Low-Input Technologies For Rural Aquaculture Development In Bangladesh

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Abstract

Fish is the main animal protein source for the people of Bangladesh. In spite of vast water resources, fish production is in decline, resulting in protein-energy malnutrition. Farmers participating in on-farm research developed low-input sustainable aquaculture practices that benefit the poor farmers, who constitute the bulk of the population.

Farmer-oriented studies have confirmed the viability of culturing silver barb (Puntius gonionotus) and nile tilapia (Oreochromis niloticus) in seasonal ponds. Productions of 1,2052,156 kg of P. gonionotus per ha were obtained in 3-6 months using rice bran as supplementary feed. While a production of 2,138-3,554 kg/ha/6 months was obtained in on-station experiments with cultures of O. niloticus, using various supplementary feeds and fertilizers, studies rearing O. niloticus were undertaken in farmers' seasonal ponds, resulting in production of 1,441-2,343 kg/ha in 4-6 months, using rice bran as supplementary feed and fertilizers. Results of a survey conducted to study the socioeconomic impact and farmers' assessment of culturing nile tilapia in seasonal ponds revealed that 70 % of the fish produced were consumed on-farm, and only 23 % of the fish sold was enough to meet operational costs. The overall return on investment was 334%.

Integration of poultry rearing (500 chicken/ha) with carp culture in perennial ponds proved to be economically feasible and resulted in the production of 5,044 kg of fish and 6,676 kg of chicken (live weight) per ha in one year.

Introduction

Fish is the main and cheapest animal protein source for the 110 million people of Bangladesh. Besides nutritional value, fisheries play an important role in the economy of Bangladesh in terms of employment, income generation, and foreign exchange earnings. It is estimated that about 8% of the population depend on fisheries for their livelihood (Planning Commission 1978). The number of households engaged in subsistence fishing is about 10.8 million (DOF 1990).

Despite its importance in nutrition, per capita consumption of fish is low -- about 7.9 kg/yr at present (World Bank 1990). In recent years, there has been a decline in per capita availability of fish, resulting in protein-energy malnutrition because of the increasing human population and decreasing yields from wild capture fisheries due to overexploitation of stocks and environmental degradation. Rural people, who depend on fish catches from the wild, have been most affected. Moreover, average fish consumption figures do not reflect the situation in rural areas: per capita consumption among the rural poor is about 4.4 kg/yr, and for the urban elite is about 22.1 kg/yr (World Bank 1990).

Against this backdrop of declining fish availability, the country has vast water resources: for example, ponds, oxbow lakes, floodplains, rivers, and reservoirs. There are more than 1.3 million ponds covering 146,000 hectares. In addition to these official figures, there exist vast numbers of small ponds and ditches (< 600 m² in area). A majority of rural households have backyard ponds or ditches that have high potential for aquaculture.

Realizing the need for increased fish production and the limitations from marine and inland capture fisheries, the government of Bangladesh is stressing increased production through freshwater aquaculture. The government has set a target production of 308,000 tons by 1994-1995 (an annual growth rate of 10.9%), as compared to a production of 153,000 tons from pond aquaculture during 1988-1989.

The International Center for Living Aquatic Resources Management (ICLARM), with funding from the United States Agency for International Development (USAID), is assisting the Bangladesh Agricultural Research Council (BARC) and the Fisheries Research Institute (FRI) in developing low-input aquaculture technologies. Resource-poor small-scale farmers constitute the bulk of the population in Bangladesh, and hence the major emphasis in project activities is on farmer-participatory on-farm research for developing aquaculture practices that would optimize resource use and maximize production. The project actively involves non-governmental organizations (NGOs) in the on-farm research activities and undertakes impact studies. Some of the activities undertaken and the results obtained are presented here.

Short-Cycle Species Culture in Seasonal Ponds

Many seasonal ponds, ditches, burrow pits, and roadside canals exist in the country. Most of these are lying fallow, covered with obnoxious aquatic weeds, and represent health hazards. At present, the yield from these waters is only 100-200 kg/ha of fish. Two of the reasons for their underutilization are: (1) farmers believe that seasonal waters are not suitable for aquaculture; and (2) the traditional culture species, viz., Indian carp (Catla catla, Labeo rohita, and Cirrhinus mrigala) do not grow well in these seasonal waters. Nile tilapia (Oreochromis niloticus), a hardy fish that can survive under poor water conditions, is resistant to disease, is a good converter of organic wastes into high quality protein (Stickney et. al. 1979, Balarin and Haller 1982, Pullin and Lowe-McConnell 1982), and is suitable for culture in derelict ponds of Bangladesh. Puntius sp. is in much demand in Bangladesh, but the locally available P. sarana is not a good species for culture because of its poor growth. Puntius gonionotus, with faster growth, would be suitable for culture in seasonal waters. Hence, the need for introducing short-cycle species into the culture system was identified. Oreochromis niloticus and P. gonionotus were introduced into Bangladesh in 1974 and 1977, respectively, but have not been established as cultured species until recently, since there were no developed management practices. Research undertaken in the last two years has revealed that these species could give high production with low-value inputs (mostly agricultural residues and by-products) and are suitable for culture in seasonal waters.

Culture of P. gonionotus in Seasonal Ponds

On-station studies were undertaken for culture of P. gonionotus in six ponds of 360 m² each. Pond preparation included draining, application of lime at the rate of 200 kg/ha, filling with water, and releasing fingerlings of average size 8-10 g, at a density of 16,000/ha. The ponds were divided into two groups, each with three ponds. The first three ponds were fertilized with cattle dung at the rate of 1,500 kg/ha, and triple super phosphate (TSP), with 46% N and urea with 42% P (2:1 ratio) at the rate of 50 kg/ha/fortnight. Organic manure was alternated with the inorganic fertilizers. No supplementary feed was given. The second group of ponds did not receive fertilization, but the fish were fed daily with rice bran at the rate of 5% of the standing fish biomass. The fish were harvested from the ponds after five months of culture. While an average production of 1,953 kg/ha was obtained from ponds where supplementary feed without fertilizers was given, ponds that received fertilizers, but no supplementary feed, only produced an average of 689 kg/ha.

During these on-station studies, discussions were held with farmers and local NGOs who showed keen interest in participating in research. They felt that their near-zero return from underutilized water

resources could be improved with on-farm resources. Eight farmers having homestead ponds of 160-600 m² in size, and with an average depth of 0.9 m, were selected as cooperators for the culture of P. gonionotus.

Pond preparation included liming at the rate of 200 kg/ha, three days after which cattle dung was applied at the rate of 1,500 kg/ha. Five days after application of cattle dung, the ponds were stocked with P. gonionotus fingerlings of 7.5 - 10 g size, at a density of 15,000/ha. The farmers were asked to feed the fish daily with rice bran at the rate of 5% of standing crop and fertilize the ponds at fortnightly intervals with cattle dung at the rate of 1,500 kg/ha. However, it was observed during the culture period that fertilization of ponds was irregular, and on certain days they could not feed the fish due to lack of rice bran in the household. The fish were sampled at monthly intervals and the ponds were harvested after 4-6 months of rearing, depending on the water availability in the ponds. The production for 4-6 months rearing ranged from 1.2 to 2.1 t/ha (Table 1). The cost of production worked out to Tk.13/kg (US $ 1 = Tk. 36) of fish against a market price of Tk. 50/kg. These studies have shown that production can be increased by as much as 10 times with very low investment, and that the system can be managed easily by poor farmers.

TABLE 1 Culture and Production Details of Puntius gonionotus in Farmers' Seasonal Ponds

Pond no.	Pond Size (m²)	Stocking Density	Size at Stocking (g)	Size atHarvesting (g)	Culture Period (month)	Gross Production(kg/ha)
1	160	15,000	8.0	99.2	4	1,437
2	600	15,000	10.0	88.5	6	1,666
3	400	15,000	9.0	84.0	6	1,205
4	280	15,000	9.5	118.0	6	2,156
5	360	15,000	8.0	120.8	6	1,644
6	160	15,000	10.0	97.4	3	1,375
7	320	15,000	7.5	94.7	6	1,266

8	600	15,000	8.0	106.0	6	1,558

Culture of O. niloticus in Seasonal Ponds

Studies were undertaken at the FRI, Mymensingh, in ponds of 280 m² each, to evaluate the production potential of O. niloticus under different feeding and fertilization regimes. Ponds were stocked with fingerlings of 10-11 g size, at a density of 20,000/ha. Production of 2,739 kg/ha/6 months was obtained with rice bran as supplementary feed but without pond fertilization, while production was 2,128 kg/ha/6 months when ponds were fertilized with 1,500 kg/ha/fortnight of cattle dung, alternating with 50 kg of TSP and urea (2:1 ratio)/ha/fortnight. However, all fish were undersized (average size 52 g + 19) when raised only with fertilization (Table 2). When 40% of the rice bran in supplementary feed was substituted by mustard oil cake, the production increased to 3,554 kg/ha/6 months, with 11.2% undersized fish (Table 2).

TABLE 2 Details of Oreochromis niloticus Production under Different Management Systems

Stocking Density	Size at Stocking	Feed	Fertilization	Production(kg/ha/6 months)		Total
(fingerlings/ha)	(g)			Undersize	Market	
				Fish	Size Fish	
				(<80 g)	(>80 g)	
20,000	10.0	Rice bran TSP and urea	-	700	2,038	2,738
20,000	10.5	-	Cattle dung,	2,138	-	2,138
20,000	11.0	Rice bran 60%	-	400	3,154	3,554
			+ mustard oil	-		

			cake 40%			

These on-station studies indicate the potential for culturing O. niloticus in seasonal ponds, but studies under farmers' conditions were also felt necessary. For this purpose, six derelict seasonal ponds were selected that were adjacent to homesteads. These ponds had not been used for fish culture previous to this study. The size of the ponds ranged from 80 to 320 m², with a maximum water depth of 1 m. The ponds were cleared of weeds before the onset of rains and lime was applied at the rate of 200 kg/ha. After filling with rainwater, the ponds were stocked with fingerlings of 5-10 g size at a density of 20,000/ha. The farmers were advised to feed the fish daily with rice bran at the rate of 5% of the standing crop. Three farmers were asked to fertilize the ponds with cattle dung at the rate of 1,500 kg/ha at fortnightly intervals and the other three farmers were asked to fertilize the ponds with TSP and urea (2:1 ratio) at the rate of 50 kg/ha/fortnight. However, the farmers could not adhere to these feeding and fertilization regimes due to lack of resources and inputs during certain days. The culture period ranged from 4 to 6 months, depending on the availability of water in the ponds.

The ponds were harvested when the water level went below 30 cm. Gross production ranged from 1,500 to 2,343 kg/ha in 4-6 months from ponds that received inorganic fertilizers, while production ranged from 1,441 to 1,925 kg/ha in 4-6 months from the ponds that received organic manure (Table 3). It is difficult to assess the effect of organic and inorganic fertilizers on production, as the farmers did not adhere strictly to the suggested fertilization schedules. However, the study indicated an average net benefit ranging from Tk. 38,250 to 72,750/ha (US $1,062 - 2,020/ha) in 4

months.

TABLE 3 Culture and Production Details of Oreochromis niloticus in Farmers' Seasonal Ponds

Pond Size	Fertilization	Stocking Density	Size at Stocking	Size at Harvesting	Culture Period	Gross Production
(m^2)			(g)	(g)	(month)	(kg/ha!)
80	TSP + urea	20,000	5.0	82.2	6	2,000
120	TSP + urea	20,000	10.0	89.0	6	2,343
80	TSP + urea	20,000	7.0	95.7	4	1,500
120	Cattle dung	20,000	8.5	97.2	4	1,441
120	Cattle dung	20,000	8.0	98.1	6	1,925

120	Cattle dung	20,000	10.0	126.0	4.5	1,594

These results created wide interest among farmers and extension agents. An NGO, Bangladesh Rural Advancement Committee (BRAC), with technical assistance from the project, extended the technology to 309 farmers (32% women) in one district. Subsequent to implementation of the program, the project undertook a survey of 113 farmers to assess the production and economics of the operation. The study revealed Table 4) that the inputs (feeds and fertilizers) applied by the farmers were much lower than had been suggested and even then, they obtained a gross average production of 1,391 kg/ha/6.5 months. While cost of production amounted to Tk. 9,223/ha (US $256), average net return was Tk. 30,860/ha (US $875.23/ha), showing the economic viability and high returns from resources that formerly gave near-zero returns.

Integrated Livestock-Fish Farming in Perennial Ponds

In rural Bangladesh, a majority of the households raise chicken or ducks for either meat or eggs. In recent years the government of Bangladesh has taken up programs to introduce high yielding varieties of poultry to replace low productive native varieties. Studies were undertaken at the FRI to study the economic viability of integrating poultry raising with fish farming under Bangladesh conditions.

Experiments were conducted in ponds of 1,000 m² in area. Broiler chickens were raised over ponds at a density of 500 chickens/ha. Three species combinations of carps, catla (Catla catla), rohu (Labeo rohita), mrigal (Cirrhinus mrigala), silver carp (Hypophthalmichthys molitrix), and grass carp (Ctenopharyagodon idella), were stocked in the ponds, at a density of 6,000/ha, each treatment with three replications (Table 5). The ponds were neither fertilized nor given supplementary feed, except for the chicken manure and some spilled chicken feed falling into the ponds. The chickens reached a marketable size of 1.4-1.8 kg each (live weight) in 7-8 weeks. It was possible to raise seven batches of chicken and one crop of fish in one year. Fish production ranged from 4,265 - 4,893 kg/ha/year. While gross biomass production was higher with 40% silver carp in treatment 1 (Table 5), gross economic returns were higher with 30% catla and 10% silver carp in treatment 2, due to the higher market price for catla in Bangladesh.

TABLE 4 Details of Cost of Production and Benefit of Oreochromis niloticus Culture in Seasonal Ponds by 113 Farmers

	Average per Pond (169.38 m²)	Per Hectare
Average Water Depth (m)	1.09	1.09
Inputs:		
Fingerlings (number)	298	17,593.00

Lime (kg)	2.06	121.62
Urea (kg)	0.30	17.71
TSP (kg)	0.68	40.15
Cattle dung (kg)	48.49	2,862.80
Rice bran (kg)	67.06	3,959.15
Costs:		
Fingerlings (Tk.)	52.94	3,125.52
Lime (Tk.)	11.91	703.15
Urea (Tk.)	1.51	89.15
TSP (Tk.)	3.40	200.73
Cattle dung (Tk.)	12.75	752.75
Rice bran (Tk.)	73.72	4,352.34
Total: (Tk.)	156.23	9,223.64
Production:		
Fish (kg)	23.57	1,391.55

Gross return (Tk.)	678.74	40,072.03
Net return (Tk.)	522.51	30,848.39

1 US$ = Tk. 36.00

These on-station studies have proved the economic viability of integrated chicken-fish farming, but have also raised some issues regarding its adoption by farmers. Will raising poultry over ponds be socially acceptable? Will the farmers be able to manage the high-yielding varieties of chicken? Will there be marketing problems for the chickens? Will the system prove economically viable under farm conditions? Will the financial resources of farmers restrict the purchase of chicken feeds?

To find answers to these questions, studies were initiated with three farmers to whom BRAC provided credit. Details of costs and returns of one of the farmers are presented in Table 6. As can be seen, a farmer could get a net benefit (excluding interest on working capital), of Tk. 12,519 (US $348) from a pond of 680 m². This study indicates that raising chickens over ponds is socially acceptable; farmers would be able to manage high-yielding varieties of chicken; the practice has proved economical; and extension agencies are willing to provide credit to farmers.

TABLE 5 Fish Production under Different Species Combinations in Integrated Poultry-Fish Farming

Species Combination	Stocking Density	Culture	Production
(fingerlings)	Period	(kg/ha)	(month)
Silver carp 40 %, rohu 20 %, mrigal 30%, and grass carp 10%	6,000	12	4,893
Silver carp 10 %, catla 30 %, rohu 20%, mrigal 30%, and grass carp 10%	6,000	12	4,492
Silver carp 30 %, catla 10 %, rohu 25 %, mrigal 25 %, and grass carp 10%	6,000	12	4,265

Involvement of Extension Agencies in Farmer-Participated Research

One of the constraints for aquaculture development in the past has been the poor links among farmers, extensionists, and researchers. The technology packages developed through on-station research are technically feasible and economically viable, but often fail to make an impact on the farmers because on-station research has failed to consider the resources of the smallholder farmers for whom these technologies are being developed. Therefore, extensionists also showed little interest in on-station research results. Hence, the project has been trying to involve farmers and extensionists (mostly NGOs, who play an active role in Bangladesh) in the process of problem identification and implementation of programs. This has many advantages: (1) it creates confidence among extensionists since they have witnessed successful adoption by farmers; (2) it reduces the time gap between technology development and dissemination; and (3) having been convinced of the economic viability of the operation, extension agencies are more willing to extend credit and other inputs to farmers. One example of such successful collaboration could be cited here. BRAC has been involved in farmer participatory research for culture of P. gonionotus and O. niloticus. Having been convinced of the viability of the culture operations, BRAC now extends the technology to a large number of smallholder farmers. During 1991, more than 2,000 rural women were involved in the culture of P. gonionotus alone. The project, in collaboration with extension agencies, also organizes Farmer's Days, when the operations and results of the research are demonstrated to farmers in the area.

Impact Studies

After the development of a culture system and its transfer to farmers by the extension agencies, the project undertakes studies to assess socioeconomic impact and farmers' assessment of the technology. These surveys are revealing: (1) the benefits the farmers are getting through the implementation of the technology; (2) the constraints, if any, in practicing the culture system; (3) refinements and improvements needed in the technology; and (4) the policy issues involved.

TABLE 6 Costs and Returns of One Year's Production in Integrated Broiler-Fish Farming, from a

Pond of 0.068 Hectares.

Costs

A. Fish Culture		
Inputs	Quantity	Costs(Tk.)
Pond lease value	-	3,000.00
Fingerlings	408 no.	408.00
Lime	15 kg	60.00
Labor costs for harvesting	-	200.00

	Total	3,668.00
B. Chicken		
Chicken shed (total cost	-	600.00
Tk. 1,200; longevity 2 yrs)		
Chicks (8 batches)	325 no.	4,875.00
Feed	1,224 kg	9,430.00
Vaccines	-	100.00
Fuel	-	260.00
Labor	-	450.00
		-
	Total	15,715.00*
TOTAL COSTS		19,383.00

Returns

A. Fish	343 kg	
11,012.00		

B. Chicken	454 kg	20,890.00
	—	
		31,902.00
NET PROFIT		12,519.00**

Total costs for 8 batches of broiler. cost per batch is only 1/8 of total.

****Excluding interest on working capital.***

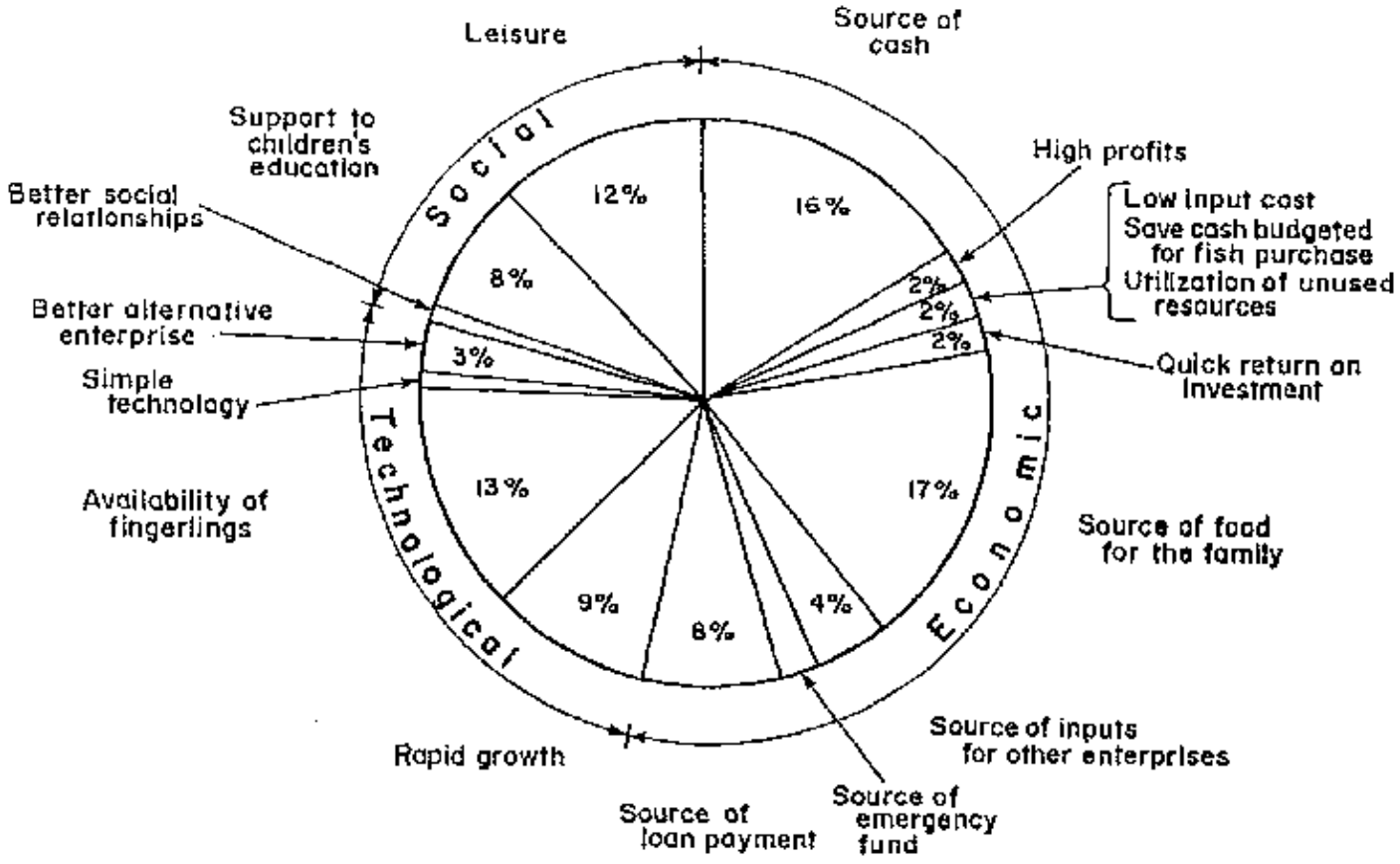

FIGURE 1. Encouragement factors for tilapia culture as reported by farmers surveyed

A survey of 113 farmers of the total 309 farmers who have taken to O. niloticus culture in their homestead ponds and ditches has revealed that: (1) a pond of 170 m² (average size of tilapia ponds) can produce on an average 23.5 kg of fish, which is almost equivalent to the national annual consumption of low-income rural households with six family members; (2) 70% of the fish produced is consumed on-farm, thus improving the nutrition of farming families; (3) revenue from 23 % of fish sold was enough to meet the operational costs; and (4) return on investment was 334% indicating economic viability of the operation. Ninety percent of the farmers surveyed indicated that they were happy with the technology and wanted to continue, while 10% favored discontinuing. The farmers pointed out several economic,

technical, and social benefits as encouragement factors Figure 1). One common observation made by all of the farmers was the small average size of O. niloticus at harvest. They would like to know ways to control breeding in O. niloticus and have larger fish. As a consequence, studies are in progress to control fry production through introduction of a carnivore, Gariepinus lazera, into the production system.

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