, they are invited to a 10-week aquacultural training program in the United States. Training is primarily "experiential": each trainee is assigned a pond to manage, and is encouraged to resolve problems on personal initiative with limited formal classroom instruction. Aquacultural training is broad because prospective volunteers are usually destined to go to several different countries. Stateside training is generally positive and appropriate, but a major drawback for volunteers assigned to Guatemala was inclusion of more sophisticated technologies that often distracted volunteers from more basic low-input technology appropriate for the target group in Guatemala.

Successful completion of stateside training was followed by a 10- to 17-week program in Guatemala for language training, cross-cultural awareness, and site-specific technical and logistical briefings. Volunteers developed skills in extension techniques, pond construction, pond management practices, and preparation of enterprise budgets.

The greatest difficulties for new Volunteers were cultural and language barriers, especially in communities where Mayan languages were predominant. From a Guatemalan perspective, new volunteers tended to be overanxious and had difficulty adapting to the slower pace of rural communities. Volunteers who rushed into fish farming before establishing rapport with farmers often became frustrated by failure to achieve expected results. In-country training and assignment of responsibilities to new volunteers subsequently were scheduled in accordance with this observation. The most productive work of a volunteer usually began after a 6-month period of adaptation to the new cultural environment.

Peace Corps Volunteers often worked directly with fish farmers, but a more unique role in new target communities was identification of potential local aquaculture promoters and subsequent one-on-one technical training of those counterparts. The volunteers, in turn, benefited from promoters' understanding of local geography and customs.

The greatest contribution of volunteers was their role in selecting and field training local counterparts. Promoters were often field trained by two or three consecutive Peace Corps Volunteer counterparts. Promoters most often concluded that training under the first volunteer was most helpful. Replacement volunteers had less credibility with promoters, especially if they had the same technical background as their predecessors. Replacement volunteers should have new and complementing skills to offer. For instance, the first volunteer should concentrate on pond construction and fish management practices. The second volunteer should have strong background in complementary skills for integrated aquaculture, such as small animal husbandry and vegetable production. The third volunteer may be trained in credit and marketing.

Peace Corps initially provided motorcycles to the volunteers, but DIGESEPE was financially unable to maintain the same support for local counterpart promoters. As a consequence of decreased mobility after a volunteer completed his tour, extension support would be withdrawn or substantially reduced for many producers before they became dedicated and competent fish farmers. Consequently, the practice of providing motorcycles to volunteers was curtailed by Peace Corps. The decision was controversial because it significantly reduced the outreach capability of volunteers. They concluded, however, that failure to reach prospective farmers was preferable to withdrawal of extension support before farmers had attained independence. Premature withdrawal of support often leads to long-term negative opinions about fish farming, thereby prejudicing any subsequent development effort.

Selection and Training of Local Extensionists

Peace Corps Volunteers were generally the first long-term field persons in prospective communities. During their first half year of service, they became acquainted with the community, began to create an awareness of family scale fish farming, and attempted to identify appropriate local candidates for employment by DIGESEPE as community extensionists or promoters.

A desired characteristic of promoters was that they be respected opinion leaders with roots in the community, social awareness, and with interest in fish farming. An early strategy was to select school teachers because they were literate and had good communication and math skills. Later it became evident that many teachers, although raised in a rural environment, lacked genuine interest in farming. Consequently, they would often leave the program as more attractive employment opportunities arose. Promoters that maintained greatest sustained interest and longevity were farmers with no more than 6 years of formal schooling, but with natural enthusiasm about food production. A more intensive and prolonged training program was required to compensate for limited formal schooling, but the investment was justified by increased enthusiasm and longevity, critical qualities for development of a non-traditional activity such as fish farming.

Continuity of field staff is important for development of non-traditional activities. When combined with genuine interest and technical competence, continuity increases extensionists' credibility among farmers, who, for lack of experience, must often accept advice on blind faith. Longevity of local extensionists in small villages is a function of social ties in that community, natural inclinations, and, to a large extent, alternative employment opportunities. In general, selection of candidate extensionists requires a compromise between initial technical competence versus other characteristics linked to longevity on the job. Project managers, considering continuity a fundamental characteristic of effective extensionists, accepted greater responsibility in developing technical competence in those candidate promoters most likely to provide that continuity. Results suggest the wisdom of that strategy.

Field Training Through Peace Corps Counterparts

Training of promoters was accomplished by both formal and informal group programs and by on-the-job training with Peace Corps Volunteer counterparts. The latter included hands-on experience in pond construction, basic fish production techniques, mathematical calculations with simple pocket calculators, record keeping, and report writing. This training mechanism was invaluable because promoters were hired at different times, making scheduling of formal training more difficult.

Formal Training of Promoters

Early formal training was organized centrally by the CARE Training Coordinator. Training in food production first emphasized technical aspects of rearing fish, but subsequently expanded to include livestock production, animal health, and horticulture. Fish farming practices discussed were first limited to simple management techniques recommended for new communities (mixed sex production of tilapia in organically fertilized ponds). However, as years passed in a given community, the interest and capabilities of both promoters and producers widened. Training of promoters became more individualized to meet specific needs of each community. Some farmers wanted information on pond management techniques to control overpopulation and stunting in tilapia ponds. Interests of other farmers included supplemental feeding, integration of fish farming with other animal or vegetable production, and seed production of common carp.

Adoption of a regionalized approach to training was motivated by several factors. Socio-economic differences between communities were often great, especially between indigenous and more traditionally Latin communities. Also, with the gradual expansion of the program, many early communities were at more advanced stages of aquacultural development compared to newer sites. The convenience of regional training was recognized from inception of the program, but became more cost effective as the number of field staff increased.

Nearly 900 person-days of formal training were received by promoters during the final 3 years of the project. At the central level, nine 1- to 5-day courses were offered on fish culture practices, extension techniques and management of poultry, swine and rabbit. At the regional level, 39 one- to 3-day courses were provided to smaller groups of promoters on extension techniques, practical mathematics, watershed management, water quality, carp spawning, monosex fish culture, animal husbandry, fish-animal integration, and horticulture.

Nonformal Training of Promoters

Formal training activities, both central and regional, imparted technical skills to promoters. It soon became obvious, however, that many still lacked communication skills to effectively extend that new knowledge to farmers. Nonformal training techniques were subsequently emphasized to improve the extension capabilities of promoters. CARE Regional Coordinators supported Promoters in planning and implementing demonstrations and group field training of farmers. The coordinators observed performance and offered recommendations for future events.

Another productive training mechanism was exchange visits among promoters. This program produced 207 person-days of contact time among promoters during which they personally experienced opportunities, problems, and adjustments attempted by neighboring promoters and fish farmers.

In addition to field training with Peace Corps counterparts, promoters received 899 person-days of formal training. Ability to effectively extend technical information was further enhanced by 207 person-days of one-on-one exchange visits with other promoters and by counseling in methods of technology transfer.

Extension of Aquacultural Technology to Farmers

Selection of Target Communities

Original target communities were identified by program managers, but subsequent communities entered the program by various mechanisms. In many cases, experienced field personnel identified and proposed potential candidate communities. Also, as fish farming became more popular, villagers from surrounding communities often contacted DIGESEPE or CARE for technical assistance.

Potential target communities were then analyzed by a Peace Corps Volunteer regarding physical conditions of the region and interest expressed by local farmers and community leaders. The analysis was submitted to the Associate Peace Corps Director, who, in turn, proposed new communities in accordance with expected availability of volunteers and Peace Corps criteria for placement of new volunteers. Approval by DIGESEPE of a new target community was contingent on compatibility with its regional strategy and commitment from the Regional Chief to assign and support a new promoter at the site.

Creating Awareness of the Value of Fish Farming

Progression from awareness to adoption of fish farming was initially slow, especially in more isolated communities where aquaculture was a new concept. Extensionists organized group meetings where pamphlets and slide presentations made the inhabitants more aware of the benefits of fish farming. Initially extentionists also supervised and participated in construction of communal ponds, a demonstration strategy that proved to be more effective among indigenous communities than among mixed-race ladinos. Informal field trips to more aquaculturally advanced communities also helped to create awareness among farmers.

The need for specific programs to create awareness among prospective producers was diminished as fish farming spread throughout the region. During later stages of the project, an occasional radio message or newspaper article and the effective rural "grapevine" adequately performed the function of maintaining awareness and interest.

Support Services to New Participants

Several support services were provided to prospective farmers. Extensionists first evaluated topography and soil texture of a proposed pond site and analyzed the quality and quantity of available water. If the site was appropriate, the farmer was assigned tasks to verify genuine interest, such as digging a test pit to check soil permeability, clearing land at the proposed site, and participating in a group session on the benefits and constraints of fish farming. Subsequently, farmer and extensionist jointly analyzed construction expenses and developed an enterprise budget that itemized expected costs and returns.

Farmers who decided to proceed often were loaned hand tools for pond construction, including picks, wheelbarrows, shovels and hand levels. On many occasions, farmers borrowed hand tools from neighbors, and used primitive sleds for transporting excavated soil. All family members generally participated in earth movement and compaction. Ponds were often built by teams of neighboring families, each interested in having their own pond. Frequent visits by the extensionist were necessary during pond construction to ensure proper pond depth and soil compaction in the dikes.

At first farmers were willing to provide labor, but they were naturally reluctant to invest scarce capital in an untested farm enterprise. Some early particpants were given a short section of polyvinyl chloride pipe to drain ponds larger than 100 m^2. This incentive was withdrawn from a community once prospective producers had ample opportunity to evaluate fish farming based on the experience of neighbors. Subsequent pond drains were most frequently made from locally available and more affordable materials, such as cement, clay bricks or stone, plastic tubing, or hollowed bamboo trunks.

Transfer of Production Technology

Guatemalan farmers had little or no previous experience in fish farming. Therefore, novice producers required frequent visits after pond construction until they felt competent and convinced about the production technology. Technology transfer was achieved by extension agent visits and by formal and informal training, Photo 3.

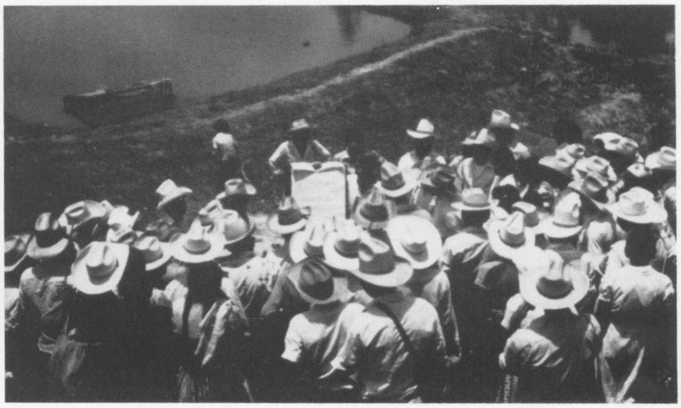

Photo 3. Formal training and demonstration were conducted in the field at the community level. Another effective mechanism for adopting and improving pond management practices was the formation of informal self-help groups.

SITE VISITS. From 1987 through 1989, more than 16,000 site visits were made by extensionists. In 1987, each producer was visited an average of 14 times. In 1989, when more farmers were experienced, the average number of visits decreased to six. Group meetings were encouraged during this period to make outreach more cost effective, as well as to encourage greater responsibility and self-sufficiency among producers. Transfer of technology to farmers by regular site visits was supplemented by formal training, producer-to-producer exchanges, and encouragement and support of informal self-help groups.

FORMAL TRAINING. Formal training of farmers was achieved through 5,400 producer-days of training and demonstrations on topics of aquacultural awareness, pond management, animal husbandry, grain storage, horticulture, soil and forest conservation and formation of cooperatives and informal producer groups.

EXCHANGE VISITS AND INFORMAL PRODUCER GROUPS. Informal training of farmers consisted of 209 farmer-to-farmer exchanges in 1989 and the formation of 47 informal self-help groups, including 22 women's groups. Each informal organization typically included 6 to 10 families. Objectives included interchange of experiences on the effectiveness of different pond management practices, marketing, fish processing and preparation, animal health, and integration of gardening with fish culture.

Since 1987, farmers received more than 16,000 site visits, 5,400 producer-days of formal training, 209 farmer-to-farmer exchange visits, and support in the formation of 47 informal producer groups. The effectiveness and continuing growth of family-scale fish farming in Guatemala are testimony to the value of the extension strategies employed in this project.

FORMAL PRODUCER ASSOCIATIONS. A strategy initially thought useful was the formation of marketing and credit-oriented producer associations. However, by the end of the project only two had been legally formalized. Demand for such entities was apparently overestimated. Marketing and credit groups were not an urgent-felt need of fish farmers. With the exception of integrated fish-poultry operations, fish culture required relatively little capital, and unconsumed fish were readily sold without support from an official producer association. Need for a credit program was observed during the final year of the project, however, as more farmers wished to adopt more capital intensive fish-poultry integrated management. It was decided not to promote a credit program at that late date because of insufficient time for administrative organization, and possibly most importantly, for training of farmers who had little or no previous experience in credit management.

Formal producer associations for credit and marketing were not needed by most farmers during early years of aquacultural development in Guatemala, but such associations are expected to be increasingly important as total fish production begins to saturate local market demand and as more farmers adopt more capital-intensive integrated operations.

Promotion of Integrated Aquaculture

There are two fundamental criteria in the choice of production technology: (1) that required inputs be economically and logistically available; and (2) that the complexity of the technology be compatible with the farmer's understanding. A novice fish farmer requires a relatively simple production system. Manual input of manure and agricultural by-products proved satisfactory for many new participating farmers. As they gained confidence, they progressed gradually and naturally to more complicated and intensive technologies.

Unfortunately, transition from tentative adoption to firm conviction is a difficult passage for many novice fish farmers. Manual additions of nutrients and pond management are labor-intensive. Novice farmers, yet unsure about the benefits of fish culture, often tend ponds only when traditional farm chores are completed. Reduced priority on pond management can lead to unsatisfactory results and subsequent rejection. Initial production technology, therefore, must strike a balance between simplicity and satisfactory fish yield.

Integration of fish farming with rearing of small animals over or near the pond required greater capital investment and coordination, but proper care of the animals assured the farmer of a nearly constant supply of pond nutrients with little additional effort. By the end of the project, 15 percent of the fish ponds were integrated with animal husbandry. Fish productivity was significantly higher and more consistent in these ponds.

From a theoretical perspective, the benefits of integrating fish farming with rearing of small animals seems obvious, but the development stage at which this technology should be promoted is less clear. Increased benefits and enthusiasm of most integrated farmers caused many project staff to conclude that integrated aquaculture should have been stressed from the beginning of the project. However, extension and implementation of integrated aquaculture requires greater technical maturity and support from extension agents, as well as from prospective farmers. It is the opinion of the authors that, even if resources to support that multi-disciplinary effort had been initially available, gradual transition from non-integrated to integrated fish culture was wise. The positive impact of non-integrated fish culture elicited additional support from government and development agencies and permitted a more realistic rate of development for farmers and extension staff.

Lessons Learned about Extension Strategies

Development of fish farming in regions in which it is not traditional is a long process, especially when target communities have limited education and resources. Short-term, heavily subsidized programs generally fail. Long-term vision from supporting and implementing agencies is necessary for aquacultural development among disadvantaged groups. Strategies for aquacultural extension have been widely publicized. Some, however, are less widely accepted in the development community. Notable lessons learned were:

- Temporary expatriate extensionists, such as Peace Corps Volunteers, are unlikely to achieve long-term impact unless a local extension service is incorporated in the development plan. However, a decisive contribution of Peace Corps Volunteers who served as lead extensionists in this program was the identification and training of local counterparts.
- Replacement volunteers enjoy greater credibility with local counterpart extensionists if they have complementary rather than similar skills. The first volunteer at a site should be technically strong in fish pond management, while subsequent volunteers may emphasize other skills, such as animal husbandry, horticulture, or agricultural business.
- Motorcycles for temporary expatriate extensionists, such as Peace Corps Volunteers, may have long-run negative impact if the same support is not provided to local extensionists. Reason: isolated farmers, prematurely deprived of extension support when the volunteer terminates, are likely to permanently reject fish culture.
- Longevity of local extensionists is especially important for introduction of non-traditional practices which require considerable time to achieve farmer trust. Greater longevity and effectiveness of host country extensionists is achieved if they are local farmers with

roots in the community and sincere interest in fish farming. In this case, additional training is required to compensate for limited formal education.

- Classroom training may improve technical competence of local extensionists without effectively enhancing ability to extend that information to farmers. Promoter-to-promoter exchange visits and on-site informal training and field evaluation of extension techniques are useful tools for improving outreach capabilities of extensionists.
- As fish culture became popular, the number of prospective fish farmers grew faster than the country's ability to provide additional trained extensionists. Group meetings of farmers and encouragement of informal producer groups permitted continued outreach to prospective and experienced farmers.
- To promote family scale fish farming, successful fish farmers with resources similar to others in the community were the most effective means of creating awareness and interest. With the exception of a few indigenous communities, communal projects were less effective. Unfortunately, in more isolated and impoverished regions, communal ponds may often be the only practical alternative.
- Construction of fish ponds by manual labor provided by the producer family stimulated greater commitment by the family. Greater commitment leads to better pond management, higher fish production, and greater farmer satisfaction. In less isolated regions, project-supported pond construction with heavy equipment would probably have resulted in more ponds during the early years, but continued growth of fish culture would have been less self-sustaining and the rate of dropout among participants likely would have been higher.

DESCRIPTION OF PRODUCTION SYSTEMS

This chapter describes methods and results of different pond management schemes practiced by participating farmers. Some conditions or management parameters were common to all fish production schemes, while others were peculiar to a given production technique.

Characteristics Common to All Fish Production Systems

Participating families were subsistence level farmers with small land holdings and limited available capital. The family provided most labor. A typical farm had few livestock, mainly free-foraging chickens. Occasionally ducks or turkeys were present, and rarely swine or cattle. All animals were traditional breeds. Their forage was often supplemented with corn or sorghum produced on the farm. Animal manures were seldom used to fertilize crops. A variety of seasonal and permanent crops was grown, but crop residues and by-products were was not composted or used for other purposes.

Pond Construction

The most common operation was a single-pond owned and operated by one family. Ponds were usually hand-dug near the home. Nearly 60 percent of these ponds were constructed on land previously unused for agricultural purposes, but 22 percent of the sites had been used for crops (usually corn, beans, bananas or fruit trees) and 9 percent was pasture.

Three-fourths of the ponds were smaller than 250 m^2, with a median size of 120 m^2. Construction of a median size farm pond required 23 person-days of manual labor and \$6 cash for drain structures. Most ponds were filled by gravity from nearby springs, but about one-fourth were supplied by streams, irrigation canals, and rain runoff, Photo 4.

Photo 4. A typical pond, with surface area of 100 to 150 m^2, was generally hand dug by the male head of household and his sons, and required 25 to 35 person-days of labor. By 1989 more than 1,200 fish ponds had been constructed by rural Guatemalan families.

Culture Species

The principal fish cultured in all farm ponds was the Nile tilapia (*Oreochromis niloticus*). Polyculture was practiced in most ponds to increase productivity and harvest size of fish. Slightly more than half the ponds were also stocked with common carp (*Cyprinus carpio*), desired by many farmers for its larger size. A large native snail (*Pomacea* sp) was stocked in 21 percent of the fish ponds, and a native predator fish (*Cichlasoma managuense*) was used in 14 percent to control overpopulation of tilapia. The stocking densities per 100 m^2 of pond were usually 100 to 300 tilapia, 10 to 30 carp, 20 to 40 predator fish, and 20 to 75 snails.

New ponds were initially stocked at no cost to farmers with fingerlings from government hatcheries. As the need for extraordinary incentives decreased, fingerlings were sold at \$2 to \$3 per hundred. By the end of the project, 60 percent of the farmers produced their own tilapia fingerlings for restocking or sale to other farmers, Photo 5.

Photo 5. Transport of tilapia fingerlings was required only for initial stocking as this fish readily spawns in small ponds, allowing farmers to restock with fingerlings harvested live from the preceding production cycle. Fingerlings were often temporarily stored in small holding ponds dug adjacent to the fattening pond.

Nutrient Inputs

By 1989, most ponds received low-grade supplemental feedstuffs, mainly kitchen scraps, spoiled or rejected corn, leaves, and fruits, and were fertilized manually with combinations of animal manures, compost, and chemical fertilizer. Fish-animal integration, especially fish-poultry, was practiced in the remaining ponds, providing for more consistent and efficient addition of nutrients in the form of chicken manure. Some integrated ponds also received limited supplemental feed.

Harvesting

Fish production cycles were usually 4 to 9 months, at which time ponds were completely drained and prepared for restocking. Most ponds were partially harvested at least once or twice before final harvest. Nearly all harvest labor was provided by the producer family. Turnaround time between production cycles was usually less than 2 weeks, especially for farmers who recovered fingerlings from the previous harvest.

Annual fish production was highly variable, depending on pond size and management practice, but average annual fish yield was 4.0 tons per hectare of pond, equivalent to 48 kg annually from a median size pond of 120 m².

The use of harvested fish was also highly variable, depending on pond size, relative isolation of the farm, and needs of the producers. Many families, especially in indigenous communities, consumed nearly all the fish harvested, while others sold most of the production. Overall, 48 percent of the total harvest was consumed by the producer family, 42 percent was sold, and the remaining 10 percent was used to restock the pond or to donate to neighbors or relatives.

Non-integrated Fish Production

The first and most common methods of fish farming promoted were low-input, non-integrated systems which are labor-intensive and have low requirements for operating capital. The quantity of nutrients added to ponds depended on the resources and interest of the family. Nutrient loading was usually 400 to 1,800 kg per hectare per month, but many ponds received no more than 100 kg of nutrient per hectare per month. All nutrients were manually added by the producer family, 73 percent of the time by women and children.

The principal nutrients added to most non-integrated ponds were animal manure (45 percent) and low-quality supplemental feeds (55 percent) such as spoiled or rejected corn, kitchen leftovers, leaves, and fruit. Ponds were usually partially harvested once or twice before being drained and completely harvested by the entire family. Fish yields were generally 1,500 to 2,800 kg per hectare in 6 months. The next cycle began soon after harvest.

Quantification of inputs and fish production was not possible for every pond. Economic analyses and estimates of productivity for each management practice were therefore derived from a subsample of farmers willing to maintain detailed data. Eleven non-integrated ponds were monitored for one production cycle. They were located in the three major geographic regions of the project: Verapaz highlands, Pacific coast, and Atlantic coast.

Nutrient inputs in the closely monitored ponds were representative of those used by other farmers. Monthly nutrient loading was not constant, but clustered around a "low input" level of 500 kg per hectare or a "high input" level of 1,500 kg per hectare. In both cases, organic and inorganic fertilizers comprised approximately 45 percent of the total nutrient load, while most of the remaining 55 percent consisted of low quality supplemental feedstuffs. The categories of nutrients, in order of decreasing abundance, were: animal manures, spoiled or rejected corn, table scraps, leaves and fruits, commercial chicken feeds, and chemical fertilizers. Chemical fertilizer and commercial chicken feed applied in a few ponds were the only nutrients purchased. The remaining 93 percent of the nutrients were obtained on the farm at no cash cost or as by-products from items purchased for another use.

The close relationship between fish production and quantity of nutrients added is shown in fig. 3. After a 6-month production cycle (including 1 week for pond maintenance) average fish yield from non-integrated ponds was equivalent to 1,514 kg per hectare for "low input" systems and 2,291 kg per hectare from "high input" ponds. Gross feed conversion ratios (FCR), expressed as kg of supplemental feed given per kg of fish harvested, was 1.1 for "low input" ponds and 2.0 for "high input" ponds. Labor and nutrient inputs and size distribution of fish at harvest are detailed in table 1.

TABLE 1. NON-INTEGRATED FISH PRODUCTION WITH LOW- AND HIGH-NUTRIENT INPUTS (500 AND 1,500 kg/HECTARE-MONTH) IN A 100-m² POND STOCKED WITH 170 TILAPIA AND COMMON CARP (9:1), WITH A 6-MONTH PRODUCTION CYCLE

	Low-input	High-input
Nutrient input, kg/cycle		
Fertilizer		
Chemical	1	3
Animal manures	13	38
Feedstuffs		
Corn	9	26
Table scraps	4	11
Leaves and fruit	3	8
Commercial chicken feed	1	4
Total nutrients	31	90
Family labor, hours	31	94
Fish yield, kg	15	23
Harvest composition, percent		
Tilapia >15 cm	11	32
Tilapia <15 cm	68	41
Common carp	19	26
Other	2	1

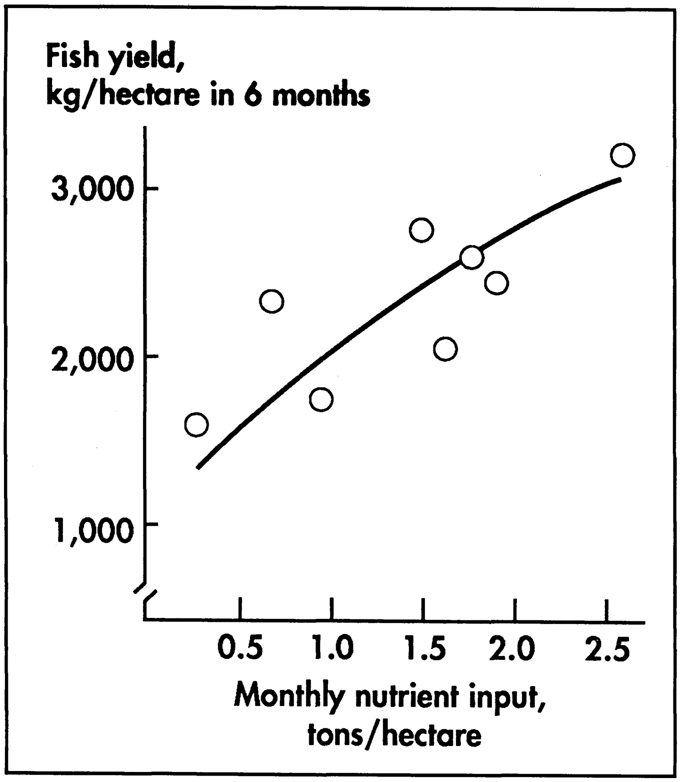

FIG. 3. Relationship between fish yield and rate of nutrient loading (45% animal manures and 55% low-grade feeds) in family-scale fish ponds.

FISH-ANIMAL INTEGRATED PRODUCTION

During the final 3 years of the project, emphasis was given to integration of fish farming with other agricultural activities, mainly broiler or layer chickens and vegetable gardens.

Integration of fish with poultry, either broilers or layers, was more capital-intensive than non-integrated fish production, but provided a more constant source of pond nutrients and produced more and larger fish. Typically, 20 to 40 birds were housed in coops above a 100-m² fish pond, and were given a commercial feed. Daily nutrient loading rates in ponds usually varied from 75 to 200 kg per hectare, 85 to 95 percent of which consisted of fresh manure droppings from the chickens, with the remainder composed of low quality feed ingredients added by the farmer. Under these conditions fish production was 2,500 to 4,000 kg per hectare in 6 months, approximately 60 percent higher than in non-integrated ponds.

Fish-Broiler Integration

Vaccinated 2-day-old chicks were usually purchased by farmers at local supply stores. The chicks were held for 2 to 4 weeks in the farm house, and then transferred to a coop built over the pond. Coops were made of bamboo, cane, sticks, and thatch available on or near the farm. Support pilings were the only purchased materials, Photo 6.

At a density of 9 birds per m² of coop, broilers were grown to 1.5 kg in 7 weeks, using commercial starter and fattening rations purchased from local agricultural supply stores. Gross feed conversion (kg of feed per kg of live broiler produced) was 1.9 to 2.6, with poultry mortality rates of 5 to 7 percent. Labor requirements for care and feeding of birds were 40 to 50 hours per production cycle. At the end of the cycle, most chickens were sold to recover the capital investment. When financially feasible, subsequent batches of chicks were purchased early to permit near-continuous rearing over the pond.

The number of birds per 100 m² of pond surface ranged from 10 to 100, with an average of 32. Bird density was more a function of availability of operating capital than production considerations.

Ten fish-broiler ponds, ranging in size from 100 to 125 m² each, were carefully monitored to determine productivity and economic viability of this production practice. The number of broilers over these ponds ranged from 20 to 100, with an average of 48 per 100 m² of pond surface area. Tilapia and carp were stocked at a ratio of 9:1 and a combined density of 210 fish per 100 m². Duration of the fish production cycle was 3 to 9 months, with an average of 6 months.

The monitored fish-broiler ponds generally received little nutrient input other than lost feed and droppings from the chicken coop. Only 1 of 10 farmers added additional chicken manure to the pond. Low quality supplemental feeds, consisting primarily of table scraps, fresh animal blood, leaves, fruits, and spoiled or rejected corn, were supplied at an average daily rate of 11 kg per hectare. In contrast with the few nutrients added directly to the pond by the producer family, the average amount of fresh manure excreted daily by chickens above the pond was 133 kg per hectare.

Average fish yield from monitored fish-broiler ponds was 3,650 kg per hectare during a 6-month production cycle. Bird density over the pond was higher than generally recommended, but few water quality problems were observed.

Some of the integrated ponds also received limited supplemental feeding with low quality feedstuffs. However, fish yields were no higher than from unfed fish-broiler ponds, indicating no additional benefit from low-quality feeds at high bird densities over the pond.

Fish-Layer Integration

Fish production was integrated with a small-scale layer operation on some farms. Birds were sometimes purchased by farmers as 6-week chicks from project-sponsored centers. They were given supplemental feed and allowed to forage freely during the day until they approached maturity about 3 months later. Another option was to buy early adult 18-week hens from local suppliers and to immediately coop the hens over the pond at a density of 4 to 7 birds per m² of coop. Egg production generally began about 1 month later at an age of nearly 5 months and average weight of 1.5 kg. Egg collection continued for about 10 months, at which time average bird weight was 2.3 kg.

Average daily egg production during the laying period was 0.5 to 0.6 egg per bird. With a commercial ration, 1.9 to 2.4 kg of feed were consumed per dozen eggs produced. Bird mortality averaged 12 percent during the laying period. Egg production and survival were somewhat lower than recorded for the same breed of hens in traditional coops with earthen floors and bedding. Labor requirements for care, feeding, and egg collection for a typical batch of hens were 20 to 25 hours per month.

Production cycles for layers over fish ponds usually lasted 1 year, including one month before egg production, 10 months of laying, and 1 month of preparation before beginning the next production cycle. Consequently, two 6-month fish production cycles were completed during a single layer cycle.

Fish-layer integration was closely monitored in seven private ponds ranging in size from 100 to 230 m². The number of layers cooped over the pond varied from 12 to 37, with an average of 17 per 100 m² of pond surface area. Ponds were stocked with tilapia and common carp at a ratio of 9:1 and a density of 140 to 300 fish per 100 m². The fish culture period varied from 4 to 11 months, with most cycles lasting 5 to 7 months. Five of the seven monitored ponds received light supplemental feeding (usually less than 1 percent of total fish weight daily) with low-grade feedstuffs, primarily spoiled or rejected corn, table scraps, and leaves. Average daily feeding rate was equivalent to 13 kg per hectare, while fresh manure was excreted by layers above the pond at an average daily rate of 94 kg per hectare. Total labor requirements for fish-layer operations were similar to fish-broiler operations.

Average production from monitored fish-layer ponds was 2,876 kg of fish and edible snails per hectare of ponds during a 6-month production cycle. Like the broiler integrated ponds, nearly two-thirds of the fish crop were individuals larger than 15 cm.

Inputs and yields of both fish-poultry management practices are compared in table 2.

TABLE 2. FISH PRODUCTION WHEN INTEGRATED WITH CHICKEN BROILERS OR LAYERS OVER A 100-m² POND STOCKED WITH 200 TILAPIA AND CARP (9:1), WITH A 6-MONTH PRODUCTION CYCLE.[1]

	Broilers (48)	Layers (17)
Nutrient inputs to pond, kg/cycle		
Feedstuffs		
Corn	2	7
Table scraps	8	5
Leaves and fruit	3	1
Commercial feed	2	4
Blood	4	0
Insects	0	5
Subtotal, feedstuffs	19	22
Fresh poultry manure[2]	233	164
Other manures	6	2
Labor for fish, hours	61	56
Fish yield, kg	36	29
Harvest composition, percent		
Tilapia >15 cm	48	42
Tilapia <15 cm	39	42
Common carp	13	16

[1] Inputs and outputs are listed only for fish pond; analyses of combined bird and fish components are presented in Appendix 6 and 7.
[2] Weight of poultry manure, with moisture content of 50%, was estimated by multiplying 0.48 times the weight of feed given to poultry.

INTEGRATION OF GARDENING WITH FISH PRODUCTION

By the final year of the project, 21 percent of the fish ponds were integrated with vegetable gardening. Crops produced less direct benefit to fish culture than did integration with animals, but a synergistic relationship did exist between the two activities. Cost and effort to develop water supply systems were more easily justified as water was needed for both fish and vegetable production. A reliable water supply to vegetable plots permitted year around gardening instead of single crops only in the rainy season. Physical proximity of the garden and pond often gave rise to more frequent attention to each of the two activities. By-products from the garden were an additional source of pond nutrients. Likewise, the pond was a more reliable source of nutrient-rich water for irrigation, and muds from the pond bottom were an excellent source of fertilizer for the garden.

Gardens varied in size from 50 to 370 m². Popular vegetables for home consumption included squash, pepper, radish, carrots, cucumbers, and green beans. More common crops for sale in markets were cabbage, tomatoes, broccoli, and onions. A mix of vegetables was usually produced simultaneously for a more diversified crop. Short cycle crops were intermixed with long cycle crops for more continuous production. Average labor requirements for a 100-m² plot were 105 hours during a 4-month cycle.

Farmers who wished to practice fish-garden integration initially received seeds from project extensionists. Subsequently, farmers produced their own seeds or purchased them with proceeds from sales. Pests and weeds were generally controlled manually in small plots, developed for home consumption. In larger commercial size plots chemical pesticides were applied with spray pumps loaned by the extensionist.

Garden plots were developed as family or community efforts, with women and children being the most active and enthusiastic participants. The benefits of fish-garden integration were judged to be real and substantial by farmers, but could not be reliably quantified because fish and vegetable production cycles were seldom synchronized and control plots were not included.

FACTORS AFFECTING POND MANAGEMENT PRACTICES

New agricultural practices are adopted only if they are compatible with needs and the physical, cultural, and economic environments. The response of farmers to different production systems confirmed some earlier ideas on program design and stimulated a reevaluation of other management practices and strategies. This section discusses factors affecting the appropriateness of management practices for small-scale fish farmers in Guatemala.

PHYSICAL AND BIOLOGICAL FACTORS

Availability of Land and Water

The scale of aquacultural enterprises was limited by availability of land and water. Most participating families had land holdings of less than 1 hectare. With such limited resources, good agricultural land was usually dedicated to traditional food production practices. Only 30 percent of the ponds were constructed on sites previously dedicated to pasture or production of corn, beans, or fruit. Most ponds were excavated in soil that was waterlogged or agriculturally unproductive. Lack of an acceptable pond site was a common constraint for many prospective fish farmers.

Availability of adequate water was an even more limiting factor for new fish ponds. Rainwater runoff from surrounding land filled only 4 percent of the ponds. An additional 26 percent of ponds were filled with available water from irrigation canals or potable water supplies, but the most common water source (62 percent) was springs and creeks. Hilly terrain permitted gravity-fed water to nearly all ponds. Less than 1 percent of the ponds were filled by pumping, a financially unfeasible alternative for most families.

Pond Size

Hilly terrain and small land holdings were factors that most influenced the size of ponds. All ponds were hand-dug by the family, which limited the size of some ponds. The median size pond was 120 m^2.

Smaller ponds produce less fish, and low fish production dampens enthusiasm of novice fish farmers. Likewise, an extension visit requires the same effort, whether a farmer's pond is large or small. These considerations have led to the establishment of minimum pond sizes in many development programs around the world. Did the strategy to construct small ponds with family labor constrain or encourage long-run growth of aquaculture? From one perspective, the question is irrelevant because pond construction with heavy equipment was a financial and logistical impossibility for most farmers. From a planning perspective, however, should a program-sponsored subsidy for construction have been encouraged? Limited availability of pond nutrients and the historical response to construction subsidies suggest the benefits of hand-dug ponds more than compensated for the disadvantages.

In an earlier aquacultural project in Guatemala, larger ponds were built with heavy equipment for less disadvantaged farmers. Most of these ponds were subsequently poorly managed or abandoned. The causes were multiple, but lack of a feeling of ownership was likely an important factor.

Effort expended by a family in the construction of hand-dug ponds motivated better pond management. Strong motivation is important for novice fish farmers since their natural tendency is to tend to their ponds only after traditional chores have been completed. Inadequate pond management during the first crop can lead to low fish production and a domino effect on subsequent crops.

The above argument in support of hand-dug ponds is subjective and impossible to prove from field data. The following consideration of availability of nutrient inputs, however, demonstrates more objectively the appropriateness of small ponds for this target group.

Financial and logistical constraints limited most pond nutrients to materials produced on the farm. With limited nutrient inputs available from small farms, enrichment levels in large ponds were often inadequate. Consequently, fish production was directly proportional to pond size up to approximately 200m^2, but larger ponds did not produce significantly more fish, figure 4. It was concluded that water restrictions, topography, and harvesting difficulties were contributing factors, but limited availability of nutrients was perhaps the most important reason to encourage construction of small ponds for most farmers in the region.

Effect of Nutrient Loading Rate on Fish Production

A general aquacultural principle is that, within limits, fish production per unit area is directly related to nutrient loading, but each additional increment of nutrient produces slightly less benefit. Nutrients should be added until the value of the last increment of nutrient is just equal to the value of the extra fish produced by those additional nutrients.

In non-integrated fish ponds, most farmers added a 55:45 mixture of animal manures and low-grade feedstuffs at rates ranging from near 500 to more than 1,500 kg per hectare per month. Based on data from 11 closely monitored non-integrated ponds, average annual fish production at nutrient loading rates of 500 kg per hectare-month was about 3000 kg per hectare. Annual fish production increased to almost 5,000 kg per hectare when nutrient loading rates were 1,500

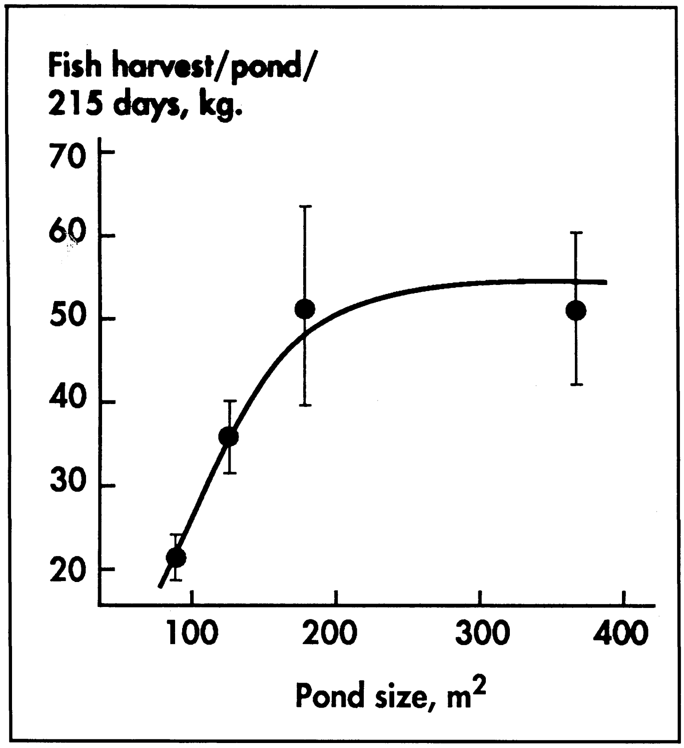

FIG. 4. Relationship between fish production and size of pond (mean value and 95% confidence intervals of four size categories: <100 m^2, n = 103; 100-149 m^2, n = 70; 150-199 m^2, n = 29; 200-500 m^2, n = 26).

kg per hectare-month. At the low loading rate, slightly less than 2 kg of nutrients were added per kg of fish produced. At the high loading rate, fish production increased by 55 percent, but nearly 4 kg of nutrients were added per kg of fish produced.

Optimum nutrient loading rate in ponds was influenced by availability and cost of nutrients, where "cost" was usually non-cash family labor and the alternative use of nutrients. Conditions were highly variable from farm to farm, so no simple conclusion on optimum loading rates was possible. For farmers capable of adding nutrients at a monthly rate of 5 to 15 kg per 100m², a simplified question was: "I can produce 20 kg of fish with 40 kg of feed and manure. Would an additional 10 kg of fish be worth adding 80 more kg of feed and manure?." For many families the response was "Yes."

Effect of Nutrient Loading Rate on Fish Size

Most families were more interested in total weight of fish produced than size of individual fish, but the latter was considered important. All fish were consumed, but many preferred a fish size of about 15 cm for individual serving to each family member.

Nutrient loading rates in ponds not only affected fish production, but also final size of individual fish. When food supply was abundant, fish reached a larger size before growth was stunted by competition with offspring.

When total nutrient inputs in non-integrated ponds were near 500 kg per hectare-month, only 30 percent of the harvest consisted of fish 15 cm or larger. But at input levels of 1,500 kg per hectare-month, nearly 60 percent of the fish were at least 15 cm. Likewise, in fish-poultry integrated ponds receiving heavy and constant manuring, approximately 60 percent of the fish crop were 15 cm or greater.

Altitude above Sea Level

Participating families lived at elevations ranging from 200 to 1,800 m above sea level. At the higher elevations, average ambient temperatures were as low as 18° C, while average temperatures along the coast were often as high as 30° C. Fish are "cold-blooded" animals, unable to regulate body temperature. Appetite and metabolism slow at cooler temperatures and accelerate in warmer climates. Other factors being equal, production of warmwater fish, such as tilapia, would be somewhat suppressed at the higher, cooler elevations. This was observed to be true in Guatemala, table 3.

TABLE 3. MEAN FISH YIELDS FOR NON-INTEGRATED PONDS AT THREE ALTITUDES (n = 238 HARVESTS)

Altitude (m above sea level)	Annual yield (hectare, kg)
< 500	5,200
500 - 1,000	4,000
> 1,000	3,500

An evaluation of the effect of altitude/temperature on fish production is complicated by other factors also strongly correlated with altitude. Higher elevations were mainly populated by indigenous communities. In comparison with mixed-race ladinos, they were economically more disadvantaged, possessed less land, and traditionally practiced less animal husbandry (an important source of pond fertilizer). These factors would tend to further depress fish production at higher elevations. On the other hand, higher altitudes are generally moist, and indigenous groups are efficient horticulturists, factors that likely increase the availability of "green" manure and agricultural by-products to boost pond productivity.

The combination of factors other than temperature that were closely linked to elevation prevent a clear understanding of the impact of altitude on fish production in Guatemala. An important observation, however, is that fish culture was demonstrated to be a profitable and acceptable agricultural activity up to an altitude of at least 1,600 m above sea level.

Duration of Production Cycle

Duration of production cycles (time from stocking to harvest) ranged from 3 to 14 months, and the average culture period was about 7 months for both integrated and non-integrated ponds.

Total weight of fish in ponds continued to increase after the third month, but at a decreasing rate. Consequently, on an annual basis, farmers produced greater total weight of fish with short-cycle crops rather than with fewer long-cycle crops. Estimated average annual fish production with three 4-month crops was approximately 4,500 kg per hectare, while a single 12-month cycle produced only 3,200 kg per hectare, figure 5.

Another advantage of short-cycle crops was that fish were available for consumption or sale at more frequent intervals. Reasons for delaying complete harvests were market timing, scarcity of water for refilling ponds, and unavailability of harvest equipment or labor. Also, in cooler regions, reproduction was delayed, so farmers would delay final harvest until the original stock had spawned and fingerlings were available for restocking. Fish sales were usually associated with complete harvests, but frequent partial harvests during the cycle improved the availability of fish for home consumption.

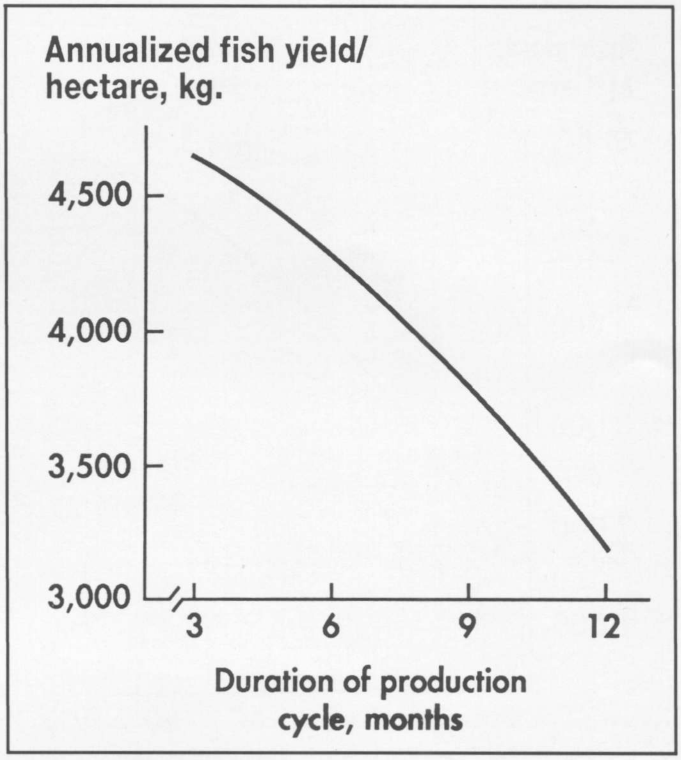

FIG. 5. Annual fish yield as a function of the duration of a production cycle (all ponds, n = 230).

Effect of Fish-Poultry Integration on Fish Production

Fish-poultry integrated ponds were more productive than non-integrated ponds. Raising poultry over ponds was a labor-saving pond fertilization technique. In non-integrated ponds, nutrients were added periodically in quantities generally ranging from 500 to 1,500 kg per hectare per month, while with fish-poultry integration, fresh manure dropped daily into the pond, usually in quantities exceeding 3,000 kg per hectare per month. An additional benefit of integration was that physical proximity of the two activities allowed more frequent monitoring and management of pond conditions, Photo 6.

Bird density over the pond ranged from less than 10 to more than 100 per 100 m² of pond surface. Fish yield was positively correlated with bird density. With 10 to 20 birds per 100 m² of pond, fish production in 6 months generally oscillated around 2,500 kg per hectare, while at bird densities of 60 to 100 birds per 100 m², fish production consistently exceeded 5,000 kg per hectare in 6 months, figure 5. The higher bird densities were greater than normally recommended in aquacultural literature, but mass fish mortalities from poor water quality were not reported.

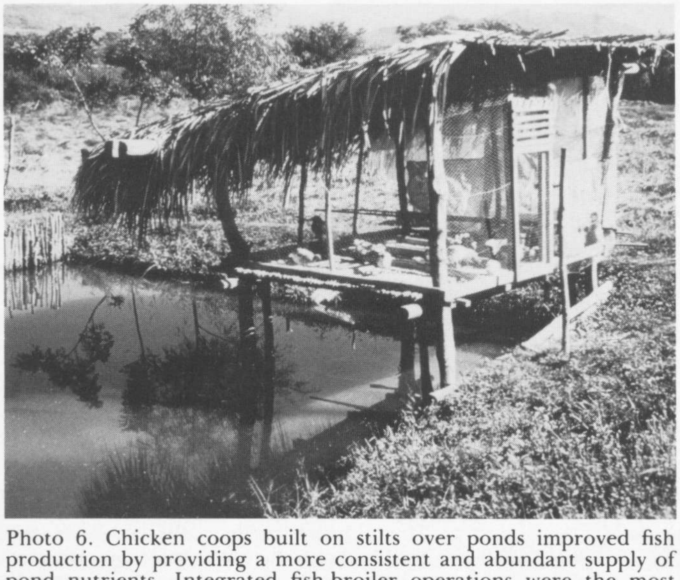

Photo 6. Chicken coops built on stilts over ponds improved fish production by providing a more consistent and abundant supply of pond nutrients. Integrated fish-broiler operations were the most productive and profitable of all enterprises studied, but high capital requirements exclude many rural families.

Biological Factors Affecting Poultry Production

Broilers are particularly susceptible to cold temperatures during the first 3 weeks of life. Chick mortalities due to cold accounted for 19 percent of the broiler mortalities. Participating farmers soon learned to keep improved varieties of chicks in their homes during the first 3 weeks.

Intensive poultry operations with nutritionally complete feeds under confinement were not common in the target region, but when practiced, chickens were normally housed in coops built on land. For fish-poultry integration, coops were built on stilts over ponds and had slatted floors to permit droppings to fall into the pond. This practice exposed the birds to additional humidity and breezes. Disease and cannibalism produced 80 percent of all layer mortality. Reduced survival was most problematic at higher, cooler altitudes. Uneven slatted floors also stressed layer hens more than broilers, as they were heavier and remained in the coop longer.

The original strategy was to favor layers over broilers, as the longer production cycle (10 months versus 2) would reduce logistical problems of chick transport, and continuous egg production would encourage improved family nutrition. However, lower than expected egg production

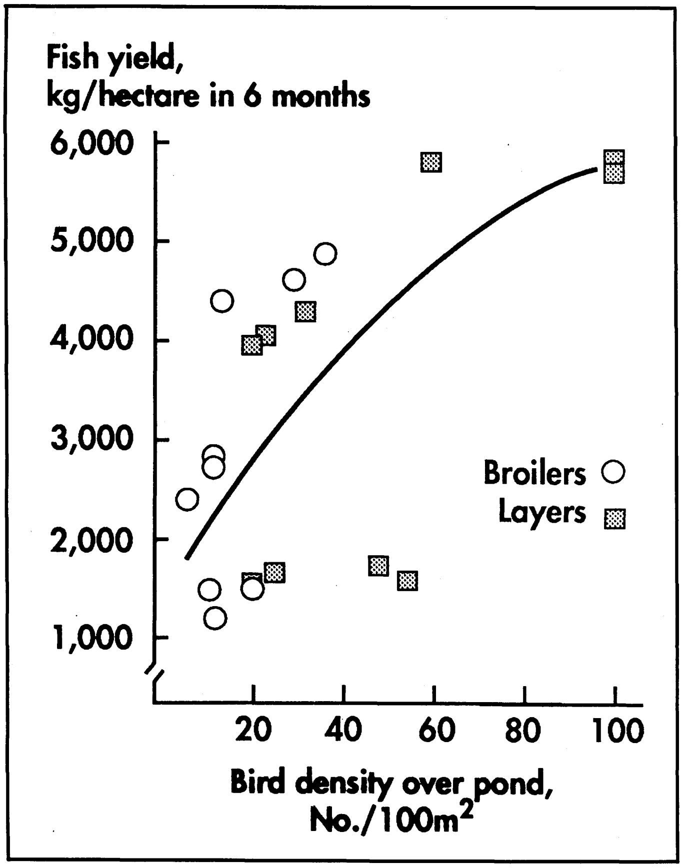

FIG. 6. Relationship between fish yield and number of chickens in coops built over ponds.

and survival, combined with more complicated feeding and vaccination schedules, made fattening of broilers more favorable.

The following lessons were learned about fish-poultry integration:

- In cooler climates, recently hatched chicks must be kept 3 weeks indoors before release to coops over ponds.
- Coop floors should be built at least 1 m above the pond surface to reduce stress on birds from humidity and cold breeze.
- Broilers do better than laying hens in rustic coops built over ponds.
- Physical and nutritional requirements of improved bird stocks create serious inconveniences for many subsistence farmers. Night cooping of native chickens is a biologically and financially better alternative for many families.
- Rustic coops with slatted floors over ponds negatively affect egg production and survival of layer hens. Local varieties freed to forage during the day and cooped only at night over the pond may be more appropriate for small-scale egg production.

Biological Factors Affecting Vegetable Plots Near Ponds

Most farmers had little land appropriate for vegetable farming. In most cases irrigated vegetable gardening would not have been practiced in the absence of fish farming since the time, effort, and cost for water supply would not have been justified for vegetable production alone.

Once project support is withdrawn, vegetable production by these farmers may be curtailed as the result of various constraints: (1) Transfer of production technology has been incomplete because Peace Corps Volunteers and promoters themselves did not receive sufficient training, (2) disease and pest control are common problems, and (3) many varieties are hybrids and cannot be used to produce seeds, and locally available seeds often have poor germination rates.

End-of-project conclusions regarding integration of vegetable production with fish farming were that the concept was appropriate and well received by many producers, but increased extension assistance and technical and infrastructural support are required for most farmers to achieve self-sufficiency.

Socio-Economic Factors Affecting Pond Management

Project data were grouped for economic analysis into five production systems: non-integrated fish enterprises with two levels of nutrient input (low and high); two integrated fish-poultry systems (fish-layer and fish-broiler); and a mixed-vegetable enterprise with irrigation from pond water. To differing degrees, all enterprises utilized on-farm labor and materials to reduce the need for cash expenditures. Non-cash inputs, however, have value (i.e. opportunity cost) and must be considered in a complete economic analysis.

Cost and return data for each alternative production system include investment costs, receipts, variable and fixed costs, and family labor. Returns to traditional agricultural use of land are presented as indicators of the appropriateness of land conversion to aquaculture. Advantages and disadvantages of each system are partly based on breakeven prices and yields and on financial (cash only) and economic (cash plus non-cash) cash flow analyses and internal rates of return.

Investment Costs

Average labor requirements and construction costs, as a function of pond size, are provided in figure 7 and Appendix I. Family labor, a non-cash cost, accounted for 84 to 91 percent of total construction costs. Cement was purchased by some farmers to build pond drainage structures. Often, the only material required was a hose for water supply when open canals were unfeasible. Some farmers purchased hose for filling or draining ponds, instead of borrowing from the extension agent.

Cash cost for construction of a typical family fish pond was only $5 to $10 and was usually not a limiting factor in farmers' decisions to build ponds. Construction of hand-dug ponds was economically limited only by availability of family labor.

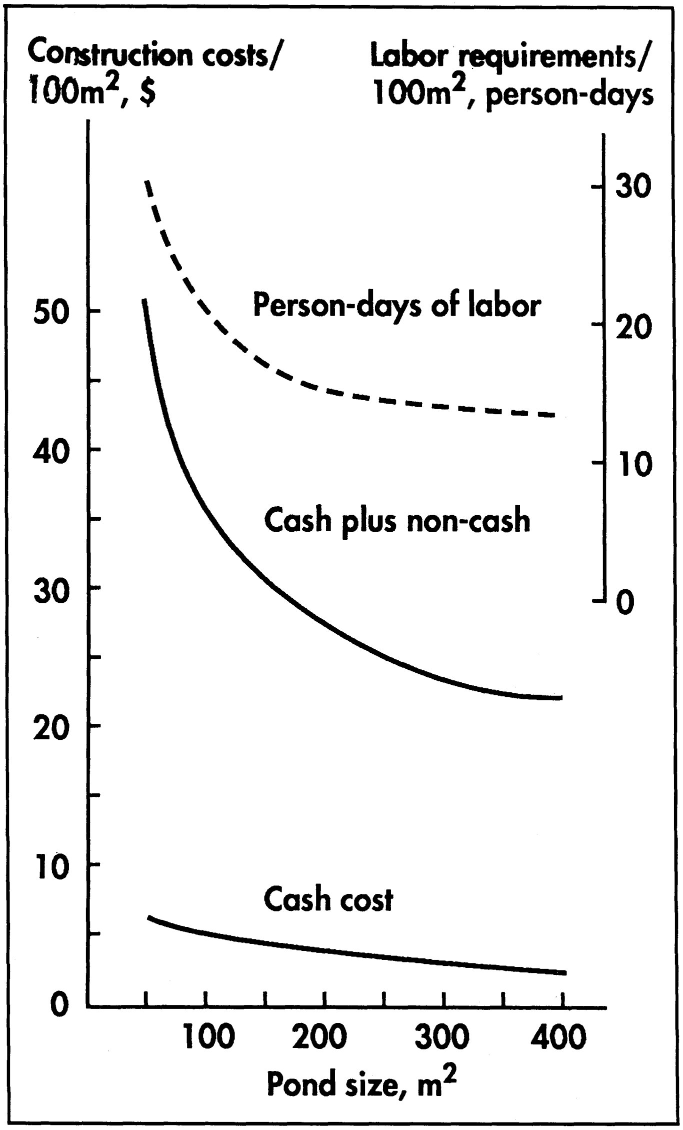

FIG. 7. Labor requirements and construction costs of hand-dug fish ponds as a function of pond size, Guatemala, 1989.

Fish-poultry integrated systems also required purchase of chicks. Consequently, cash investment requirements were higher than for non-integrated fish or crop enterprises. Purchase of chicks and carp fingerlings was a recurrent cost for each production cycle, whereas tilapia fingerlings were a "one-time" cost because this species readily spawns in ponds. No investment costs were charged to corn and mixed vegetable production, as that land had been prepared for traditional agriculture many generations earlier.

Financial and Economic Analyses of Individual Enterprises

Financial analyses include only cash items, whereas economic analyses also incorporate values for non-cash items, such as labor and feed from on-farm sources.

Annualized enterprise budgets, financial and economic cash flows, and 20-year internal rates of return were developed for all enterprises. The only fixed cost was depreciation of ponds over 20 years and poultry coops over 4 years. No opportunity cost for land was charged in enterprise budgets and cash flow analyses. However, financial and economic internal rates of return include a cash land value equal to the average commercial worth of small agricultural plots in the target regions. Family labor, a non-cash variable cost, was incorporated separately into enterprise budgets after calculation of net return to land and management. Labor requirements for all enterprises are summarized by task in Appendix II. Costs and returns for integrated enterprises are itemized for fish and poultry to allow analysis of both components.

Physical production assumptions are specified in Appendix III. Assumed commonalities for all production systems include percent of fish production consumed on farm, fingerling restocking strategies, opportunity costs, and fish size preferences. Economic analyses are expressed on a per hectare basis in the narrative to facilitate comparison with other fish and agricultural activities. Tables and appendices describe the economic impact on individual families based on typical production units of 100 m^2.

LOW-NUTRIENT, NON-INTEGRATED FISH ENTERPRISE.

Cash and non-cash variable inputs for low-input, non-integrated fish production included feedstuffs, fertilizers, labor, and fingerling fish. Variable cash costs were carp fingerlings, corn, feed concentrate, and chemical fertilizers. Non-cash variable costs included family labor, tilapia fingerlings, and household or farm by-products, such as table scraps, leaves, blood, cassava, fruit, and animal manures. Approximately 74 percent of fixed and variable costs were non-cash items, primarily family labor and on-farm feedstuffs. An enterprise budget for this system is presented in Appendix IV.

Financial indicators suggest low-nutrient non-integrated fish farming was viable both financially and economically. With the sale of 40 percent of the fish, net annual financial (cash only) return to land and management was $1,082 per hectare. When opportunity costs and receipts for non-cash items were included, net annual economic return to land and management was $1,734 per hectare. The 20-year internal rate of return to management was 31 percent on a financial (cash only) basis and 29 percent on an economic (cash plus non-cash) basis.

Time required for financial breakeven of this enterprise was a single fish crop (6 months), but with the relatively high non-cash cost of pond construction, four fish crops (24 months) were needed for economic breakeven. Risk of failing to cover cash costs was low, as price and marketed fish yield required to break even were only 24 percent of actual prices and yield.

HIGH-NUTRIENT NON-INTEGRATED ENTERPRISE.

Categories of pond nutrients in this enterprise were similar to the low-nutrient system, but quantities were approximately three times as great. Labor requirements for feeding were proportionally higher, accounting for 71 percent of total family labor and nearly half of the total economic cost of production. The enterprise budget for this system is presented in Appendix V.

Only 24 percent of all production costs were cash items, but 40 percent of the fish crop produced cash receipts. Therefore, financial viability was greater than economic viability. Net annual financial return to land and management was $1,685 per hectare, while net annual economic return to land and management was $1,271 per hectare. Similarly, the 20-year internal rates of return were 48 percent (financial) and 22 percent (economic).

High-nutrient, non-integrated fish farming produced lower net returns than the low-nutrient system when an opportunity cost for family labor was included. However, net financial return to land, labor, and management was higher for the high-nutrient system. Optimum management strategy for a non-integrated fish enterprise, therefore, depended largely on availability and perceived value of family labor. High-nutrient fish farming was more appropriate when family labor was underemployed and income generation was inadequate.

Financial breakeven was achieved with a single 6-month fish crop, but with the inclusion of non-cash items, five crops (30 months) were needed for economic breakeven. Market prices and fish yields were nearly three times as high as required for financial breakeven, indicating low cash risk for farmers.

FISH-BROILER INTEGRATED ENTERPRISE.

This integrated enterprise was both cash- and labor-intensive. In comparison with the high-nutrient non-integrated enterprise, labor requirements for fish-broilers were more than double and cash costs were more than 30 times greater. However, some cost savings were gained by integration. Combining tasks created savings. For example, feeding broilers and cleaning coops simultaneously enriched the fish pond at zero additional labor cost. Likewise, an abundant supply of poultry manure reduced dependence on labor-intensive collection of on-farm nutrients and purchase of supplemental feedstuffs.

The broiler component of this integrated enterprise was cash intensive, requiring high cash outlay for chicks, feed, vaccines, and transportation. Family labor was the only non-cash variable cost, accounting for only 11 percent of total variable cost for broilers. Manure, the only non-cash receipt from broilers, was included as both cost to fish production and return to poultry. Although these items cancelled to zero for the combined enterprise, a full accounting provided a better indication of the chicken and fish components in isolation.

In contrast with the broiler component, cash cost of fish production was only 13 percent of total fish production cost. Labor requirements for fish were less than half those of the broiler component and intermediate between the high- and low-nutrient non-integrated fish enterprises. The enterprise budget for the integrated fish-broiler activity is presented in Appendix VI.

Start-up and operating costs were high for the fish-broiler enterprise, but economic and financial indicators were highly positive. Net annual return to land and management exceeded $25,000 per hectare and had an internal rate of return greater than 200 percent.

In comparison with non-integrated fish enterprises, association with broilers more than doubled financial viability and nearly tripled economic viability of family-scale fish farming in Guatemala. The high capital investment requirements, however, excluded many farmers.

Financial breakeven for the combined enterprise required only one broiler cycle or 2 months, while economic breakeven occurred in 6 months with harvest of the first fish crop.

High operating cash requirements for broilers make risk analyses more critical, but a reasonably acceptable risk for broilers was indicated by actual yields and market prices that exceeded financial breakeven values by 54 percent. Financial risk for the enterprise was further cushioned by the fish component, with a much wider margin between actual and breakeven prices and yields. Less capital-intensive variations on this system existed for poorer farmers, such as native chicken stocks confined over the pond at night and allowed to forage freely for food during the day. However, insufficient data were available for economic analysis.

FISH-LAYER INTEGRATED ENTERPRISE.

The layer component of this fish-poultry enterprise was also capital-intensive. Variable cash cost for layers was similar to broilers and was at least 15 times greater than non-integrated fish enterprises. The only non-cash variable cost for layers was family labor, which accounted for 19 percent of total variable cost. Ninety-seven percent of the variable cash cost for the fish-layer integrated enterprise was to sustain the layer activity.

The fish component required primarily non-cash inputs. Cash for purchase of carp fingerlings and some pond nutrients was only 17 percent of total variable costs for fish. Labor and other pond nutrients from on-farm sources were non-cash inputs. Fish required only one-third of the total labor needs of the combined enterprise.

Cash receipts for the integrated enterprise were derived from sale of 40 percent of the fish, all eggs, and spent layers after 1 year of egg production. Non-cash receipts included fish consumed at home and chicken manure for pond fertilization. The enterprise budget is presented in Appendix Table VII.

The enterprise was financially more viable than non-integrated fish farming, by a considerable margin, with net return to land and management exceeding $8,000 per hectare and an internal rate of return of 200 percent. With the inclusion of non-cash opportunity costs and receipts, the poultry component in isolation produced slightly negative net returns, but the fish component, with high fish yield at low cost, made the integrated enterprise also economically viable. Net economic return to land and management exceeded $4,100 per hectare and internal rate of return was 56 percent. Time required for financial and economic breakeven of the combined enterprise were 9 and 23 months, respectively. The layer component in isolation required nearly 4 years for economic breakeven.

Financial indicators, such as net return to land and management and internal rate of return, suggest the average fish-layer integrated operation was viable. However, financial risk for the capital-intensive layer component, already substantial because of great variability in survival and laying efficiency, was further aggravated by a narrow margin of safety (24 percent) between actual and breakeven prices and yields for eggs. Therefore, there was a transition of farmers from fish-layer to fish-broiler operations.

ALTERNATIVE AGRICULTURAL CROPS.

Corn was the most widespread and traditional crop in the region, and was grown mostly for home consumption. Financial and economic analyses for a small-scale corn enterprise were developed from information provided by project promoters and the Guatemalan Ministry of Agriculture.

Three-fourths of all production costs were opportunity costs for non-cash items, primarily family labor. The only cash costs were fertilizer and pesticides. No investment cost was charged because most land was in agricultural use for many generations. Financial and economic analyses assume that 75 percent of the crop was consumed by the family, and the remaining 25 percent was sold for cash. The enterprise budget for corn is presented in Appendix VIII.

With the sale of only one-fourth of the corn crop, net financial return to land and management was negative, but where pesticides could be eliminated with no loss in production, net financial returns were marginally positive. When opportunity costs for family labor and other non-cash items were included, economic losses exceeded $1,000 per hectare. However, net economic return to land, labor, and management was $152 per hectare for a single crop. When all opportunity costs are analyzed, the economic breakeven price was considerably greater than the market value of corn, but with no charge for family labor breakeven price was 25 percent below the market price.

Economic analysis alone suggests that small-scale corn production, as practiced in the region, was not a competitive agricultural enterprise. However, food preferences, nutritional needs, and agricultural traditions are overriding considerations. Most corn is produced for home consumption, and is a staple dietary item that will continue to be grown regardless of cash or economic returns.

Mixed Vegetables. Mixed vegetable gardening was promoted primarily for income generation, as the market value generally exceeded the perceived value to farmers for home consumption. The enterprise budget for this activity was based on two irrigated crops per year in small garden plots.

Cash inputs were required for seed, fertilizers and chemical pesticides. Family labor, the only non-cash cost, was 61 percent of total production cost. Financial and economic analyses presume 75 percent of the crop produced cash receipts, and the remaining vegetables were consumed by the producer family.

Both economic and financial indicators were highly positive for mixed vegetable production. Net financial and economic return to land and management for each 4-month crop exceeded $2,000 per hectare. Financial and economic breakeven required only one production cycle. Actual market prices and yields were more than three times higher than required for financial breakeven, indicating low risk against unexpected declines in production or market value. The enterprise budget for mixed vegetables is presented in Appendix IX.

Fish farming enhanced the integrated mixed vegetable enterprise by improving water availability, but vegetable plots had little direct impact on fish production. Internal rates of return for a single mixed vegetable cycle during the rainy season were 88 percent (cash items only) and 68 percent (cash plus non-cash items). A second crop, made possible by irrigation water from the fish pond or its supply canal, doubled financial and economic internal rates of return to management.

FINANCIAL AND ECONOMIC COMPARISON OF ENTERPRISES

Cash and non-cash items for the four aquaculture and two alternative crop systems were separated to analyze the degree to which each placed cash demands on or provided income to households. Summaries of annual enterprise budget indicators, table 4, cash flow analyses, and time required for financial and economic breakeven, table 5, permit comparison of the resource efficiency of each enterprise.

TABLE 4. FINANCIAL AND ECONOMIC ANNUAL ENTERPRISE BUDGET INDICATORS FOR SIX ENTERPRISES ON PRODUCTION AREAS OF 100 m^2 (US$), GUATEMALA, 1989[1]

Enterprise	Investment costs		Gross receipts		Variable costs[2]		Income above variable costs		Net returns to land and management		Internal rate of return[3] (20-year)	
	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic
Non-integrated fish											*Pct.*	*Pct.*
Low nutrient	5.34	35.54	16.72	39.92	5.64	20.80	11.08	19.12	10.82	17.34	31	29
High nutrient	5.34	35.54	29.65	66.26	12.54	51.77	17.11	14.49	16.85	12.71	48	22
Integrated fish												
Fish-broilers	10.12[4]	59.50	711.94	775.37	443.31	506.61	278.63	268.76	277.17	251.24	694	289
Broilers	4.78	23.96	666.40	672.24	428.79	479.51	237.61	192.73	236.41	186.73	–	–
Fish	5.34	35.54	45.54	103.13	4.52	27.10	41.02	76.03	40.76	64.51	–	–
Fish-layers	10.12[4]	59.50	299.85	346.48	218.24	296.80	81.61	49.68	80.14	41.91	203	56
Layer	4.78	23.96	264.99[5]	268.18[5]	212.40	263.12	52.59	5.06	51.39	–0.94	–	–
Fish	5.34	35.54	34.86	78.30	5.84	33.68	29.02	44.62	28.75	42.85	–	–
Alternative crops												
Corn (1 crop/year)	0.00[6]	0.00	1.50	6.00	3.66	15.68	–2.16	–9.68	–2.16	–10.24	negative	negative
Mixed vegetables												
1 crop/year	0.00[6]	0.00	38.21	50.95	11.96	30.59	26.85	20.36	26.25	20.36	88	68
2 crops/year	0.00[6]	0.00	76.42	101.90	23.92	61.18	52.50	40.72	52.50	40.72	175	136

[1] All fish production cycles were 180 days with 2 crops annually. Layers had one-year cycles, while broilers had six 49-day cycles per year. Corn had one 100-day cycle during the rainy season. For vegetable production, a second crop was feasible when integration with aquaculture permitted irrigation.
[2] Family labor is included as non-cash variable cost.
[3] These calculations include a land value of $30 per 100 m^2.
[4] Includes initial broiler/layer purchases but not subsequent repurchases.
[5] Includes receipts from sale of spent layers and value of manure, where appropriate.
[6] Assumes crop land was already in agricultural use and required no additional investment costs.

TABLE 5. FINANCIAL (CASH) AND ECONOMIC (CASH PLUS NON-CASH) ANNUAL CASH FLOWS AND TIME REQUIRED TO BREAKEVEN FOR SIX ENTERPRISES ON PRODUCTION AREAS OF 100 m^2, GUATEMALA, 1989

Enterprise	Annual cash flow, US$				Time to breakeven, months	
	First Year[1]		Succeeding Years[1]			
	Financial	Economic	Financial	Economic	Financial	Economic
Non-integrated fish						
Low nutrient	5.74	–16.42	11.08	19.12	6	24
High nutrient	11.77	–21.05	17.11	14.49	6	30
Integrated fish						
Fish-broilers	268.51	199.50	278.63	259.00	2	6
Fish	35.68	30.73	41.02	66.27	5	11
Broilers	232.83	168.77	237.61	192.73	2	2
Fish-layers	71.48	–9.76	81.60	49.68	9	23
Fish	23.67	9.08	29.01	44.62	6	12
Layers	47.81	–18.84	52.59	5.06	10	45
Alternative crops[2]						
Corn	–2.16	–9.69	–2.16	–9.69	never	never
Mixed vegetables	52.51	40.72	52.51	40.72	4	4

[1] Aggregated total of all costs and returns at the end of the first year, including investment costs. Succeeding years do not include any investment costs.
[2] One cycle of corn and two cycles of mixed vegetables. No initial investment costs were required as fields were already in similar agricultural use.

Variable Costs and Income above Variable Cost

Individual variable costs (nutrients, fertilizer, labor, seed, vaccinations and miscellaneous), expressed as a percent of total variable costs, are presented in table 6 for all enterprises. Low cash variable costs for corn, mixed vegetables, and non-integrated fish enterprises were attractive to poorer farmers. The primary cost for these enterprises was non-cash labor, while the two integrated enterprises with high commercial feed inputs were cash-intensive, with variable costs 10 to 20 times greater than all other enterprises. The fish component of fish-poultry integrated enterprises required only 1 to 3 percent of the combined cash variable costs and 6 to 12 percent of the combined cash plus non-cash variable costs.

Cash income above variable costs was positive for all enterprises except corn. The fish-broiler enterprise had the greatest cash income above variable costs, followed in decreasing order by fish-layer, mixed vegetables, high-nutrient fish culture, low-nutrient fish culture, and corn. Relative ranking of enterprises remained the same when opportunity costs and receipts for non-cash items were included, except that low-nutrient fish culture was economically superior to high-nutrient fish culture.

In absolute terms, income above variable costs was highest for the fish-poultry enterprises. However, in terms of relative financial gain, cash receipts from integrated fish-poultry enterprises exceeded cash variable costs by 37 to 64 percent while receipts from non-integrated fish and mixed vegetable enterprises exceeded their respective variable costs by 136 to 219 percent.

Family Labor

Family labor was a non-cash cost, but was considered a valuable resource required for many tasks associated with farming and rural life. Integrated fish systems required most labor, while non-integrated fish culture was the least labor intensive of all enterprises. The enterprises ranked in order of increasing labor intensity were: low-nutrient fish, corn, high-nutrient fish, mixed vegetables, fish-layer, and fish-broiler, figure 8. Family labor requirements, according to specific labor tasks, are presented for all enterprises in Appendix II.

Integration with poultry was a productive and labor-saving method of improving the economic viability of fish farming. Fish-poultry integrated ponds produced more fish than high-nutrient, non-integrated fish farming, and pond labor requirements were one-third lower.

Much of the labor for fish farming was provided by women and children for whom the minimum wage in the economic analyses might overestimate true opportunity cost of their work. Approximately half the labor required for pond operation was provided by women and children. Ponds were constructed almost exclusively by men and their sons, but women performed most of the feeding, fertilizing, and marketing tasks. Children were involved in feeding, fertilization, fish harvest, and pond maintenance.

Another convenient characteristic of fish enterprises was flexibility regarding scheduling of family labor. Consequences of missing a daily feeding were less serious for fish than for poultry. Fish harvests could also be postponed if, for example, ripe vegetables were ready for market.

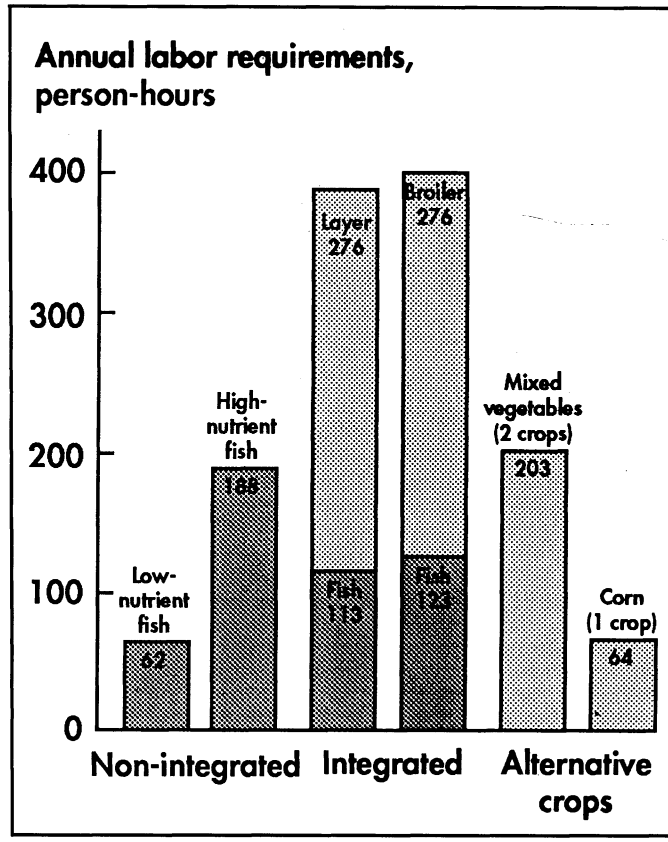

FIG. 8. Annual labor requirements per 100-m² plots for four family-scale fish production enterprises and two alternative crops.

Net Return to Land and Management

Integrated fish-poultry enterprises had the highest net return to land and management, with fish-broiler being superior to the fish-layer system. Net cash returns were higher for the fish component of integrated enterprises than for non-integrated fish production. The high-nutrient fish enterprise produced higher net cash returns than low-nutrient fish farming, but with the inclusion of all opportunity costs and receipts, the low-

TABLE 6. DISTRIBUTION OF INPUTS, EXPRESSED AS PERCENT OF TOTAL VARIABLE COST FOR SIX ENTERPRISES, GUATEMALA, 1989

Enterprise	Percent of cash plus non-cash variable cost						Total
	Feedstuffs	Fertilizer[1]	Seed[2]	Vaccinations	Labor	Other[3]	
Non-integrated fish							
Low nutrient input	14	4	27	0	55	0	100
High nutrient input	18	4	11	0	67	0	100
Fish-poultry integrated							
Fish-broilers							
Broilers	59	0	22	1	10	2	94
Fish	0	1	1	0	4	0	6
Combined	59	1	23	1	14	2	100
Fish-layers							
Layers	50	0	18	0	17	3	88
Fish	2	1	2	0	7	0	12
Combined	52	1	20	0	24	3	100
Alternative crops							
Corn	0	4	2	0	75	19	100
Mixed Vegetables	0	8	9	0	61	22	100

[1] Includes organic and chemical fertilizers.
[2] Fingerlings, layers or broilers according to the enterprise.
[3] Transportation of layers, broiler chicks and produce. For corn and mixed vegetables, the cost of pesticide chemicals.

nutrient fish enterprise was economically superior, table 4.

The mixed vegetable enterprise had lower net return to land and management than fish-poultry integrated systems but was financially and economically superior to non-integrated fish enterprises. However, irrigation water was not charged to the mixed vegetable enterprise. In most cases, a second crop during the ensuing dry season would have been unfeasible without construction of a water supply system to the fish pond. Gardening should, therefore, be more appropriately viewed as a complementary rather than competing activity for fish farmers.

Corn had negative net return to land and management, but it is a traditional crop of great nutritional value. Fish production should not be considered as a substitute for corn but as complementary.

Annual Financial and Economic Cash Flow

Financial (cash) and economic (cash plus non-cash) cash flow for each enterprise can differ greatly, depending on labor requirements and the proportion of the product sold for cash. End-of-year accumulated costs and returns are summarized for all activities in table 5.

Poultry and mixed vegetables, produced almost exclusively for income generation, had greater positive cash flows than non-integrated fish production. However, fish raised for both sale and home consumption gave farmers flexibility for short-term adjustments to the nutritional and financial needs of their families.

FINANCIAL CASH FLOW.

In financial cash flow analyses, no receipts were entered for products consumed by the family, and no charge was included for on-farm nutrients or family labor. All enterprises, except corn, had positive financial cash flow at the end of the first year. The fish-broiler system had the highest positive cash flow, followed by fish-layer and mixed vegetable enterprises. Fish farming systems, intended primarily for non-cash home consumption, had lower positive financial cash flow. The fish component of integrated enterprises was substantially superior to non-integrated fish farming.

ECONOMIC CASH FLOW.

Economic cash flow analysis included non-cash costs for labor and on-farm nutrients and non-cash receipts for products consumed or used by the producer family. The fish-broiler enterprise had the greatest positive economic cash flow, followed in descending order by fish-layer, mixed vegetables, non-integrated fish, and corn enterprises. This generally paralleled the above financial ranking where only cash items were considered. The only change in ranked order of enterprises occurred within the two non-integrated fish enterprises, with high-nutrient fish production being financially superior but economically inferior to the low-nutrient fish enterprise.

Time Required to Breakeven

Financial breakeven occurred in less than 1 year for all enterprises except corn. All fish culture systems, both integrated and non-integrated, broke even financially in 6 months or less. When non-cash costs were

TABLE 7. FINANCIAL AND ECONOMIC BREAKEVEN PRICES AND YIELDS FOR SIX ENTERPRISES ON PRODUCTION AREAS OF 100 m^2, GUATEMALA, 1989

Enterprise	Financial (cash items only)[1]				Economic (cash + non-cash items)			
	Unit price, $/kg		Marketed yield[2] kg/100m2/yr		Unit value, $/kg		Yield kg/100m2/yr	
	Actual	Breakeven	Actual	Breakeven	Actual	Breakeven	Actual	Breakeven
Non-integrated fish								
Low-nutrient	1.33[3]	0.32	18	4	1.33	0.75	30	17
High-nutrient	1.45[3]	0.47	27	9	1.45	1.16	46	37
Fish-poultry integrated								
Fish-broilers								
Broilers	1.70	1.10	392	254	1.70	1.22	392	281
Fish	1.46[2]	0.12	41	3	1.46	0.56	69	26
Fish-layers								
Eggs[4]	7.72	6.23	29	23	7.72	8.03	29	30
Fish	1.45[3]	0.20	31	4	1.45	0.61	58	23
Alternative crops[5]								
Corn	0.22	0.54	7	17	0.22	0.60	27	74
Mixed vegetables	0.04	0.01	1,805[6]	559[6]	0.04	0.03	2,407[6]	1,456[6]

[1] Variable cash costs for all enterprises were 95 to 100% of total cash costs.
[2] Marketed yield is the quantity actually sold or required to be sold to breakeven. The proportion actually sold of each product were: fish, 60%; poultry products, 100%; corn, 25%; mixed vegetables, 75%. The remainder was consumed at home.
[3] Weighted average price according to fish size.
[4] Expressed in 100-egg units. Net cost for egg production was calculated as production cost minus receipts for spent layers. Financial breakeven prices and yields for eggs are calculated after subtracting spent layer cash receipts from total cash costs.
[5] Corn - 1 cycle; mixed vegetables - 2 cycles.
[6] Yield is in number of vegetable units. Breakeven yield calculations assume weighted average vegetable market price of $0.042 per unit.

added, only the fish-broiler and mixed vegetable enterprises broke even the first year. Fish-layer and the two non-integrated fish systems required 23 to 30 months for economic breakeven, table 5.

Risk Analysis

Two indicators of risk to farmers are: (1) margin between breakeven and actual market prices, and (2) variability in expected profits. A greater margin between breakeven and actual market prices indicates reduced risk to farmers in event of production failure or unexpected fall in market prices. Highly variable production levels, resulting from variations in growth and survival, also increase risk.

From a financial (cash only) perspective, the fish component of the fish-poultry enterprises offered the greatest margin of safety against financial risk, while the poultry components had the greatest financial risk. Buffer against financial risk was substantial and similar for the vegetables and the two non-integrated fish enterprises, table 7.

From an economic (cash plus non-cash) perspective, the ranked order of enterprises according to degree of buffer against economic risk was the same as for financial risk, with integrated fish activities having the greatest margin of safety and poultry components the least. Egg production, analyzed in isolation, was marginally non-viable; actual egg yield was slightly below that required for economic breakeven. However, with the addition of the fish component, the fish-layer enterprise became economically viable. Fish, when produced in a low-nutrient system or integrated with poultry, offered the greatest margin of safety against economic risk. Likewise, economic risk was low for vegetable production.

TABLE 8. FINANCIAL (CASH) AND ECONOMIC (CASH PLUS NON-CASH) COST OF PRODUCTION FOR FISH, BROILERS AND EGGS ACCORDING TO ENTERPRISE, GUATEMALA, 1989

		Per unit cost, $/kg			Production cost as percent of market price, percent	
Product	Enterprise	Market value	Financial	Economic[1]	Financial	Economic
Fish						
	Broiler-fish	1.46[2]	0.07	0.56	5	39
	Layer-fish	1.45[2]	0.12	0.69	8	47
	Low-nutrient	1.33[2]	0.20	0.76	15	57
	High-nutrient	1.45[2]	0.28	1.17	19	81
Broiler[3]	Broiler-fish	1.70	1.09	1.22	64	72
Eggs[4]	Layer-fish	7.72	4.36	8.03	56	104

[1] Includes family labor
[2] Weighted average according to fish size.
[3] Net economic production costs for broiler meat was calculated by subtracting manure receipts from the production cost of the poultry component.
[4] Egg figures are expressed as 100-egg units. Net production cost for eggs was calculated by subtracting spent layer and manure receipts, where appropriate, from the production cost of the poultry component.

TABLE 9. SUMMARY OF ECONOMIC ADVANTAGES AND DISADVANTAGES OF INTEGRATED AND NON-INTEGRATED FISH PRODUCTION AND ALTERNATIVE CROPS, GUATEMALA, 1989

NON-INTEGRATED SYSTEMS		VS.	INTEGRATED SYSTEMS	
Advantages	Disadvantages		Advantages	Disadvantages
-less labor required	-water used only for fish production		-multiple water use is feasible	-capital intensive
-independence from off-farm inputs	-lower production		-shorter breakeven time	-more technical skills required
-fewer skills required	-fish production may be constrained by seasonal unavailability of some on-farm nutrients		-higher fish production	-more economic risks
-low start-up costs	-pond enrichment more labor intensive		-greater income above variable costs	-more dependence on off-farm markets
-lower variable costs			-more frequent flow of cash receipts	-commercial feeds required
-higher returns-to-variable cost ratio			-reduced labor for pond enrichment	
			-lowest fish production costs	

LOW-NUTRIENT NON-INTEGRATED		VS.	HIGH-NUTRIENT NON-INTEGRATED	
Advantages	Disadvantages		Advantages	Disadvantages
-lower labor requirements	-lower cash return		-higher cash return	-low income generation
-lowest overall cash requirement	-lower total production		-greater income above variable costs	-more labor required
-lowest economic risk	-smaller fish size		-more farm by-products used	-higher variable costs
-lower fish production costs				-nutrient availability may limit pond size
-higher returns to variable cost ratio				
-reduced risk of oxygen stress				

BROILER-FISH INTEGRATED		VS.	LAYER-FISH INTEGRATED	
Advantages	Disadvantages		Advantages	Disadvantages
-shorter production cycle	-labor intensive		-daily sales and revenue	-longer payback period
-higher net cash return	-higher variable costs		-possibilities to use native poultry stocks	-longer production cycle
-fast recovery of start-up costs	-output not available daily			-higher production cost
-high return to labor				-greater mortality of birds
-higher income above variable costs				
-high survival of birds				

Fish-layer operations had the highest financial and economic risk of all enterprises as demonstrated by the narrowest margin between actual and breakeven prices and yields. In contrast with the fish-broiler and non-integrated fish enterprises, survival rates and laying efficiency of hens were highly variable, thus further compounding the risk for the fish-layer enterprise.

Internal Rates of Return

Land values of $3,000 per hectare were included in the calculation of financial and economic 20-year internal rates of return to management. With the exception of corn, all enterprises had financial internal rates of return exceeding 30 percent and economic internal rates of return of at least 22 percent. The fish-broiler enterprise demonstrated the highest financial internal rate of return, followed by fish-layer, mixed vegetables, high-nutrient fish, and low-nutrient fish. The ranking according to economic internal rate of return was fish-broiler, vegetables, fish-layer, low-nutrient fish, and high-nutrient fish, table 4.

Choice of Most Appropriate Enterprise

All enterprises except corn were profitable. If families did not include full opportunity cost for labor, even corn could be produced at a cost below market value. So which activity was the best? Each had advantages and disadvantages depending on family needs and resources, tables 8 and 9.

The cash investment capability of a farmer determines whether integrated or non-integrated systems are most appropriate. The availability of on-farm by-products also influences optimum production intensity and size of non-integrated ponds. The availability of family labor and animal husbandry skills likewise are important considerations in the selection of the most appropriate management scheme. Alternative uses of land, labor and cash must also be analyzed. Comparison of present agricultural practices, related costs, returns, labor requirements, and other required resources should be conducted to evaluate possible alternative enterprises. Objective comparisons are sometimes difficult, and wrong choices may have grave consequences for a poor family. Outreach programs that assist in the integrated analysis of the above factors help farmers to avoid financial disaster during the learning period for new agricultural enterprises.

Photo 7. Family nutrition and income were benefits from fish farming. Fish were sold at pond bank or in local markets. In contrast with poultry or vegetable operations, the harvest of fish can be somewhat delayed without seriously affecting total annual production. Flexibility to adjust fish harvests in accordance with short term nutritional and income needs is a positive characteristic of fish farming that is difficult to quantify economically.

Economic cash flow analysis, as described earlier, is one method to determine the most efficient use of a farmer's resources. However, many assumptions are needed for long-term cost/benefit projections. Benefits such as skill enhancement and improvement in health and employment opportunities are difficult to quantify and generally not incorporated into economic analyses. Likewise, such costs as opportunity costs for alternative use of cash or labor are difficult to value. In the final analysis, family goals regarding nutrition, use of under-utilized resources, and other social benefits may be more important than financial and economic considerations.

APPENDIX I: POND CONSTRUCTION LABOR

Appendix I. Labor requirements and cost for pond construction by pond size (US$), Guatemala, 1986-89.

Pond size, m²	Labor requirements[1] person-days	Pond construction items[2]			Per unit cost, $/m²	
		Labor	Materials	Total	Cash	Total
50	15.1	22	3	25	0.06	0.50
100	20.5	30	5	35	0.05	0.35
150	26.1	38	7	45	0.05	0.30
200	31.6	46	8	54	0.04	0.27
250	37.0	54	8	62	0.03	0.25
300	42.3	62	8	70	0.03	0.23
350	48.0	70	8	78	0.02	0.22
400	53.0	78	8	86	0.02	0.22

[1] Person-day of labor equals 8 hours and is valued at $1.47 per person-day.
[2] Pond construction materials were a cash cost and labor was non-cash.

APPENDIX II: ENTERPRISE LABOR REQUIREMENTS

APPENDIX II. ANNUAL LABOR REQUIREMENTS (PERSON-HOURS) PER ACTIVITY FOR SIX ENTERPRISES ON 100 m², GUATEMALA, 1989[1]

Activity	Non-integrated fish		Integrated fish-poultry				Alternative crops[2]	
	Low-nutrient	High-nutrient	Layer-Fish		Broiler[2]-Fish		Corn	Mixed vegetables
Stocking	8.8	8.8	-	8.8	-	8.8	-	-
Feeding	8.0	134.4	180	58.8	204	68.8	-	-
Harvesting	14.0	14.0	-	14.0	-	14.0	-	-
Marketing	7.6	7.6	24	7.6	24	7.6	-	-
Pond maintenance	12.0	12.0	-	12.0	-	12.0	-	-
Other	11.6	11.6	72	11.6	48	11.6	128	203
Total	62.0	188.4	276	112.8	276	122.8	128	203

[1] Two cycles per year were assumed for fish and alternative crops; one cycle per year for layers; and six cycles for broilers.
[2] Alternative crops are reduced to a single cycle per year if irrigation is not available.

APPENDIX III. PHYSICAL PRODUCTION ASSUMPTIONS FOR ENTERPRISE BUDGETS

1. Costs associated with pond construction were included as an annual depreciated value, using an expected life of 20 years. Broiler and layer coop construction costs were depreciated over a 4-year life. Materials were locally available at a minimal cash cost, and family labor was used to construct the coop. One coop was sufficient for 48 broilers or 18 layers over a 100-m² pond.

2. Enterprise budgets involving fish assumed that 60 percent of the fish harvested were consumed on the farm and 40 percent were sold. Of the 40 percent sold, fish larger than 15 cm were sold first and at a higher price than smaller fish ($1.62 and $1.21 per kg live weight). Corn is a traditional crop for food security, with a single crop produced annually. A second crop is feasible with irrigation. In enterprise budgets, 75 percent of all production was consumed and 25 percent was sold. Mixed vegetables, primarily for income generation, were distributed as 75 percent for sales and 25 percent for home consumption.

3. Tilapia fingerlings were restocked with fish obtained from the previous harvest. Receipts and cost were included as non-cash values for clarity. Carp fingerlings were purchased. Snails naturally reproduced in ponds.

4. Fish production cycles were 180 days; broiler production cycles were 49 days, with three cycles per fish cycle; and layer production cycles were 11 months of egg production, with sale of spent layers thereafter.

5. No charge was included for land or management. Assumes crop land was already in agricultural use and required no additional investment costs.

6. Broiler and layer manure quantity was calculated as 50 percent of the feeds given to the poultry, recovered as fresh manure with a moisture content of 60–70 percent. Manure quantities were not included in the meat subtotals.

7. Costs for family labor were non-cash.

8. Internal Rate of Return (IRR) calculations included financial (cash) and economic (cash plus non-cash) receipt/cost, and land valued at $30 per 100 m². Actual land costs were $17-36 per 100 m².

APPENDIX IV: LOW NUTRIENT FISH ENTERPRISE BUDGET

APPENDIX IV. ENTERPRISE BUDGET FOR LOW-NUTRIENT NON-INTEGRATED FISH ENTERPRISE IN 100-m² POND WITH 500 kg/ha/MONTH NUTRIENT INPUT (FEED AND FERTILIZER); INITIAL STOCKING RATE 170 FISH WITH A 26-WEEK CYCLE INCLUDING 1-WEEK TURNAROUND TIME BETWEEN CYCLES, GUATEMALA, 1989, IN U.S. $

Item	Unit	Quantity Per Cycle	Price Or Cost/Unit	One Cycle			Two Cycles (1 Year)		
				Cash Cost Or Value	Non-Cash Cost Or Value	Total Benefit Or Cost	Cash Cost Or Value Per Year	Non Cash Cost/Value Per Year	Total Benefit Cost/Year
1. Gross receipts[1]									
Tilapia									
<15 cm	kg	10.40	1.21	3.90	8.69	12.58	7.79	17.38	25.17
>15 cm	kg	1.56	1.62	2.53	0.00	2.53	5.05	0.00	5.05
Carp	kg	2.86	1.62	1.85	2.78	4.63	3.71	5.56	9.27
Snails	kg	0.35	0.61	0.09	0.13	0.21	0.17	0.26	0.43
Total		15.17		8.36	11.60	19.96	16.72	23.19	39.92
2. Variable costs									
Fingerlings									
Tilapia[2]	kg	1.36	1.21		1.65	1.65		3.29	3.29
Carp	unit	17	0.07	1.19		1.19	2.38		2.38
Nutrients									
Feed									
Corn	kg	9	0.12	1.08		1.08	2.16		2.16
Table scraps	kg	4	0.01		0.04	0.04		0.08	0.08
Leaves and other	kg	3	0.01		0.03	0.03		0.06	0.06
Chicken concentrate	kg	1	0.31	0.31		0.31	0.62		0.62

Continued on Page 31

Item	Unit	Quantity Per Cycle	Price Or Cost/Unit	One Cycle: Cash Cost Or Value	One Cycle: Non-Cash Cost Or Value	One Cycle: Total Benefit Or Cost	Two Cycles (1 Year): Cash Cost Or Value Per Year	Two Cycles (1 Year): Non Cash Cost/Value Per Year	Two Cycles (1 Year): Total Benefit Cost/Year
Fertilizer									
Organic manure	kg	13	0.01		0.13	0.13		0.26	0.26
Chemical fert.	kg	1	0.24	0.24		0.24	0.48		0.48
Total nutrients	kg	31							
Total variable costs				2.82	1.85	4.67	5.64	3.69	9.33
3. Income above variable costs				5.54	9.75	15.29	11.08	19.50	30.58
4. Fixed costs									
Depreciation on pond	20 yr.								
Labor portion					0.76	0.76		1.51	1.51
Non-labor portion				0.13		0.13	0.27		0.27
Total fixed costs				0.13	0.76	0.89	0.27	1.51	1.78
5. Total costs				2.95	2.60	5.55	5.91	5.20	11.11
6. Net returns to land, labor and management				5.41	9.00	14.40	10.82	17.99	28.81
7. Family labor costs	man-days	3.9	1.47		5.73	5.73		11.47	11.47
8. Net returns to land and management				5.41	3.26	8.67	10.82	6.52	17.34

[1] 40% of harvested fish were sold; the remainder was consumed by the producer family.
[2] Fingerlings were obtained from reproduction in ponds.

APPENDIX V: HIGH NUTRIENT FISH ENTERPRISE BUDGET

APPENDIX V. ENTERPRISE BUDGET FOR HIGH-NUTRIENT NON-INTEGRATED FISH ENTERPRISE IN 100-m² POND WITH 1,500 kg/ha/MONTH NUTRIENT INPUT (FEED AND FERTILIZER); INITIAL STOCKING RATE 170 FISH WITH A 26-WEEK CYCLE INCLUDING 1-WEEK TURNAROUND TIME BETWEEN CYCLES, GUATEMALA, 1989, IN U.S. $

Item	Unit	Quantity Per Cycle	Price Or Cost/Unit	One Cycle: Cash Cost Or Value	One Cycle: Non-Cash Cost Or Value	One Cycle: Total Benefit Or Cost	Two Cycles (1 Year): Cash Cost Or Value Per Year	Two Cycles (1 Year): Non Cash Cost/Value Per Year	Two Cycles (1 Year): Total Benefit Cost/Year
1. Gross receipts[1]									
Tilapia									
<15 cm	kg	9.60	1.21	0.00	11.62	11.62	0.00	23.23	23.23
>15 cm	kg	7.32	1.62	10.96	0.89	11.86	21.93	1.78	23.71
Carp	kg	5.92	1.62	3.84	5.75	9.59	7.67	11.51	19.18
Snails	kg	0.11	0.61	0.03	0.04	0.07	0.05	0.08	0.13
Total		22.95		14.83	18.30	33.13	29.65	36.60	66.26
2. Variable costs									
Fingerlings									
tilapia[2]	kg	1.36	1.21	0.00	1.65	1.65	0.00	3.29	3.29
carp	unit	17	0.07	1.19		1.19	2.38		2.38
snails	unit	14	0.004		0.06	0.06		0.11	0.11
Nutrients									
Feed									
Corn	kg	26	0.12	3.12		3.12	6.24		6.24
Table scraps	kg	11	0.01		0.11	0.11		0.22	0.22
Leaves and fruit	kg	8	0.01		0.08	0.08		0.16	0.16
Chicken concentrate	kg	4	0.31	1.24		1.24	2.48		2.48
Fertilizer									
Organic manure	kg	38	0.01		0.38	0.38		0.76	0.76
Chemical fert.	kg	3	0.24	0.72		0.72	1.44		1.44
Total nutrients	kg	90							
Total variable costs				6.27	2.27	8.54	12.54	4.54	17.08
3. Income above variable costs				8.56	16.03	24.59	17.11	32.06	49.17
4. Fixed costs									
Depreciation on pond	cost/20 yr.								
Labor portion	$30.20/20 yr.				0.76	0.76		1.51	1.51
Non-labor portion	$5.34/20 yr.			0.13		0.13	0.27		0.27
Total fixed costs				0.13		0.13	0.27		0.27
5. Total costs				6.40	3.03	9.43	12.81	6.05	18.86
6. Net returns to land, labor, and management				8.42	15.28	23.70	16.85	30.55	47.40
7. Family labor costs	man-days	11.8	1.47	0.00	17.35	17.35	0.00	34.69	34.69
8. Net returns to land and management				8.42	-2.07	6.35	16.85	-4.14	12.71

[1] 40% of harvested fish were sold; the remainder was consumed by the producer family.
[2] Fingerlings were obtained from reproduction in ponds.

APPENDIX VI: FISH-BROILER ENTERPRISE BUDGET

APPENDIX VI. ENTERPRISE BUDGET FOR INTEGRATED FISH-BROILER ENTERPRISE IN 100-m² POND WITH 48 BROILERS OVER POND; INITIAL STOCKING RATE 180 FISH WITH A 26-WEEK CYCLE; THREE 49-DAY BROILER CYCLES PER FISH CYCLE, GUATEMALA, 1989, IN U.S. $

				One Fish Cycle Three Broiler Cycles			Two Fish Cycles Six Broiler Cycles (1 Year)		
Item	Unit	Quantity Per 180 Day Cycle	Price Or Cost/Unit	Cash Cost Or Value	Non-Cash Cost Or Value	Total Benefit Or Cost	Cash Cost Or Value Per Year	Non-Cash Cost/Value Per Year	Total Benefit Per Year
1. Gross receipts									
Broilers (3 cycles)	kg	196	1.70	333.20		333.20	666.40		666.40
Broiler manure[1]	kg	243	0.012		2.92	2.92		5.84	5.84
Fish[2]									
Tilapia									
<15 cm	kg	13.09	1.21	0.00	15.84	15.84	0.00	31.68	31.68
>15 cm	kg	16.59	1.62	19.23	7.65	26.88	38.47	15.29	53.76
Carp	kg	4.64	1.62	3.01	4.51	7.52	6.01	9.02	15.03
Snails	kg	2.18	0.61	0.53	0.80	1.33	1.06	1.60	2.66
Total		232.50		355.97	31.71	387.69	711.94	63.43	775.37
2. Variable costs									
Fish									
Fingerlings									
Tilapia[3]	kg	1.36	1.21		1.65	1.65		3.29	3.29
Carp	each	20	0.07	1.40		1.40	2.80		2.80
Snails	each	26	0.004		0.10	0.10		0.21	0.21
Nutrients									
Feed									
Concentrate	kg	2	0.31	0.62		0.62	1.24		1.24
Blood	kg	4	0.01		0.04	0.04		0.08	0.08
Table scraps	kg	8	0.01		0.08	0.08		0.16	0.16
Corn	kg	2	0.12	0.24		0.24	0.48		0.48
Leaves and fruit	kg	3	0.01		0.03	0.03		0.06	0.06
Fertilizer									
Organic fertilizer	kg	6	0.01		0.06	0.06		0.12	0.12
Fresh broiler manure[1]	kg	243	0.012		2.92	2.92		5.84	5.84
Subtotal variable costs for fish				2.26	4.88	7.14	4.52	9.76	14.28
Broilers									
Chicks	each	144	0.39	56.16		56.16	112.32		112.32
Feed concentrate	kg	486.82	0.31	150.91		150.91	301.83		301.83
Vaccines	each	144	0.02	2.88		2.88	5.76		5.76
Transportation	trip	6	0.74	4.44		4.44	8.88		8.88
Subtotal variable costs for broilers				214.39	0.00	214.39	428.79	0.00	428.79
Total variable costs				216.65	4.88	221.53	433.31	9.76	443.07
3. Income above variable costs				139.32	26.83	166.15	278.63	53.67	332.30
4. Fixed costs									
Depreciation									
Coop	4 yr.								
Labor portion					2.40	2.40		4.80	4.80
Materials				0.60		0.60	1.20		1.20
Pond	20 yr.								
Labor portion					0.76	0.76		1.51	1.51
Non-labor portion				0.13		0.13	0.27		0.27
Total fixed costs				0.73	3.15	3.88	1.46	6.31	7.77
5. Total costs				217.39	8.03	225.42	434.77	16.07	450.84
6. Net returns to land, labor, and management				138.59	23.68	162.27	277.17	47.36	324.53
7. Family labor costs									
Broilers (3 cycles)									
Feeding	man-days	12.75	1.47		18.74	18.74		37.49	37.49
Marketing	man-days	1.50	1.47		2.21	2.21		4.41	4.41
Other	man-days	3.00	1.47		4.41	4.41		8.82	8.82
Subtotal broiler		17.25		0.00	25.36	25.36	0.00	50.72	50.72
Fish (1 cycle)	man-days	7.68	1.47		11.29	11.29		22.58	22.58
Total labor		24.93		0.00	36.65	36.65	0.00	73.29	73.29
8. Net returns to land and management				138.59	-12.97	125.62	277.17	-25.93	251.24

[1] Broiler manure quantity was calculated as 50% of the broiler feed input recovered as fresh manure with a moisture content of 60-70%. Manure quantity was not included in the meat subtotal.
[2] 40% of the harvested fish were sold; the remainder was consumed by the producer family.
[3] Fingerlings were obtained from reproduction in ponds.

APPENDIX VII: FISH-LAYER ENTERPRISE BUDGET

APPENDIX VII. ENTERPRISE BUDGET FOR INTEGRATED FISH-LAYER ENTERPRISE IN 100-m² POND WITH 17 LAYER HENS OVER POND; INITIAL STOCKING RATE 180 FISH WITH A 26-WEEK CYCLE; ONE LAYER CYCLE PER TWO FISH CYCLES, GUATEMALA, 1989, IN U.S. $

				One Fish Cycle (180 d) with 180 LAYER DAYS[1]			Two Fish Cycles (360 d) with 208 LAYER-DAYS[1] (1 Year)		
Item	Unit	Quantity	Price Or Cost/Unit	Cash Cost Or Value	Non-Cash Cost Or Value	Total Benefit Or Cost	Cash Cost Or Value Per Year	Non-Cash Cost/Value Per Year	Total Benefit Cost/Year
1. Gross receipts									
Tilapia									
<15 cm	kg	10.80	1.21	0.00	13.07	13.07	0.00	26.14	26.14
>15 cm	kg	10.83	1.62	14.02	3.53	17.55	28.03	7.06	35.10
Carp	kg	4.15	1.62	2.69	4.03	6.72	5.38	8.07	13.45
Snails	kg	2.98	0.61	0.73	1.09	1.82	1.45	2.18	3.64
Subtotal, fish		28.76		17.43	21.72	39.15	34.86	43.45	78.30
Spent layers	each	15	2.21	0.00	0.00	0.00	33.15	0.00	33.15
Eggs	each	1449	0.08	115.92	0.00	115.92	231.84	0.00	231.84
Layer manure[2]	kg	133	0.012	0.00	1.59	1.59	0.00	3.19	3.19
Subtotal, layers				115.92	1.59	117.51	264.99	3.19	268.18
Total receipts				133.35	23.32	156.66	299.85	46.64	346.48
2. Variable costs									
Fish									
Fingerlings									
tilapia[3]	kg	1.36	1.21		1.65	1.65		3.29	3.29
carp	each	12	0.07	0.84		0.84	1.68		1.68
snails	each	45	0.004		0.18	0.18		0.36	0.36
Nutrients									
Feed									
Corn	kg	7	0.12	0.84		0.84	1.68		1.68
Concentrate	kg	4	0.31	1.24		1.24	2.48		2.48
Leaves and fruit	kg	1	0.01		0.01	0.01		0.02	0.02
Table scraps	kg	5	0.01		0.05	0.05		0.10	0.10
Insects	kg	5	0.01		0.05	0.05		0.10	0.10
Fertilizer									
Organic manure	kg	2.36	0.01		0.02	0.02		0.05	0.05
Layer manure[2]	kg	133	0.012		1.59	1.59		3.19	3.19
Subtotal, fish				2.92	3.55	6.47	5.84	7.11	12.95
Layers									
Concentrate	kg	265.65	0.31	82.35		82.35	150.98		150.98
Layers	each	17	3.12	53.04		53.04	53.04		53.04
Vaccines	each	51	0.02	1.02		1.02	1.02		1.02
Transportation	trip	4	0.92	3.68		3.68	7.36		7.36
Subtotal, layers				140.09	0.00	140.09	212.40	0.00	212.40
Total variable costs				143.01	3.55	146.56	218.24	7.11	225.34
3. Income above variable costs				-9.66	19.76	10.10	81.61	39.53	121.14
4. Fixed costs									
Depreciation									
Pond	20 yr.								1.51
Labor portion					0.76	0.76		1.51	0.27
Non-labor portion				0.13		0.13	0.27		
Coop	4 yr.								
Labor portion					2.40	2.40	0.00	4.80	4.80
Materials				0.60		0.60	1.20	0.00	1.20
Total fixed costs				0.73	3.15	3.88	1.46	6.31	7.77
5. Total costs				143.74	6.71	150.45	219.70	13.41	233.11
6. Net returns to land, labor, and management				-10.39	16.61	6.21	80.15	33.22	113.37
7. Family labor costs									
Fish	man-days	7.05	1.47		10.36	10.36		20.73	20.73
Layers									
Feeding	man-days	11.25	1.47		16.54	16.54		33.08	33.08
Marketing	man-days	1.50	1.47		2.21	2.21		4.41	4.41
Other	man-days	4.50	1.47		6.62	6.62		13.23	13.23
Total		24.30		0.00	35.72	35.72	0.00	71.44	71.44
8. Net returns to land and management				-10.39	-19.11	-29.51	80.15	-38.22	41.93

[1] Birds were purchased as 18-week-old hens. The 11-month layer-cycle was continuous and was divided into 180 and 128 day periods. Layers are replaced after one year.
[2] Chicken manure was calculated as 50% of the layer feed concentrate input recovered as fresh manure with a moisture content of 60-70%.
[3] Tilapia fingerling were obtained from reproduction in ponds.

APPENDIX VIII: CORN ENTERPRISE BUDGET

APPENDIX VIII. ENTERPRISE BUDGET FOR CORN ENTERPRISE ON 200-m^2 PLOT WITH TWO 100-DAY GROWING CYCLES PER YEAR, GUATEMALA, 1989, IN U.S. $

Item	Unit	Quantity	Price Or Cost/Unit	One Cycle: Cash Cost Or Value	One Cycle: Non-Cash Cost Or Value	One Cycle: Total Benefit Or Cost	Two Cycles (1 Year): Cash Cost Or Value Per Year	Two Cycles (1 Year): Non-Cash Cost/Value Per Year	Two Cycles (1 Year): Total Benefit Cost/Year
1. Gross receipts									
Corn	kg	54.55	0.22	3.00	9.00	12.00	6.00	18.00	24.00
2. Variable costs									
Seed	kg	0.45	1.21		0.54	0.54		1.09	1.09
Fertilizer	kg	5.45	0.24	1.31		1.31	2.62		2.62
Pesticides	m^2	200.00	0.03	6.00		6.00	12.00		12.00
Total variable costs				7.31	0.54	7.85	14.62	1.09	15.71
3. Income above variable costs				-4.31	8.46	4.15	-8.62	16.91	8.29
4. Fixed costs							0.00	0.00	0.00
Depreciation of tools			1.10		1.10	1.10		2.20	2.20
5. Total costs				7.31	1.64	8.95	14.62	3.29	17.91
6. Net returns to land, labor, and management				-4.31	7.36	3.05	-8.62	14.71	6.09
7. Family labor costs	man-days	16	1.47	0.00	23.52	23.52	0.00	47.04	47.04
8. Net returns to land and management				-4.31	-16.16	-20.47	-8.62	-32.33	-40.95

[1] Traditionally a single cycle is produced each year. Irrigation is required for a second cycle. No charge for irrigation has been included. The primary purpose of corn production is family nutrition rather than income generation. A sales to home consumption ratio of 25:75 was applied.

APPENDIX IX: MIXED VEGETABLE ENTERPRISE BUDGET

APPENDIX IX. ENTERPRISE BUDGET FOR MIXED VEGETABLE ENTERPRISE ON 142-m^2 PLOT USING POND WATER FOR IRRIGATION WITH TWO 115-DAY CYCLES PER YEAR, GUATEMALA, 1989, IN U.S. $[1]

Item	Unit	Quantity	Price Or Cost/Unit	One Cycle: Cash Cost Or Value	One Cycle: Non-Cash Cost Or Value	One Cycle: Total Benefit Or Cost	Two Cycles (1 Year): Cash Cost Or Value Per Year	Two Cycles (1 Year): Non-Cash Cost/Value Per Year	Two Cycles (1 Year): Total Benefit Cost/Year
1. Gross receipts									
Cabbage	each	193	0.11	15.92	5.31	21.23	31.84	10.62	42.46
Tomatoes	each	272	0.06	12.24	4.08	16.32	24.48	8.16	32.64
Onions	each	400	0.03	9.00	3.00	12.00	18.00	6.00	24.00
Broccoli	each	68	0.09	4.59	1.53	6.12	9.18	3.06	12.24
Squash	each	96	0.03	2.16	0.72	2.88	4.32	1.44	5.76
Raddish	each	680	0.004	2.04	0.68	2.72	4.08	1.36	5.44
Other vegetables				8.31	2.77	11.08	16.62	5.54	22.16
Total		1709		54.26	18.09	72.35	108.52	36.18	144.70
2. Variable costs									
Seed	kg	0.10	38.90	3.89		3.89	7.78		7.78
Fertilizer	kg	13.64	0.24	3.27		3.27	6.55		6.55
Pesticides, dry	kg	0.45	4.04	1.82		1.82	3.64		3.64
Pesticides, liquid	liter	0.50	16.00	8.00		8.00	16.00		16.00
Total variable costs				16.98	0.00	16.98	33.96	0.00	33.96
3. Income above variable costs				37.28	18.09	55.37	74.56	36.18	110.74
4. Fixed costs				0.00	0.00	0.00	0.00	0.00	0.00
5. Total costs				16.98	0.00	16.98	33.96	0.00	33.96
6. Net returns to land, labor, and management				37.28	18.09	55.37	74.56	36.18	110.74
7. Family labor costs	man-days	18	1.47	0.00	26.46	26.46	0.00	52.92	52.92
8. Net returns to land and management				37.28	-8.37	28.91	74.56	-16.74	57.82

[1] Without pond water for irrigation, one crop per year during the rainy season would be common. No charge for irrigation has been included. Vegetable production is primarily for income generation. A sales to home consumption ratio of 75:25 was applied.