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Aquaculture Technology Adoption in Kapasia Thana, Bangladesh: Some Preliminary Results from Farm Record-Keeping Data

Mahfuzuddin Ahmed
M. Abdur Rab
Mary Ann P. Bimbao

ICLARM
INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

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MANILA, PHILIPPINES

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Cover: A woman farmer-cooperator prepares a fish feed bran and oil cakes as regular source of supplementary food in fishponds. **PHOTO BY M. AHMED**

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Fig. 1. Map of study area: Kapasia and Sreepur thana, Gazipur district, Bangladesh 1

Foreword

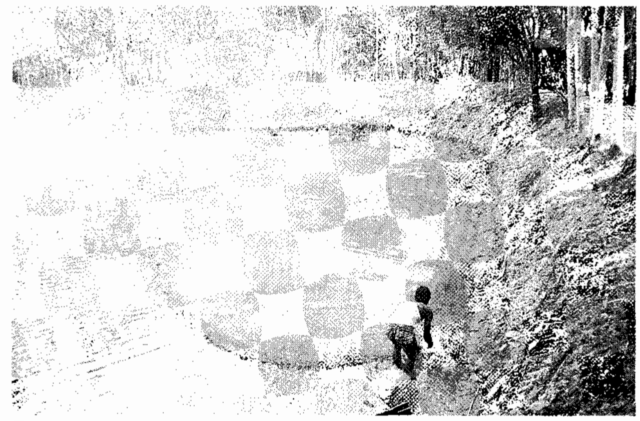
Improving rural well-being often involves the adoption of new or improved farming technologies. Many constraints limit adoption, however, including access to basic information on possible new technologies. This constraint is especially powerful when the technology is completely new to the adopters or when only limited technical information is available. Aquaculture is a good example of such a farming technology.

ICLARM's research on the adoption processes for small-scale aquaculture technologies in Bangladesh have shown the importance of technical information dissemination in the early stages of adoption. This study described in this Technical Report investigates a wide range of factors which affect adoption of three aquaculture technologies in one district of Bangladesh. By collecting and analyzing detailed on-farm technical information including labor, the study was able to distinguish the specific role of information dissemination in adoption. Provided the new technology, such as small-scale aquaculture of carps or tilapias, is suitable, the study supports the need for appropriate technical extension program in adding a valuable extra crop to existing farms, and also adding extra animal protein to local diets and on the market.

Meryl J. Williams
Director General
ICLARM

Aspects of the Aquaculture Technology Extension Program with Farmer-Cooperators in Kapasia Thana, Gazipur District, Bangladesh

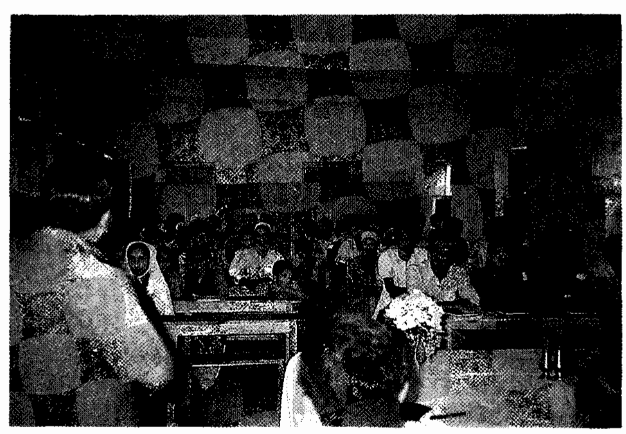

A typical fish harvest.


Farmer-cooperators use ropes made of rice straw to clear the waterbody before stocking fingerlings.

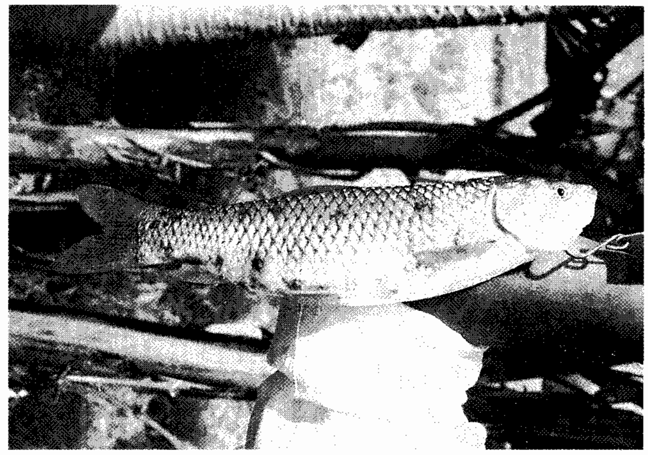

Water hyacinth is mixed with cattle and/or poultry manure, lime, urea and wood ash to make compost.


Fish harvesting using a castnet.

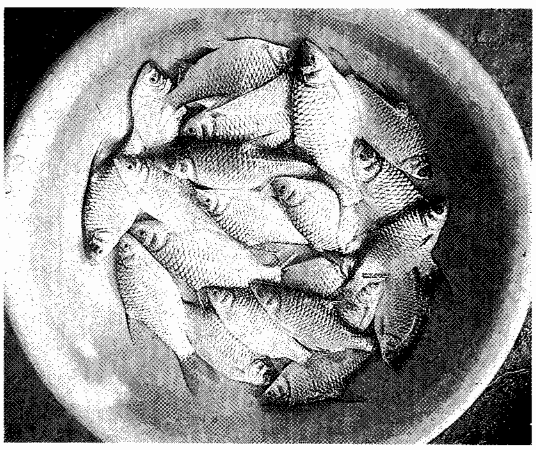

Compost is used for fertilizing the waterbody.


Close communication between farmers and project staff through training workshops is an important feature of the extension strategy.

Poultry shed built with local materials (bamboo and nipa) for integrated poultry-fish farming.

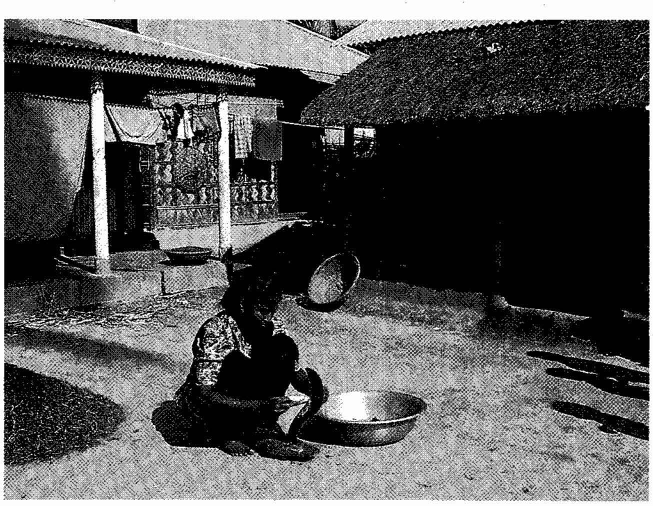


A grass carp (*Ctenopharyngodon idella*) infected with epizootic ulcerative syndrome.



Marketable size of silver barb (*Puntius gonionotus*): 100-200 g.

Two introduced fish species: common carp (*Cyprinus carpio*) [right] and silver barb (*Puntius gonionotus*) [left] whose growth performance and market prices are attractive in the project area.



A young household member prepares fish (harvested from her own pond) for home consumption.

Aquaculture Technology Adoption in Kapasia Thana, Bangladesh: Preliminary Results from Farm Record-Keeping Data

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Abstract

Three aquaculture technologies, namely, (i) polyculture of carps [rohu *(Labeo rohita)*, catla *(Catla catla)*, mrigal *(Cirrhinus mrigala)*, silver carp *(Hypophthalmichthys molitrix)*, mirror/common carp (*Cyprinus carpio*), grass carp *(Ctenopharyngodon idella)* and bighead carp *(Aristicthys nobilis)*]; (ii) monoculture of Nile tilapia *(Oreochromis niloticus)*; and (iii) monoculture of silver barb *(Puntius gonionotus)*, were extended to farmers in Kapasia thana, Gazipur district, Bangladesh. Preliminary results taken from farm record-keeping data indicated that there were significant changes in fish production and resource use by the farmer-cooperators from their previous practices. An average annual fish production of 2,728 $kg{\cdot}ha^{-1}$ was achieved by farmer-cooperators who adopted carp polyculture technology, against the previous or 'benchmark' level of 618 $kg{\cdot}ha^{-1}$. The number of users and application rates of production inputs particularly on-farm resources (such as cattle and poultry manure, and rice bran) which were advocated by the extension program also increased significantly from the benchmark levels, although their levels were still below the suggested technology rates. A fish disease (ulcerative disease syndrome), affected fish production particularly in waterbodies stocked with silver barb. On average, only 58% of the target fish production levels were achieved. Nevertheless, high profits (net income per hectare) were still realized: BDT65,888 (US$1 =BDT37.00, 1991; BDT 38.91,1992) [carp polyculture]; BDT47,876 [Nile tilapia monoculture]; and BDT22,977 [silver barb monoculture]. After the extension program, 40% of the fish harvest was consumed by the farm household compared to the benchmark level of 33%, while the proportion of fish sold decreased from 64% to 58%. The key factor that influenced farmers' decision to adopt or reject the aquaculture technology was their knowledge about the technology. Moreover, the intensity of technology adoption was significantly determined by the size and the previous culture status of the waterbody before the extension effort.

CHAPTER 1

Introduction

Background

In recent times, the government of Bangladesh and its development partners have been stressing the need for introducing modern methods of aquaculture as a means of increasing fish supply for the country's growing population, as well as for generating income and employment in the rural areas. Numerous small waterbodies (ponds and ditches) that are part of the farm resources of the rural households and community have been identified as an important resource base for rural aquaculture development. Various authors (e.g., Mahabubullah 1983; Islam and Dewan 1987; Khan 1990; Ahmed 1992) have recognized the potential of small-scale aquaculture in these waterbodies. However, lack of critical inputs (e.g., fish seed and feed), capital (credit) and the knowledge gap of farmers were labeled as major factors that hindered adoption of aquaculture.

A project entitled "Socioeconomic Impact of the Fish Culture Extension Program on the Farming Systems of Bangladesh" was implemented by the International Center for Living Aquatic Resources Management (ICLARM) in collaboration with the Government of Bangladesh (GOB) agencies [Bangladesh Agricultural Research Council (BARC), Fisheries Research Institute (FRI), Department of Fisheries (DOF)] from June 1990 to April 1994 to look at issues relating to the adoption of aquaculture in small waterbodies. The main objectives of the project were to assist farmers adopt improved aquaculture methods in small waterbodies in and around their homestead by providing the necessary extension and technical services, and to assess the socioeconomic impact of introducing such aquaculture technologies in the rural households and community (Ahmed 1992; Ahmed et al. 1993). The

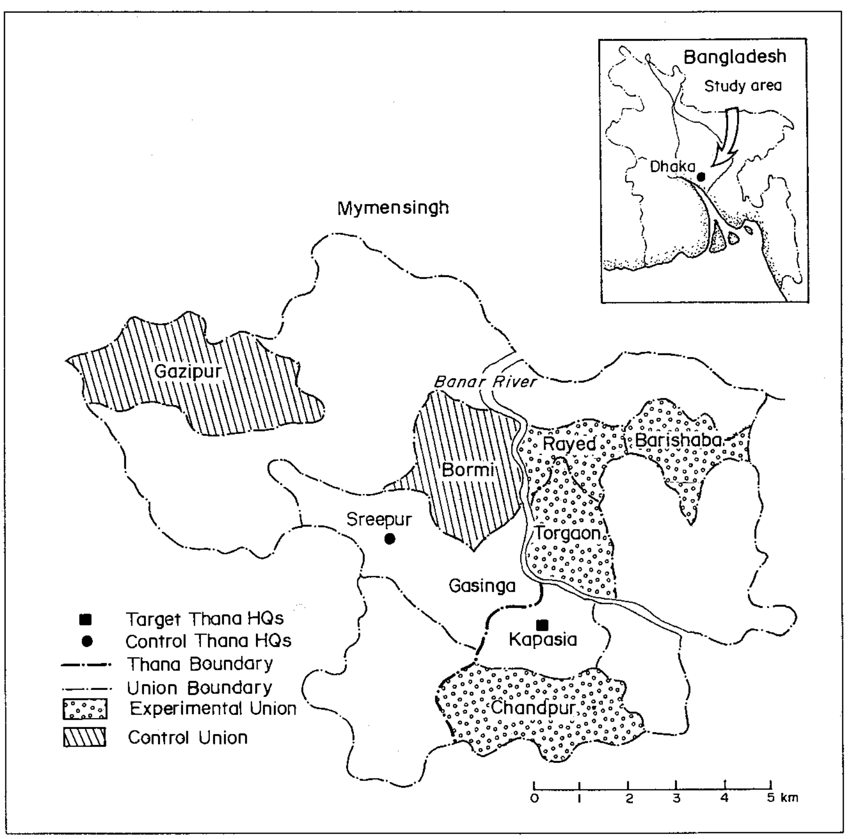

Fig. 1.1. Map of study area: Kapasia thana, Gazipur district, Bangladesh.

project chose two thanas (sub-districts) of Gazipur district, namely, Kapasia and Sreepur as extension and control areas, respectively (Fig. 1.1; see Ahmed et al. 1993 for details on the design of the project).

This report does not include any data on pond operators in the control area, i.e., Sreepur. However, a benchmark survey on household socioeconomics was conducted on 148 sample farmers in the control area and 193 sample farmers in the extension target area (Kapasia). During the first year of the project (1991-92), a total of 257 farmers from Kapasia were extended with improved aquaculture technologies. This report focuses on the technology adoption in the ponds operated by these farmers. Of these 257 farmers, 86 came from the 193 sample households that were surveyed under the benchmark survey (Ahmed et al. 1993). Of the 257 farmers, 215 harvested during the study period and this report is based on this data. A separate report will address productivity differentials and factor productivities in the ponds operated by the adoption farmers.

Extension Strategy

Farms in Bangladesh are small but diverse and farmers have to choose among a wide range of crops and livestock to satisfy different farming goals, e.g., household food supply and cash income. Farms are operated on limited resources (such as land, water, labor and capital) and subjected to large seasonal and climatic variations, continually adapting to new and improved crops as well as farming techniques (Hossain 1977; Asaduzzaman 1979; Gill 1991; Ahmed et al. 1993). The extension strategy in the present study was, therefore, to disseminate aquaculture technologies to suit a wide range of aquatic environments (such as perennial and seasonal waterbodies [ponds and ditches] including roadside ditches) and goals of potential fish farmers.

An assessment of input needs for pond operators for a period of one year was made through personal interviews and farmer group meetings. These discussions with farmers, as well as considering the overall farming system and the socioeconomic conditions of farm households, were important in determining the appropriate aquaculture technology that would benefit the farm households. There was a potential for integrating aquaculture and agriculture, given the seasonal water resources which could be used for culturing fish and the resources available from current farm production activities. Thus, the project promoted the use of on-farm resources, by-products and wastes which were generated through integrating aquaculture into the agricultural production system of farm households. It discarded the conventional high-input approach, i.e., intensive aquaculture, having to rely on external support for inputs (Lightfoot et al. 1992).

The extension program also included provision of services such as farm visits, technical advice, training and demonstrations which were carried out by extension assistants based in the villages and supervised by two extension officers based at the thana headquarters.

The important features of the extension program were:

- organization of outreach training programs at the community level to improve farmers' understanding on the technical aspects of aquaculture;
- assessment of the farm resource-base through extensive consultations with farmers and emphasizing low-external inputs and low-cost technology;
- provision of assistance to farmers in identifying alternative fish seed, feed and fertilization materials including their sources of supply;

- regular contact and advice to farmers throughout waterbody preparation, stocking, rearing and marketing phases; and
- no credit obligation from the project to the farmers.

While credit is considered an important feature in many extension packages concerning transfer of technology, particularly to resource-poor farmers, the project did not have this provision. The premise was that the suggested low-cost aquaculture technologies would enable farmers to finance the improvements themselves by using existing resources or by credit from other sources. The project stressed that farmers should be self-reliant and use existing supply channels wherever possible. Moreover, the cross-section of the local population identified as principal owners or operators of the waterbodies belonged to the landed class ranging from marginal farmers to rich landowners, who constituted 60% of the total farm households in the study area (Ahmed et al. 1993).

The extension program included all rural households within the study area which were able to practise aquaculture in the existing waterbodies. The project staff surveyed the waterbodies, identified their owners and operators, and invited them for training and awareness in aquaculture. The farmers were appraised of the importance and benefits of culturing fish during training and consultations. Techniques for waterbody preparation, stocking and handling of fingerlings, and other aquaculture practices were discussed with the farmers. Throughout the culture period, field assistants visited the waterbodies to monitor input use, and fish health and growth. Close communication between the extension staff and farmers allowed regular appraisals of how the farmers were keeping up with the practices suggested.

Input Support

The project supplied no direct production inputs (either in cash or kind) to the farmers. Rather, its support was in terms of facilitating the procurement of inputs that were not locally available, particularly fish seed and the renting of equipment. These required relatively large capital investments. This scheme was found appropriate because the type of aquaculture practices suggested were relatively low cost and flexible in terms of input combinations and quantities. Most of the inputs such as inorganic fertilizers (e.g., urea and triple superphosphate [TSP]), lime and ingredients for supplementary feed (e.g., rice bran, oil cake and grass/aquatic vegetation) were to a large extent already available at the farm. The farmers have a long tradition of using these materials (Ahmed and Rab 1992).

It was also assumed that the low levels of input needs and possibilities of substitutions of on-farm wastes and by-products for commercial inputs would enable resource-poor farmers to operate on any size of waterbody and to adjust the technology to suit their economic circumstance. On the other hand, when cash inputs like fingerlings, inorganic fertilizers and lime were required, farmers were willing to spend cash in the same manner as they had done supporting other farm enterprises.

Fingerling Procurement

There was no fish seed or nursery farm in Kapasia thana. Farmers who intended to adopt the technology had an immediate problem of getting the required fingerlings. The main sources of fingerlings were the vendors who sold fingerlings of Indian major carps [rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*) and calbasu (*Labeo calbasu*)], available only during the monsoon season (June to September). This supply was not sufficient to meet the fingerling demand in the target extension unions (village units). Moreover, these fingerlings, which were collected mainly from rivers, were of low quality and mixed with other species. Thus, the project extension staff identified public and private farms as potential sources of good quality fingerlings and helped farmers to establish contacts with some local fingerling traders who acted as agents in transporting the fingerlings from the identified fish seed farms to the growout farmers in the study area. However, from the second year the project extension staff trained some of the farmer-cooperators to operate nurseries in order to produce fingerlings for their own need and to supply neighboring growout farmers (ICLARM 1993).

Equipment Service

The project made available to farmers four pumps and four nets for use in cases when these equipment were not easily available in the locality. Nominal fees were charged, just to cover maintenance costs of the equipment. Farmers who borrowed the pumps provided their own fuel and labor and paid for the cost of moving the machines to their farms. Nets were lent out in the same manner. However, very few (<10%) farmers availed of these services; rather they relied on private suppliers.

Aquaculture Technologies

The project recommended three aquaculture technologies that were developed at the Bangladesh Fisheries Research Institute: polyculture of carps [rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), mirror/common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*) and bighead carp *(Aristicthys nobilis*); monoculture of Nile tilapia (*Oreochromis niloticus*); and monoculture of silver barb (*Puntius gonionotus*). On-station and on-farm research had indicated that these technologies give high yields and income (Gupta 1991; Gupta et al. 1992; Gupta and Rab 1994). The suggested inputs and application rates for these aquaculture technologies are given in Table 1.1 and the details on practices are given below.

Carp Polyculture

Carp polyculture refers to the simultaneous farming of two or more carp species in the same waterbody. Traditionally, farmers in Bangladesh culture three to four species of Indian major carps, i.e., rohu, catla, mrigal and calbasu. Recent additions of exotic species - silver, common and grass carps - have proven successful (Gupta 1992).

ENVIRONMENT AND WATERBODY SIZE

The soil type and water quality of the waterbodies are important factors in fish production. The better soil type is a clay soil which can hold water and support primary production in the water column with nutrients such as iron, calcium and magnesium. Red/sandy soils may be acidic and are not suitable for most fishponds. Similarly, clay soils with chronically turbid waters may be unable to support aquatic productivity and these waters may have low dissolved oxygen. Large (>600 m^2) perennial waterbodies (ponds and ditches) which can hold more than 1 m of water are considered the most suitable for carp polyculture.

Table 1.1. Suggested input use (per ha) for the three aquaculture technologies extended to farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type		
Inputs	Carp polyculture (year-round production cycle)	Nile tilapia monoculture (6-8 months production cycle)	Silver barb monoculture (6-8 months production cycle)
Fingerlings (stock at 4-7 days after applying fertilizers during waterbody preparation)			
Number ('000)	6.2-7.4	19.8-21.0	15.0-16.0
Size (cm)	7.6-10.2	2.5-3.8	3.8-6.4
Basal application (kg·ha^{-1})			
Lime	250	250	250
Cattle manure (5-7 days after liming	3,000	1,000	1,000
Urea] 4 days after applying	62	25	25
TSP] cattle manure	62	25	25
During growout period (kg·ha^{-1})			
Lime	250	0	250
Urea	300	180	60
TSP	300	125	120
Cattle manure	7,400	5,000	4,000
Poultry manure	600	0	0
Compost	5,000	0	0
Rice bran	5,000	7,500	5,000
Oil cake	2,500	0	0
Vegetation (grass, water spinach banana leaves and vegetable wastes)	6,200	0	0

Note: Estimates based on available profiles of various proven aquaculture at the time of undertaking the extension program (Gupta 1991; Ahmed 1992; Gupta et al. 1992).

WATERBODY PREPARATION

Waterbody preparation includes repairing or strengthening pond dikes and slopes, removing aquatic weeds and cutting of hanging tree branches. Moreover, predatory and weed fishes must be eliminated either by draining the waterbody, using a fish toxicant or repeated netting operations. Lime should be applied to the waterbody at the rate of 250 kg·ha^{-1}: in powder form, if the pond/ditch is dry; or dissolved in water and sprayed, if the pond/ditch is filled with water (Table 1.1). About five to seven days after lime is applied, the waterbody should be fertilized with organic fertilizer (cattle manure) at 3,000 kg·ha^{-1}. Basal application of inorganic fertilizers (urea and TSP) at 124 kg·ha^{-1} should be made four days after applying cattle manure.

STOCKING OF FINGERLINGS

Four to seven days after fertilization, 7.6-10.2-cm fingerlings of the different carp species can be stocked at the rate of 6,200-7,400 kg·ha^{-1} (Table 1.1). Farmers were advised to maintain the species composition of: silver carp and/or catla, 40%; rohu, 30%; mrigal and/or common carp, 25%; and grass carp, 5%.

APPLICATION OF LIME AND FERTILIZERS

During the growout period, application of another 250 kg·ha^{-1} of lime is advisable (Table 1.1). The waterbody must also be fertilized with organic (cattle and poultry manure, and compost) and inorganic (urea and TSP) fertilizers. Suggested application rates at weekly intervals for organic and inorganic fertilizers, respectively, are 250 $kg \cdot ha^{-1}$ and 12 $kg \cdot ha^{-1}$. Compost comprised a significant percentage (40%) of the required organic fertilizer application level. A cubic meter of compost pit will require 75 kg green vegetation, 500 g lime, 300 g urea, 15 kg cattle and/or poultry manure and 5 kg wood ash.

FISH FEEDING

Regular daily feeding is necessary for optimal fish growth. The suggested supplementary feeding rates are: 14 $kg \cdot ha^{-1}$ rice bran; 7 $kg \cdot ha^{-1}$ oil cake; and 17 $kg \cdot ha^{-1}$ grass and aquatic weeds. Daily feeding rates should be 4-5% of the fish biomass in the waterbody, adjusted every fortnight based on observed fish growth.

FISH HARVESTING

Partial harvesting of the fish can start after about six months of rearing when fish should attain an average size of 300-500 g.

Monoculture of Nile Tilapia and Silver Barb

Oreochromis mossambicus has been cultured in Bangladesh since 1954 but became unpopular because of its slow growth. Nile tilapia (*O. niloticus*) therefore was introduced in 1974. This fish is hardy, a good converter of organic wastes into quality protein and resistant to disease. It grows to market size in three to four months, thus it is well suited for culture in seasonal waterbodies in Bangladesh (Gupta et al. 1992).

Silver barb (*Puntius gonionotus*), a fish species native to Southeast Asia (Thailand, Indonesia, Laos and Vietnam), was introduced into Bangladesh in 1974. It is locally known as "Thai sharputi" or "Rajputi". This species can survive well in shallow, turbid waters. Like Nile tilapia, silver barb is a species that can be grown to market size in three to four months of culture. When reared in perennial waterbodies, two crops can be harvested (Gupta and Rab 1994). Silver barb is akin to the indigenous species *Puntius sarana*, which is popular and in high demand in Bangladesh.

ENVIRONMENT AND WATERBODY SIZE

Soil and water conditions that are usually less than ideal for carp polyculture can be tapped for Nile tilapia and silver barb monoculture. Small (<600 m^2) seasonal waterbodies which can hold water for four to eight months can also be used.

WATERBODY PREPARATION

Waterbody preparation for the monoculture of Nile tilapia and silver barb is similar to that for carp polyculture (Table 1.1).

STOCKING OF FINGERLINGS

Four to seven days after applying fertilizers, the waterbody is ready for stocking with fingerlings. Fingerling sizes and stocking rates for Nile tilapia and silver barb are 2.5-3.8 cm at 19,800-21,000 $fingerlings \cdot ha^{-1}$ and 3.8-6.4 cm at 15,000-16,000 $fingerlings \cdot ha^{-1}$, respectively (Table 1.1).

APPLICATION OF LIME AND FERTILIZERS

During the growout period (6-8 months), lime should be applied at the rate of 250 $kg{\cdot}ha^{-1}$ in waterbodies stocked with silver barb (Table 1.1). Organic fertilizer application rates at weekly intervals are 95 $kg{\cdot}ha^{-1}$ and 70 $kg{\cdot}ha^{-1}$, respectively, for Nile tilapia and silver barb; while the corresponding fortnightly interval rates are 190 $kg{\cdot}ha^{-1}$ and 140 $kg{\cdot}ha^{-1}$. Inorganic fertilizer application rates at weekly intervals are 10 $kg{\cdot}ha^{-1}$ and 7 $kg{\cdot}ha^{-1}$, respectively, for Nile tilapia and silver barb.

FISH FEEDING

The stocked fish are to be provided daily with supplementary feed, i.e., rice bran at the rate of 40 $kg{\cdot}ha^{-1}$ for Nile tilapia and 27 $kg{\cdot}ha^{-1}$ for silver barb (Table 1.1). Daily feeding rates should be 8-10% of the fish biomass in the waterbody, adjusted every fortnight based on observed fish growth.

FISH HARVESTING

Nile tilapia can be harvested when each weighs about 200 g. The harvestable size for silver barb ranges from 100 to 200 g. However, in seasonal waterbodies, the fish should be harvested before the waterbody dries up.

CHAPTER 2

Methods and Estimation Procedures

Data Sources

Pond Record-Keeping Data

The project extension staff prepared a pond record-keeping book (Appendix 1), designed to document input-output data and other relevant variables concerning the aquaculture activities of farmer-cooperators (target-farmers) in Kapasia thana, from waterbody preparation to fish harvesting. Moreover, data on fish disposal patterns, and the marketing of fish, including marketing channels, were also recorded. The extension staff also assisted farmer-cooperators in maintaining these records. Field assistants provided technical advice with regard to waterbody preparation and fish stocking, rearing and harvesting techniques. On a regular basis, they also monitored and verified the recorded data through observed fish growth and physical condition of ponds.

Under the extension services of the project during July 1991 - June 1992, record-keeping books were maintained for 257 waterbodies. However, only 215 books were analyzed because the farmers who did not harvest during the reference period were excluded.

Benchmark Survey Data

Data on the socioeconomic and demographic characteristics of the operator households were taken from an earlier benchmark survey report in Kapasia and Sreepur thanas in Gazipur district, from July 1990 - June 1991, particularly for making a comparison between adopter and nonadopter households (Ahmed et al. 1993).

Analytical Framework

This report used both descriptive and econometric methods of analysis. Data are presented and analyzed in terms of frequency distribution, simple means and cross tabular form. A probit model was fitted to determine the factors that influence the rate and intensity of adoption of the aquaculture technologies.

Estimation of Fish Production

The farmer-cooperators, either operating in seasonal or perennial waterbodies, practised partial and total fish harvesting. The production from those who implemented total fish harvesting was straightfoward, i.e., total production equals the actual catch during the harvest. Production from partially harvested waterbodies was estimated based on the harvest and the fish biomass in the waterbody on the date of last harvest. This estimation method is specified as:

$$Q_i = WH_i + BM_i \quad \text{... 1)}$$

$$BM_i = \sum_{j=1}^{n} AH_{ij}\left[\left(NF_{ij} - NFH_{ij}\right)s_j\right] \quad \text{... 2)}$$

where

Q_i = production of fish during the culture period of waterbody i;
WH_i = weight of harvested fish from waterbody i;
BM_i = biomass of fish in waterbody i;
AH_{ij} = average fish weight during the last harvest in waterbody i of species j;
NF_{ij} = number of fingerlings stocked in waterbody i of species j;
NFH_{ij} = number of fish harvested from waterbody i of species j;
s_j = survival rate of species j; and
n = number of species, where n = 1 for tilapia and silver barb monoculture and > 1 for carp polyculture.

The average survival rates of the different species in the disease-affected and disease-free waterbodies were estimated from the number of fully harvested ponds (Table 2.1). These coefficients were used to estimate the fish biomass in the waterbodies at the last harvest date. The total fish production in each waterbody was estimated by adding the actual fish harvests and estimated fish biomass in the waterbody.

Table 2.1. Survival rate of fingerlings (%) by technology type and disease status, in the waterbodies of farmer-cooperators in Kapasia *thana*, Gazipur district, Bangladesh, July 1991 - June 1992.

Technology type/ disease status	No. of fully harvested waterbodies	Average survival rate (%)
Carp polyculture		
Disease-free waterbodies	15	85
Disease-affected waterbodies	5	38
Nile tilapia monoculture	8	100
Silver barb monoculture		
Disease-free waterbodies	25	72
Disease-affected waterbodies	30	24

Valuation of Production Material Inputs and Outputs

Cash inputs (e.g., inorganic fertilizers, lime and oil cake) were valued at their respective purchase costs. On-farm resources (e.g., cattle and poultry manure, and rice bran) used as production inputs were valued at their opportunity costs, i.e., the prices received if these were sold by the farmer. Other material inputs (e.g., grass and termites) were not given imputed cash values as their opportunity costs were virtually zero.

Fish sold to wholesalers or consumers were valued at their selling prices. Fish consumed at home, and those given away to neighbors and relatives were valued at the prevailing market prices.

Valuation of Labor

Unlike in crop and livestock production, the intensity of labor use in aquaculture is relatively low and is distributed throughout the year. The labor requirement for aquaculture can be taken from the unused labor time of the farm household (Ahmed and Rab 1992) and was valued at zero opportunity costs; as such, labor was excluded in the income and productivity analyses.

Except for fish harvesting where some farmer-cooperators relied on hired labor, all labor requirements in these aquaculture operations were provided by the pond operator and his/her household. In this study, labor use in aquaculture was divided into four phases: waterbody preparation, fingerling stocking, poststocking management (i.e., feeding, fertilizing and caretaking) and harvesting (Table 2.2). Poststocking management required the most labor (108 hours•ha^{-1}) followed by fish harvesting (45 hours•ha^{-1}).

Table 2.2. Average labor use (hours) in aquaculture, of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

Aquaculture activities	Average labor use (hours) Per pond	Per hectare
Waterbody preparation	1.45	11.12
Draining	3.00	43.58
Netting	4.08	21.90
Poisoning	0.28	1.50
Cleaning of aquatic weeds	0.94	4.05
Liming and fertilizing	3.31	18.00
Fingerling stocking	0.81	4.00
Poststocking management	9.63	107.88
Harvesting[a]	4.00	45.25
Total	27.50	257.28

[a]Harvesting was also done by the professional fishers who are paid in cash or, in kind on contractual basis.

Adoption Rate of the Aquaculture Technologies

It takes time before an innovation or technical change is accepted by farmers, particularly those in subsistence economics, characterized by low educational attainment and bound by tradition. Moreover, the farmers' decision to adopt a new technology depends on various socioeconomic and demographic characteristics of the farm household and markets and on technical factors of the production activity. In agriculture, a few studies have been made in this area of research in Bangladesh (e.g., Asaduzzaman 1979), but for aquaculture, equivalent studies are lacking.

In this technology adoption study, the dependent variable is defined as the decision to adopt or reject an improved aquaculture technique. Hence, the dependent variable is dichotomous, i.e., it is limited to 1 and 0. There are a number of difficulties associated with the use of the ordinary least squares (OLS) method in estimating functions with a dichotomous dependent variable. The major difficulty relates to the predictability of the estimated function. Prediction may fall outside the (0, 1) interval which requires distributional assumptions so that all predictions must lie within the appropriate interval. Since the primary aim is to interpret the dependent variable as the likelihood of making a choice, transformation of the function based on some notion of probabilities must be made. A suitable transformation is the cumulative probability function which is a constrained version of the linear probability model (Maddala 1977; Padilla 1990).

The most popular transformations based on the cumulative probability distribution function are the probit and logit models. The two models have quite similar transformation and produce comparable results except at the extremes of probabilities. However, they differ in that the probit model assumes that the underlying probability distribution is normal, while the logit model, assumes a logistic or log normal distribution. The logit model is also computationally easier. The logit model (Pyndick and Rubenfield 1981) is specified as:

$$
\begin{aligned}
P_i &= F(Z_i) = F(a, x_1 \ldots X_n, U) \\
&= 1/[1 + \exp(-Z_i)] \\
&= 1/[1 + \exp(-(a, x_1 \ldots X_n, U))] \qquad \ldots 3)
\end{aligned}
$$

where

F = cumulative probability function;
P_i = probability that an individual will make a choice given x_i;
Z_i = underlying index value; which is a linear combination of the explanatory variables
a = coefficient;
x_1 = explanatory variables; and
U = stochastic error term.

The index Z_i is a linear combination of independent variables and can be derived as:

$$
\begin{aligned}
P_i &= 1/[1 + \exp(-Z_i)] \\
&\text{or } \exp(Z_i) = P_i/1-P_i \qquad \ldots 4)
\end{aligned}
$$

Taking the natural logarithm of both sides,

$$\text{or } Z_i = Ln\left(\frac{P_i}{1-P_i}\right)$$

$$\text{or } Z_i = Ln\left(\frac{P_i}{1-P_i}\right) = a + \sum_{i=1}^{n} b_i x_i$$

$$= a + b_1 x_1 + b_2 x_2 + \ldots + b_{ni} x_{ni} + U \qquad \ldots 5)$$

where

i = 1, 2, ..., n observation;
X_{ni} = nth explanatory variable for the ith observation;
a, b_i = coefficients; and
U = stochastic error term.

The logit model was used to fit data from the socioeconomic benchmark survey covering 193 sample farm households (Ahmed et al. 1993). The dependent variable was defined by dividing the respondents into two groups: adopters and nonadopters (Table 2.3). Seven variables (knowledge about the technology; previous culture status and area of the waterbodies; proportion of working age of family members engaged in nonfarming activities in the farm household; proportion of own (operator and family) labor to total farm labor; operators' type; and risk of flood) were hypothesized to influence the decision to adopt or reject the aquaculture technology. The logit model, estimated using the computer software package LIMDEP (Limited Dependent Variable), was specified as:

$$LnY = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + U \quad ...6)$$

where

Y = probability of adoption of the aquaculture technology;
x_1 = proportion of family members (above 10 years) engaged in nonfarming activities;
x_2 = area of the waterbody;
x_3 = proportion of own (farmer and family) labor to total farm labor;
x_4 = operator type
1 single
0 otherwise;
X_5 = culture status of the waterbody before the extension effort
1 regular stocking and harvesting
0 otherwise;
X_6 = risk of flood
1 waterbody prone to flood
0 otherwise;
X_7 = operators' knowledge about the technology
1 operator attending training sessions
0 otherwise;
a = intercept;
b_i = coefficients; and
U = stochastic error term.

Table 2.3. Means of continuous variables and frequencies of dichotomous variables by adopter and nonadopter farms in Kapasia thana, Gazipur district, Bangladesh, July 1991- June 1992.

Explanatory variables	Adoptor n=86	Nonadoptor n=107	All n=193
Continuous variables			
Proportion of nonfarming members in the household (%)	83.6	80.6	81.9
Area of the waterbody (decimal)	46.7	24.2	24.2
Proportion of own (operator and family) labor to total farm labor (%)	61.9	66.6	64.6
Dichotonomous variables (frequency)			
Risk of flood	8	16	24
Knowledge about the technology	74	32	106
Culture status of the waterbody before extension	48	33	81
Single operator (owner or lessee)	57	52	109

Intensity of Adoption of the Aquaculture Technologies

Adoption is a binary variable but a related issue in this technology adoption study is the intensity of adoption, i.e., were the recommended input application rates followed by the

farmers? And if not, how far did the actual levels deviate from the recommended levels?
A semi-logarithmic function was used to explain the factors that determine the intensity of technology adoption of the 86 adopters. The intensity of adoption was defined as the ratio of the value of the actual inputs used to the value of the input levels suggested by the technology. Hence, the dependent variable is continuous and limited within 0 to 1. Fingerling stocking was excluded from the model as farmers broadly followed the recommended stocking densities.

The variables that were considered crucial to explain the intensity of adoption were operators' knowledge about the aquaculture technology, the operators' type, occupation, education and landholdings, and area and culture status of the waterbody before the extension effort. The semi-logarithm model specified was:

$$LnY = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + U \quad \text{...7)}$$

where

- Y = intensity of adoption of the improved aquaculture technology;
- x_1 = operators' knowledge about the technology
  - 1 trained
  - 0 not trained;
- x_2 = occupation of the operator
  - 1 farming
  - 0 nonfarming;
- x_3 = operator type
  - 1 single
  - 0 joint;
- x_4 = landholdings of the operators' household;
- x_5 = education of the operator
  - 1 educated
  - 0 not educated;
- x_6 = culture status of the waterbody before the extension effort
  - 1 cultured
  - 0 not cultured;
- x_7 = area of the waterbody;
- a = intercept;
- b_i = coefficients; and
- U = stochastic error term.

CHAPTER 3

Impact Assessment

Culture Practices

Waterbody Clearance Techniques

The guidelines for extension assistance to the farmer-cooperators emphasized that the waterbody should be well prepared before stocking the fingerlings. Removing unwanted fish species is an important aspect of waterbody preparation. Several options of waterbody clearance such as intensive netting, draining and poisoning were suggested. The extension workers did not, however, endorse any particular waterbody clearance technique. Results show that intensive netting (practised by 47% of the farmers) was preferred over poisoning (25%) and draining (18%) (Table 3.1). The other 10% of the waterbodies were ready for stocking fingerlings without any clearance.

Stocking Density, Species Composition and Size of Fingerlings

Table 3.1. Waterbody clearance techniques by technology type, of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type							
	Carp polyculture		Nile tilapia monoculture		Silver barb monoculture		All	
Waterbody clearance technique	n=95	%	n=23	%	n=139	%	n=257	%
Draining	18	19	5	22	24	17	47	18
Netting	46	48	8	35	67	48	121	47
Poisoning	18	19	9	39	37	27	64	25
No preparation needed	13	14	1	4	11	8	25	10

At the time the extension program was initiated, aquaculture was an irregular practice among the farmers in the target areas (Ahmed 1992). Irregular stocking and occasional harvesting of fish were dominant features of the aquaculture practices of the small waterbody operators. During the pre-extension period (July 1990 to June 1991), only 33% of the waterbody operators surveyed stocked fingerlings; among these, almost 97% were engaged in the polyculture of Indian major carps, such as catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) (Ahmed et al. 1993). Stocking of exotic species like silver *(Hypophthalmichthys molitrix)*, mirror/common (*Cyprinus carpio*) and grass (*Ctenopharyngodon idella*) carps, and Nile tilapia (*Oreochromis niloticus*) were negligible. Silver barb (*Puntius gonionotus*) was not cultured at all in Kapasia thana. Moreover, proper stocking densities and species ratios of fingerlings were not maintained. Thus, the extension staff emphasized the importance of following the stocking densities and species ratios suggested in the aquaculture technologies.

Table 3.2 shows the distribution of farmer-cooperators who chose the specific aquaculture technologies: 38% adopted the carp polyculture technology; 8%, Nile tilapia monoculture; and 54%, silver barb monoculture. Many farmer-cooperators who practised the monoculture technologies also stocked a small proportion of carps. Similarly, a few carp polyculture farmer-cooperators stocked some silver barb and Nile tilapia. Results indicated that 78%, 94% and 67% of the farmer-cooperators complied strictly with the recommended species combinations for carp polyculture, Nile tilapia monoculture and silver barb monoculture, respectively; the rest added other species.

Farmer-cooperators adopted the specific aquaculture technology appropriate to the sizes of their waterbodies. Monoculture was adopted for small (<600 m^2) waterbodies and polyculture for larger waterbodies. The average waterbody sizes of farmer-cooperators who adopted monoculture ranged from 160 m^2 to 540 m^2 and for the polyculture technology, 1,170 m^2 to 1,260 m^2 (Table 3.2).

Table 3.2. Number of farmer-cooperators, average waterbody area (m^2) and fish stocking density (no.·ha^{-1}), by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

Technology type	Farmer-cooperators No.	%	Average waterbody area m^2	SD	Stocking density No.·ha^{-1}	SD
Carp polyculture						
Carps only	64	30	1,260	726	7,600	1,415
Carps with other species	18	8	1,170	627	11,600	5,286
Nile tilapia monoculture						
Nile tilapia only	15	7	230	103	20,000	2,497
Nile tilapia with other species	1	1	160	-	19,800	-
Silver barb monoculture						
Silver barb only	78	36	370	340	16,800	4,474
Silver barb with other species	39	18	540	393	18,300	2,809
Total	215	100	720	655	14,100	5,789

SD = Standard deviation.

Farmer-cooperators who adopted Nile tilapia monoculture technology followed the recommended stocking densities (Tables 1.1 and 3.2). Those who adopted silver barb monoculture and carp polyculture stocked more fingerlings than the recommended levels, particularly for carp polyculture.

Indian major carps, specifically catla and rohu, were the dominant species stocked by farmer-cooperators who adopted carp polyculture (Table 3.3). Silver barb represented 26% of the stocked fingerlings in waterbodies where other species were stocked besides the recommended carp species. In silver barb monoculture, only 18% of the stocked fingerlings were other species: mainly Indian major carps, exotic carps and Nile tilapia.

Farmer-cooperators who adopted monoculture stocked fingerlings at the recommended sizes (Tables 1.1 and 3.4). On the other hand, farmer-cooperators who adopted carp polyculture stocked, on average, 5.5-cm fingerlings, which is smaller than the suggested range of 7.6-10.2 cm.

Most (92%) farmer-cooperators stocked fingerlings during July and August when fingerlings were in abundant supply (Table 3.5). Fish harvesting began in November 1991 and continued until June 1992 when the input-output record-keeping books were collected.

Table 3.3. Species composition in the waterbodies of farmer-cooperators, by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Carps only			Carps with other species			Silver barb with other species		
Species	No.·ha^{-1}	SD	%	No.·ha^{-1}	SD	%	No.·ha^{-1}	SD	%
Silver barb	0	-	0	3,032	1,522	26	15,065	2,244	82
Catla	2,518	835	33	2,607	1,880	23	1,199	1,553	7
Rohu	2,619	868	34	2,697	1,937	23	391	990	2
Mrigal	1,165	959	15	619	501	5	115	362	1
Silver carp	426	572	6	274	455	3	433	798	2
Grass carp	220	98	3	200	97	2	2	15	<0.1
Mirror carp	646	588	9	940	486	8	185	438	1
Common carp	0	-	0	624	2,646	5	143	890	1
Nile tilapia	0	-	0	624	2,646	5	728	2,561	4
All	7,594	1,415	100	11,617	5,286	100	18,261	2,809	100

SD = Standard deviation.

Material Input Use

INPUT USERS AND NONUSERS

Prior to the launching of the extension program, the use of feeds and fertilizer for aquaculture of the farmers in Kapasia thana was very limited (Ahmed et al. 1993). As a result of the extension effort, new kinds of inputs were used while the application rates of existing inputs were increased (Table 3.6). Cattle and poultry manure, inorganic fertilizers and lime were used to increase pond water fertility. Rice bran, oil cake, grass and termites were utilized as fish feeds.

Table 3.4. Average stocking size of fingerlings (cm) by technology type, in the waterbodies of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

Technology type	Average size cm	SD
Carp polyculture		
Carps only (n=64)	5.5	0.76
Carps with other species (n=18)	5.3	0.59
Nile tilapia monoculture		
Nile tilapia only (n=15)	2.7	1.43
Nile tilapia with other species (n=1)	3.0	-
Silver barb monoculture		
Silver barb only (n=78)	3.9	0.82
Silver barb with other species (n=39)	4.6	1.04

SD = Standard deviation.

Table 3.5. Stocking and harvesting months by technology type, in the waterbodies of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, May 1991 - June 1992.

	Technology type							
	Carp polyculture		Nile tilapia monoculture		Silver barb monoculture		All	
Months	n=82	%	n=16	%	n=117	%	n=215	%
Stocking of fingerlings								
May - June 1991	4	5	0	0	12	10	16	7
July - August 1991	78	95	15	94	104	89	197	92
September 1991	0	0	1	6	1	1	2	1
Harvesting of fish								
November - December 1991	0	0	1	6	8	7	9	4
January - February 1992	2	2	2	12	29	25	33	15
March - April 1992	36	44	10	63	51	43	97	45
May - June 1992	44	54	3	19	29	25	76	36

All farmer-cooperators used cattle manure, inorganic fertilizers and rice bran (Table 3.6). About 89% applied lime and 29%, poultry manure. Oil cake was used by 47%. The new inputs used were: grass (used by 46% of the farmer-cooperators); termites (20%); and compost (1%).

Table 3.6. Number of input users before and after extension of the aquaculture technologies in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Before extension[a]		After extension by technology type[b]								
			Carp polyculture		Nile tilapia monoculture		Silver barb monoculture		All		% increase in the no. of input users after extension
Inputs	n=140	%	n=82	%	n=16	%	n=117	%	n=215	%	
Lime	24	17	70	85	16	100	106	91	192	89	422
Inorganic fertilizers	67	48	82	100	16	100	117	100	215	100	109
Cattle manure	93	66	82	100	16	100	117	100	215	100	51
Poultry manure	4	3	32	39	6	38	25	21	63	29	946
Compost	0	0	2	2	0	0	1	1	3	1	-
Rice bran	67	48	82	100	16	100	117	100	215	100	109
Oil cake	2	1	54	66	0	0	47	40	100	46	32
Grass/aquatic vegetation	0	0	38	46	0	0	5	4	43	20	-
Termites	0	0	0	0	1	6	11	9	12	6	-

[a]From Ahmed et al. (1993).
[b]Multiple responses.

TIMING AND INPUT APPLICATION RATES

Organic and inorganic fertilizers were applied at two stages of the culture period: when the waterbody was being prepared before stocking fingerlings; and when fish had been stocked. About 62% of the lime were used as a basal application, the rest during the fish rearing stage (Table 3.7). The bulk of the poultry manure, cattle manure and inorganic fertilizers (91%, 74% and 60%, respectively) were applied at intervals after the fingerlings were stocked. Many carp polyculture (45%) and Nile tilapia (50%) farmer-cooperators applied lime and inorganic fertilizers (urea and TSP) at the rate of 151-250 kg·ha^{-1}, whereas 42% of the silver barb farmer-cooperators' application rates were above 250 kg·ha^{-1} (Table 3.8).

The average input application rates used by the farmer-cooperators before the extension effort were very low compared to those afterwards, although farmers still applied lower rates than the recommended levels (Table 3.9).

Farmer-cooperators applied inorganic fertilizers below the recommended technology rates: short by 494 kg·ha^{-1} for carp polyculture; 155 kg·ha^{-1} for Nile tilapia monoculture; and 31 kg·ha^{-1} for silver barb monoculture (Tables 1.1 and 3.10). Only 48%, 80% and 86% of the

Table 3.7. Average input use (kg·ha^{-1}) during waterbody preparation and growout periods, of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Quantity (kg·ha^{-1})			%	
Inputs	Waterbody preparation period	Growout period	Total	Waterbody preparation period	Growout period
Lime	152	94	246	62	38
Inorganic fertilizers	84	125	210	40	60
Cattle manure	1,190	3,386	4,576	26	74
Poultry manure	8	83	91	9	91

Table 3.11. Average input use of organic fertilizers and feeds (kg·ha^{-1}), by source and by technology type, in the waterbodies of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type							
	Carp polyculture n=82		Nile tilapia monoculture n=16		Silver barb monoculture n=117		All n=215	
Inputs (kg·ha^{-1})	On-farm	Bought	On-farm	Bought	On-farm	Bought	On-farm	Bought
Cattle manure	4,954	0	4,821	0	4,276	0	4,576	0
% by source	100	0	100	0	100	0	100	0
Poultry manure	80	0	124	0	95	0	91	0
% by source	100	0	100	0	100	0	100	0
Compost	12	0	0	0	5	0	7	0
% by source	100	0	0	0	100	0	100	0
Rice bran	1,758	198	6,715	0	3,823	336	3,251	258
% by source	90	10	100	0	92	8	93	7
Oil cake	0	163	0	0	0	60	0	95
% by source	0	100	0	0	0	100	0	100
Grass/aquatic vegetation	181	0	0	0	12	0	76	0
% by source	100	0	0	0	100	0	100	0
Termites	0	0	15	0	113	0	63	0
% by source	0	0	100	0	100	0	100	0

for harvested fish that were not stocked but came from the wild or from breeding in the pond, usually called 'weed fish'. This practice was also reported in Noakhali district (Jensen 1987). These terms of contract for fish harvesting may look unfavorable to the farmer-cooperators but in actual practice, the hired fishers in Kapasia thana as in most parts of the country, found it difficult to earn their own labor and equipment costs, because there was not enough fish to harvest.

The terms of contract for fish harvesting changed after the extension effort. Nevertheless, both practices of harvesting by the farmer-cooperators themselves and by hiring professional fishers continued (Table 3.12).

Table 3.12. Distribution of the waterbodies of farmer-cooperators, by type of harvesters, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

Harvester type	No. of waterbodies n=215	%[a]
Self harvest	204	95
Harvesting by hired fishers	188	87
Payment in kind	74	34
Payment in cash	114	53

[a]Multiple responses.

Production

Fish Production

Most of the farmer-cooperators started partial fish harvesting after four to five months of culture: only 38% implemented total fish harvesting (Table 3.13). The mode of fish harvesting is largely determined by the amount of water retained in the waterbodies, and only secondarily by fish size. Thus, total fish harvesting is the norm for short-cycle monoculture: 47% of the waterbodies used for monoculture were subjected to total fish harvesting, compared to 24% for polyculture.

Table 3.13. Number of waterbodies, average fish production and culture period, by technology type and by mode of fish harvest, of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type		
Mode of harvest	Carp polyculture n=82	Nile tilapia monoculture n=16	Silver barb monoculture n=117
Total harvest			
Number of waterbodies (%)	24	50	47
Average production (kg·ha^{-1})	1,480	2,400	1,054
Average culture period (months)	8.60	8.68	8.16
Average annual production (kg·ha^{-1})	2,065	3,318	1,550
Partial harvest			
Number of waterbodies (%)	76	50	53
Average production (kg·ha^{-1})	2,262	2,016	1,198
Average culture period (months)	9.28	7.23	8.11
Average annual production (kg·ha^{-1})	2,925	3,346	1,773
All waterbodies			
Number (%)	100	100	100
Average production (kg·ha^{-1})	2,071	2,208	1,131
Average culture period (months)	9.11	7.95	8.14
Average annual production (kg·ha^{-1})	2,728	3,333	1,667

Silver barb, which was cultured in 8.14 months (range: 180-250 days), gave the lowest average production at 1,131 kg·ha^{-1} (Table 3.13). Carp polyculture, with the longest culture period (9.11 months, range: 250-300 days), gave on average, 2,071 kg·ha^{-1}. If extrapolated in terms of yearly productivity, Nile tilapia monoculture was more productive by 95% and 7%, respectively, than silver barb monoculture and the carp polyculture. The previous or 'benchmark' level of production reported in Ahmed et al. (1993) was 618 kg·ha^{-1} per year, where the farmers were practising mainly polyculture of Indian major carps.

Risks and Constraints

EPIZOOTIC ULCERATIVE SYNDROME (EUS)

Epizootic ulcerative syndrome (EUS), an infectious disease, was the major limiting factor for fish productivity in the extension target area during the production year under study. Out of 257 waterbodies, nearly 46% were affected, covering a total of 8.8 ha in the four target extension unions of Kapasia thana (Ahmed and Rab 1995). Early preventive measures such as applying lime to the affected waterbodies and salt bath for the infected fish helped minimize the damage. Silver barb was the most vulnerable species. Fish production was significantly affected by EUS (Table 3.14). Recent trends in aquaculture development have shown the potential for growing short-cycle fish species like silver barb in marginal and seasonal waterbodies (Gupta and Rab 1994). The apparent susceptibility of silver barb to EUS, therefore, needs thorough investigation.

FLOODING

Eight waterbodies were affected by flooding: five with silver barb monoculture; two with carp polyculture and one with Nile tilapia monoculture (Table 3.15). Average production from flood-affected waterbodies was 75% lower than waterbodies that were not affected by floods. In Bangladesh, a flood-prone country, this low rate of production from flooded waterbodies can be interpreted as a major risk factor.

Table 3.14. Average fish production (kg·ha⁻¹) in the waterbodies of farmer-cooperators, by incidence of fish disease and by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Average production						
Technology type	% of disease-affected affected waterbodies	Disease-affected waterbodies (kg·ha^{-1})	SD	Disease-free waterbodies (kg·ha^{-1})	SD	All waterbodies (kg·ha^{-1})	SD
Carp polyculture	37	1,022	430	2,233	721	2,071	802
Carps only (n=64)	35	1,029	430	2,182	669	2,074	731
Carps with other species (n=18)	40	1,014	480	2,465	913	2,062	1,044
Nile tilapia monoculture	0	0	-	2,208	1,279	2,208	1,279
Nile tilapia only (n=15)	0	0	-	2,087	1,227	2,087	1,227
Nile tilapia with other species (n=1)	0	0	-	4,014	-	4,014	-
Silver barb monoculture	63	623	331	1,459	544	1,131	624
Silver barb only (n=78)	64	560	332	1,358	517	1,000	595
Silver barb with other species (n=39)	62	823	250	1,614	558	1,391	605

SD = Standard deviation.

Table 3.15. Average fish production (kg·ha⁻¹) in the waterbodies of farmer-cooperators, by occurrence of floods and by technology type, in Kapasia thana, Gazipur disctrict, Bangladesh, July 1991 - June 1992.

	Average production	
Technology type	kg·ha^{-1}	SD
Carp polyculture	2,071	803
Flood-affected waterbodies (n=2)	880	391
Flood-free waterbodies (n=80)	2,101	789
Nile tilapia monoculture	2,208	1,280
Flood-affected waterbodies (n=1)	504	-
Flood-free waterbodies (n=15)	2,322	1,239
Silver barb monoculture	1,131	624
Flood-affected waterbodies (n=5)	222	167
Flood-free waterbodies (n=112)	1,162	618

SD = Standard deviation.

SOIL TYPE AND WATER QUALITY

Fishpond waters should contain abundant plankton. In the target extension area, most of the waterbodies had relatively good attributes for aquaculture: 65% had clay soils; 62% had plankton-rich, turbid waters (Table 3.16). Average fish production in waterbodies with clay soils was higher than for red/sandy soils by 23% and 34%, respectively, for silver barb monoculture and carp polyculture (Table 3.16). Nile tilapia production in waterbodies with red/sandy soils was higher by 25% than for clay-soil waterbodies. Waterbodies with plankton-rich, turbid waters, had fish productivities higher by 16% than clay-soil turbid waters.

Table 3.16. Average fish production (kg·ha^{-1}) in the waterbodies of farmer-cooperators, by soil/water quality characteristics and by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type								
	Carp polyculture n=82			Nile tilapia monoculture n=16			Silver barb monoculture n=117		
Soil type/ water quality	No. of waterbodies	Average production (kg·ha^{-1})	SD	No. of waterbodies	Average production (kg·ha^{-1})	SD	No. of waterbodies	Average production (kg·ha^{-1})	SD
Soil type									
Red/sandy	28	1,693	465	4	2,593	1,590	43	986	539
Clay	54	2,267	872	12	2,079	1,213	74	1,214	657
Water quality									
Clay turbid	26	1,963	633	7	2,119	1,289	48	990	544
Plankton-rich turbid	56	2,122	871	9	2,277	1,346	69	1,220	660

SD = Standard deviation.

Realization of Target Production

The production levels achieved by farmer-cooperators were all below the expected production levels. Only 74%, 57% and 56% of the target production levels were achieved for the Nile tilapia monoculture, silver barb monoculture and carp polyculture, respectively (Table 3.17). However, given the low rate of input use, the production performance in most of the ponds were encouraging (see costs and benefits). On average, fish production in waterbodies not affected by disease and flooding was more than double that achieved in affected waterbodies (Tables 3.14 and 3.15).

Table 3.17. Expected and realized average fish production (kg·ha^{-1}) in the waterbodies of farmer-cooperators, by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type		
Production	Carp polyculture n=82	Nile tilapia monoculture n=16	Silver barb monoculture n=117
Expected production using the technology (kg·ha^{-1})	3,705	2,964	1,976
Production achievement (%)[a]			
All waterbodies	56	74	57
Disease-affected waterbodies	28	-[b]	32
Nondisease-affected waterbodies	60	-[b]	74
Flood-affected waterbodies	24	17	11
Nonflood-affected waterbodies	57	78	59

[a] (Actual production/production in question) x 100.
[b] No incidence of disease.

Costs and Benefits

Production Costs

Average total cost per hectare ranged from BDT14,222 to BDT19,077 (US$1=BDT37.00, 1991; BDT38.91, 1992) (Table 3.18). Cash costs represented 76%, 73% and 44%, respectively, for carp polyculture, silver barb monoculture and Nile tilapia monoculture. Fingerlings accounted for the highest cash expenditures in silver barb monoculture (53% of total costs) and carp polyculture (43%). Fingerlings were expensive because of the services involved in transporting them from fish seed farms to the growout farms. However, fingerling costs will decrease as small-scale village nurseries and hatcheries are expected to develop in the future. The imputed costs for fish feed, i.e., rice bran, was highest: 43% of total cost for Nile tilapia monoculture. The imputed costs for cattle (10%) and poultry (<1%) manure, and cash expenses for lime (8%) and inorganic fertilizers (7%) did not differ significantly among the three aquaculture systems. Fish harvesting cash expenditure represented only 4% of total costs, since most of the farmer-cooperators did this activity themselves.

Income

Average gross income per hectare ranged from BDT41,636 to BDT80,111 (US$1 = BDT37.00, 1991; BDT38.91, 1992) (Table 3.19). Although Nile tilapia monoculture gave higher fish production per hectare than carp polyculture, higher carp prices resulted in higher gross income per hectare. The average net income per hectare from carp polyculture, Nile tilapia and silver barb monoculture represented 82%, 77% and 54% of the average gross incomes per hectare, respectively. The average net cash income of the Nile tilapia farmers was relatively higher than that of other farmer-cooperators because the former used more on-farm resources

Table 3.18. Average production cost per hectare (BDT·ha^{-1}) of farmer-cooperators, by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992. (US$1=BDT37.00, 1991; BDT38.91, 1992)

	Technology type											
	Carp polyculture n=82			Nile tilapia monoculture n=16			Silver barb monoculture n=117			All n=215		
Production costs (BDT·ha^{-1})	Value	SD	%	Value	SD	%	Value	SD	%	Value	SD	%
Cash	10,807	3,994	76	6,452	3,347	44	13,990	8,347	73	12,215	7,039	72
Fingerlings	6,128	2,182	43	4,203	3,188	29	10,026	7,756	53	8,106	6,307	48
Lime	1,075	683	8	1,276	562	9	1,410	979	7	1,272	862	8
Inorganic fertilizers	1,286	1,049	9	809	323	5	1,152	784	6	1,177	879	7
Rice bran	182	633	1	0	-	0	309	1,076	2	238	887	1
Oil cake	1,238	163	9	0	-	0	452	835	2	718	1,252	4
Pesticide	47	87	<1	0	-	0	37	76	<1	38	78	<1
Harvesting cost	851	2,125	6	164	524	1	604	1,884	3	666	1,920	4
Noncash	3,415	1,658	24	8,045	3,088	56	5,087	2,520	27	4,669	2,588	28
Cattle manure	1,738	672	12	1,688	1,049	12	1,499	633	8	1,604	692	10
Poultry manure	60	109	<1	180	390	1	71	199	<1	75	194	<1
Rice bran	1,617	1,268	11	6,177	2,433	43	3,517	2,163	18	2,990	2,279	18
Total	14,222	4,705	100	14,497	4,388	100	19,077	9,072	100	16,884	7,752	100

SD = Standard deviation.

Table 3.19. Gross and net incomes per hectare (BDT·ha^{-1}) of farmer-cooperators, by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992. (US$1=BDT37.00, 1991; BDT38.91, 1992).

	Gross income		Net income		Net cash income	
Technology type	Value (BDT·ha^{-1})	SD	Value (BDT·ha^{-1})	SD	Value (BDT·ha^{-1})	SD
Carp polyculture	80,111	31,054	65,888	30,751	69,303	31,072
Disease-affected waterbodies (n=11)	39,539	16,613	25,428	16,355	28,253	16,795
Disease-free waterbodies (n=71)	86,397	27,888	72,156	27,549	75,663	27,767
Nile tilapia monoculture (n=16)[a]	62,373	36,157	47,876	35,612	55,921	35,933
Silver barb monoculture	41,636	22,977	22,561	21,664	27,647	22,764
Disease-affected waterbodies (n=46)	22,951	12,207	6,826	11,681	11,279	12,083
Disease-free waterbodies (n=71)	53,743	20,025	32,756	20,541	38,252	21,788
All	57,912	33,046	41,028	33,771	45,697	34,092
Disease-affected waterbodies (n=73)	25,836	14,122	10,100	14,072	14,239	14,139
Disease-free waterbodies (n=142)	69,484	30,151	52,185	31,802	57,046	32,001

SD = Standard deviation.
[a]No incidence of disease.

as production inputs and the unit cost of Nile tilapia fingerlings was lower.

Carp polyculture was the most profitable system with a return on investment (defined as the ratio of net income to total costs) of 463%, compared to 330% and 118% for Nile tilapia and silver barb, respectively (Tables 3.18 and 3.19). The average net incomes per hectare of carp polyculture farmers were higher by 38% and 192% than the average net incomes per hectare of Nile tilapia and silver barb farmers, respectively. Similarly, the average net cash income from carp polyculture were higher by 24% and 151%, respectively, than incomes from Nile tilapia and silver barb monoculture.

Fish disease significantly reduced incomes. On average, the incomes of the silver barb and carp farmers in disease-free waterbodies were higher by 251% and 157%, respectively, than those from disease-affected waterbodies (Table 3.19).

Disposal and Marketing of Fish

Disposal Pattern

Before the introduction of these aquaculture technologies, 64% of the total fish harvested by farmers in Kapasia thana were sold, 33% were consumed by the operating households, and 3% were given to neighbors and relatives (Ahmed et al. 1993). However, after the extension effort, about 58% of the fish harvest were sold, 40% consumed at home, and 2% were given to neighbors and relatives (Table 3.20). Whereas most of the carp (78%) and silver barb (65%) harvests were sold, 67% of the Nile tilapia harvest was consumed by the farm households.

Marketing Channels

Out of the 215 harvested waterbodies, 69% indicated fish sales (Table 3.21). The benchmark survey conducted before the introduction of the aquaculture technologies reported that among the fish sellers and traders in the rural fish markets in Kapasia thana, none was a pond operator (Ahmed et al. 1993). This means that the fish harvested by the pond operators were

Table 3.20. Disposal pattern of fish harvest (kg) by technology type, of farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type							
	Carp polyculture n=82		Nile tilapia monoculture n=16		Silver barb monoculture n=117		All n=215	
	Quantity (kg)	%	Quantity (kg)	%	Quantity (kg)	%	Quantity (kg)	%
Production	8,169	100	405	100	3,867	100	5,250	100
Consumption	1,668	20	273	67	1,285	33	1,356	40
Sold	6,348	78	121	30	2,499	65	3,790	58
Given away	153	2	11	3	83	2	104	2

Table 3.21. Number of farmer-cooperators who sold fish at different market points, by technology type, in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type							
	Carp polyculture n=64		Nile tilapia monoculture n=10		Silver barb monoculture n=74		All n=148	
Marketing channel	No.	%	No.	%	No.	%	No	.%
Sold at the farm gate	39	61	8	80	53	72	100	68
for further resale								
local Bepari[a]	8	12	0	0	8	11	16	11
broker	2	3	2	20	1	1	5	3
fishers	20	31	1	10	22	30	43	29
for end-user								
neighbor/local people	12	19	6	60	25	34	43	29
Sold at the village market	35	55	0	0	33	45	68	46
for further resale								
wholesaler	8	12	0	0	4	5	12	8
retailer	1	2	0	0	1	1	2	1
for end-user								
consumer	32	50	0	0	29	39	61	41
Sold at the thana market	6	9	2	20	5	7	13	9
for further resale								
wholesaler	4	6	0	0	2	3	6	4
retailer	1	2	2	20	1	1	4	3
for end-user								
consumer	2	3	0	0	2	3	4	3

[a]Local name for small trader.

immediately sold at the farm gate to local fishers and fish traders, who then transported and sold the fish in the rural markets. Normally, these local fishers and fish traders are the ones hired by the pond operators to harvest the fish.

The fish marketing practice in Kapasia thana after the extension effort also changed: only 68% of the pond operators sold their fish harvest at the farm gate; 46% sold fish at the village market; 9% sold at the thana market; and 44% sold fish directly to consumers at the village and thana markets (Table 3.21).

In terms of the volume of fish marketed, farmer-cooperators sold 45% of their fish harvest to local traders; brokers and retailers at the farm gate; 45% to consumers, traders and wholesalers at the village markets; and only 10% to wholesalers, retailers and consumers at the thana market (Table 3.22). Almost 41% were sold directly to the consumers in retail markets.

Table 3.22. Volume (kg) of fish sold by the farmer-cooperators at different market points by technology type in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

	Technology type							
	Carp polyculture n=64		Nile tilapia monoculture n=10		Silver barb monoculture n=74		All n=148	
Marketing channel	Quantity (kg)	%	Quantity (kg)	%	Quantity (kg)	%	Quantity (kg)	%
Sold at the farm gate	2,716	43	85	70	1,232	49	1,795	45
for further resale								
local Bepari[a]	755	12	0	-	220	9	436	11
broker	343	5	32	26	25	1	163	4
fishers	1,320	21	2	2	555	22	848	21
for end-user								
neighbor/local people	298	5	51	42	432	17	348	9
Sold at the village market	2,920	46	0	-	1,101	44	1,814	45
for further resale								
wholesaler	495	8	0	-	162	6	295	7
retailer	32	0.5	'0	-	2	0.1	16	0.4
for end-user								
consumer	2,393	38	0	-	937	38	1,503	38
Sold at the thana market	681	10	36	30	164	6	380	10
for further resale								
wholesaler	521	8	0	-	55	2	254	6
retailer	7	0.1	36	30	27	1	19	0.5
for end-user								
consumer	153	2	0	-	82	3	107	3

Local name for small trader.

CHAPTER 4

Factors Affecting the Adoption of Aquaculture Technologies

Adoption Rate of the Aquaculture Technologies

Summary statistics of the logit model which estimated the adoption rate of the aquaculture technologies are presented in Table 4.1. It required six iterations for the model to converge and estimate the parameters. The model chi-square ratio (likelihood ratio test) -2 (ln L_o - ln L_{max}) equals 73.493 which rejected the null hypothesis ($H_0=B_1=B_2=B_3=0$) at P<0.01. The likelihood ratio index (LRI), comparable to the R^2 in linear models, is a measure of goodness of fit. The LRI of 0.28 of this model indicates a moderate goodness of fit for the model on the scale of 0 to 1.

Table 4.1. Summary statistics of the logit model of aquaculture technology adoption decision in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

Items	Value
Number of iterations	6[a]
Log likelihood	-95.886
Restricted (slopes=0) Log-L	-132.63
Likelihood ratio index (LRI)[a]	0.28
Likelihood ratio test[b]	73.493
Significance level	0.32E-13
Correctly predicted (149/193)	77.2%

[a]LRI = 1 - (log likelihood of function/log likelihood where B=0).
[b]Test of H_o: B=0, Chi-square test (6 df).

Another indicator of the significance of the model is its predictive ability. The fraction of concordant pairs of predicted probabilities and responses, which gives this measure, equals 77.2% This implies that the model correctly predicted 77% of the farmers as adopters or nonadopters of the aquaculture technology. Thus, the independent variables that were hypothesized to explain the decision of farmers to adopt the aquaculture technologies were well defined.

The maximum likelihood parameter estimates from the logit model suggest that the key variable influencing the adoption of the aquaculture technologies is the extent of knowledge the farmers have (i.e., the exposure to trainings) about the technology (Table 4.2). Farmers who were better informed and those with a higher level of understanding of the aquaculture technology, had greater chances of adopting the technology. For each 1% increase in what the farmers knew about the aquaculture technology through training efforts, the probability that they would adopt the technology increased by 2.3%.

Table 4.2. Adoption of aquaculture technologies: maximum likelihood estimates for 193 farmer-cooperators in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

Explanatory variables	Coefficients	t-values
Proportion of nonfarming members in the households (x_1)	-0.019	-2.762**
Area of the waterbody (x_2)	-0.014	-2.282*
Proportion of own (operator and family) labor to total farm labor (x_3)	-0.015	-2.388**
Operator type (x_4)	0.909	2.230*
Culture status of the waterbody before the extension effort (x_5)	0.256	0.690
Risk of flood (x_6)	-0.811	-1.483
Knowledge about technology (x_7)	2.308	5.946**
Model chi-square	73.49**	

**Significant at 1% level.
*Significant at 5% level.

The proportion of nonfarming members in the operators' households and proportion of own (farmer and family) labor to total farm labor were inversely related to the probability that farmers would adopt the aquaculture technology. This is consistent with the reasoning that the probability of adoption would be higher if there were more household members who have farming as their principal occupation. Similarly, as the farmer and household members devote more labor (time) in other farm enterprises, the probability of adopting the aquaculture technology decreases. This implies that farmers gave priority to farm enterprises other than aquaculture.

Results further showed that the operator type and area of the waterbody were significant factors that determined the adoption of these types of aquaculture technologies. Smaller waterbodies and those managed by single operators had higher probabilities of being used for these types of aquaculture.

Table 4.3. Intensity of the adoption model with ordinary least square estimates for 86 waterbodies in Kapasia thana, Gazipur district, Bangladesh, July 1991 - June 1992.

Explanatory variables	Coefficients	t-values
Knowledge of the operator about the technology (x_1) (trained=1; nontrained=0)	0.04	0.11
Occupation of the operator (x_2) (farming=1; nonfarming=0)	-0.56	-1.98*
Operator type (x_3) (single=1; otherwise=0)	0.19	0.73
Quantity of land owned by the operating household (x_4)	-0.16	-0.68
Education of the operator (x_5) (educated=1, noneducated=0)	-0.28	-1.31
Culture status of the waterbody before the extension effort (x_6) (cultured=1; noncultured=0)	0.86	3.48**
Area of the waterbody (x_7)	-0.02	-4.24**
Constant	0.12	0.26
F-value	7.42**	
Adjusted R^2	0.35	

**Significant at 1% level.
*Significant at 5% level.

Intensity of Adoption of the Aquaculture Technologies

The model has a high F-value, significant at 1%. (Table 4.3). Only 35% of the variations in the intensity of adoption was explained by the variables in the model. The significant variables that influenced the intensity of adoption were the area and culture status of the waterbodies before the extension effort ($P<0.01$) and the occupation of the operators ($P<0.05$). Farmers who were, prior to the extension effort, already practising aquaculture using traditional methods, were better motivated to follow the suggested inputs and their respective application rates. Moreover, farmers who were operating smaller waterbodies had greater chances of following the suggested input rates. Past studies in agriculture enterprises, especially in crop production, have shown that there is a negative relationship between technology adoption and farm size (Hossain 1977; Asaduzzaman 1979; Rab 1988).

Results further show that farmer-cooperators who have farming as their principal occupation, are less likely to follow the suggested input rates. This may indicate that there is a higher priority of resource diversion to other farming enterprises rather than to aquaculture. Aquaculture is new to farmers. Moreover, it is not perceived to be an important source of cash income for them. On the other hand, agriculture has been traditionally a direct source of farm income. Thus, unless an aquaculture technology is relatively profitable, it would be difficult for farmers to shift existing resources from agriculture to adopt or intensify their traditional aquaculture practices.

Chapter 5

Conclusions

The key factor to affect immediate increases in fish production from small ponds and ditches is the level of aquaculture information available to farmers. The present study has shown that aquaculture extension can work well in Bangladesh, especially on small farms and when household members are mainly involved with farming already but still have excess labor to devote to new enterprises on the farm. Rather than creating new schemes for credits, inputs and marketing, development programs should focus more on information dissemination, training and monitoring visits as means of transferring technologies on fish farming. The low cost and less commercial input-dependent nature of the suggested aquaculture technologies allowed easy adoption. Perhaps the most appropriate aquaculture technology is one that can be practised by farmers having diverse socioeconomic circumstances and resource system characteristics. Thus, intensified extension programs on flexible technological choices can significantly enhance the rate of aquaculture technology adoption.

Fish yields obtained by the farmer-cooperators indicate that minimal investments can produce appreciable increases in production. Cost-benefit analyses of the three aquaculture technologies have shown high net incomes relative to production costs. Equally important is the nutritional benefits derived by the farm households. Higher fish yields from own production means that fish becomes more available for household consumption because farmers usually do not buy fish due to its high market price. Thus, cultured fish becomes an important source of animal protein in the diet of the farm households.

The strategy that has emerged to be effective in promoting the adoption of aquaculture technologies is to develop a technology relevant to the needs and resources of the farm households through on-farm research and consultation with farmers, which must further be supported by intensive information dissemination and training schemes. The widespread adoption of these aquaculture technologies would mean improving the standard of living of the resource-poor farm families in Bangladesh.

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Appendix I

Record-Keeping Book
(Translated from Bengali)

Farmer/Project Copy **Book No:...Financial Year:......**

ICLARM/GOB FISH CULTURE EXTENSION IMPACT STUDY PROJECT
ANNUAL REPORT OF POND FISH CULTURE ACTIVITIES

Pond/Ditch No : .... **Age of Pond** :............

Area of Waterbody:................. **Depth** :............

Operators Name :............ **Fathers Name** :............

Village/Mauza :.............. **Union** :............

Upazila :..............

Operators Status : [ ]

1 Single Owner 2 Joint Owner
3 Single Lease 4 Joint Lease
5 Institutonal

Operator Type : [ ]

1 Model 2 Fellow

Selected Technology : [ ]

1 Carp 2 Nilotica 3 Thai Shorputi

Harvesting Period : [ ]

1 Whole Year 2 (6-8) Months

Dates of Stocking :----/----/----

Expected dates of Harvesting :----/----/----

Signature
(Operator)

Signature
(Extension Officer)

I. SUGGESTED PRACTICES AND EXPECTED INCOME-EXPENDITURE ACCOUNTS PER DECIMAL WATER AREA

1. Pond preparation

a) Cleaning of aquatic vegetation
b) Removal of Predatory fish
c) Pond Repair
d) Liming/Fertilization doses :

	Time of application	Amount (Kg)		
		Carp.	Nilotica.	S. Puti
Lime	During pond preparation	1	1	1
Cowdung	5-7 days after liming	12	4	4
-Urea	4 days after cowdung application	0.25	0.1	0.1
-TSP		0.25	0.1	0.1

2. Fingerlings Stocking

(should be stocked 4-7 days after fertilization)

a) Mixed carps 25-30 fingerlings (3-4 inches)

Species	Percentage
1. Silver carp	15
2. Catla	25
3. Rohu	30
4 Grass carp	05
5. Mrigal	10
6. Mirror carp/others	15
Total	100

or b) Nilotica 80-85 fingerlings (1-1.5 inches)
or c) Shorputi 60-65 fingerlings (1.5-2.5 inches)

3. Rearing/Management :

a) Liming & fertiling	Carp 1 year	Nilotica 6-8 months	Shorputi 6-8 months
(1) Lime (Kg)	1.00	-	1.00
(2) Urea (Kg)	1.25	0.75	0.25
(3) TSP (Kg)	1.25	1.25	0.50
(4) Cowdung (Kg)	30.00	20.00	15.00
(5) Chicken manure (Kg)	2.50	-	-
(6) Compost (Kg)	20.00	-	-

b) Feeding	Carp	Nilotica	Shorputi
Rice/Wheat (1) Bran (Kg)	20.00	60.00	40.00
(2) Oil cake (Kg)	10.00	-	-
(3) Fisf meal (Kg)	-	-	-
(4) Grass/Aquatic Vegetation (Kg)	25.00	-	-

4. Expected Income and Expenditure per year :

Item	Carp	Nilotica	Shorputi
Production (Kg)	15	12	8
Market Price (per Kg)	40.00	25.00	40
Expected Income (Tk)	600.00	300.00	320.00
Expected Expendt (Tk)*	162.00	107.00	95.00
Expected Profit(Tk)	438.00	103.00	225.00

*Excluding harvesting and labor costs.

II. INPUT REQUIREMENTS AND RULES OF APPLICATION

a) Fingerlings :------------unit

Name of Species	Number	Name of Species	Number
Rohu		Mirror Carp	
Catla		Nilotica	
Mrigal		Shorputi	
Silver Carp		Bighead	
Grass Carp		Kalbaos	
Common Carp			

b) Liming/Fertilization :

Lime/ Fertilizer	Total Qty.	During Pond Preparation	After Stock -ing	Application Methods		
				Qty	Interval	No.of Appli.
1) Lime						
2) Urea						
3) TSP						
4) Potash						
5) Cowdung						
6) Manure						
7) Compost						
8)						
9)						

c) Feeding :

Items	Monthly Quantity						
	Total	Jul	Aug	Sep	Oct	Nov	Dec
Oil Cake							
Wheat/ Rice Bran							
Rice/Wheat granule							
Fish Meal							

c) Feeding (contd.) :

Items	Monthly Quantity					
	Jan	Feb	Mar	Apr	May	June
Oil Cake						
Rice/wheat Bran						
Rice/Wheat granule						
Fish Meal						

III.STOCKING RECORD

Date	Name of Fish	No.	Av. Weight	Av. length	Price	Source of finance	Signature Remarks

IV. GROWTH MONITORING

Date	Species	No.	Av. Weight	Av. length	Expected weight	Remarks

V. POND VISIT RECORD

Date	Name and Designation of the Visitor	Advice	Signature/ Remarks

VI. RECORDS OF MEETING, TRAINING AND DEMONSTRATION

a) Training :

Date	Subject	Duration	Comments	Signature/ Remarks
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------	-----------	------------	----------	------------
------	-----------	------------	----------	------------
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b) Meeting :

Date	Subject	Duration	Comments	Signature/ Remarks
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------	-----------	------------	----------	------------
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c) **Pond Demonstration :**

Date	Subject	Duration	Comments	Signature/ Remarks

VII. INPUT AND COST ACCOUNTS

	1	2	3	4	5	6	7	8
Date	Dewater	Repair	Lime	Urea	TSP	MP	C.dung	Compost
Tot-al								

INPUT AND COST ACCOUNTS (CONTD.)

	9	10	11	12	13	14	15
Date	Oilcake	Bran	Grass	Medicine	Harvesting	Misc.	Total
Total							

VIII. PRODUCTION, DISPOSAL AND INCOME ACCOUNTS

Date	Harvested Fish		Total Wt .	Sale		Self Consumption		Given away		Share of Harvestor (kg)
	Name	No.		Wt	P	No.	Wt	No.	Wt	
Tot.										