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Impact of Improved Aquaculture Technologies: Results of an Extension Program on the Farming Systems of Bangladesh*

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Abstract

The paper discusses the results of a new strategy for extension of improved fish culture practices within the existing farming systems of Bangladesh. Implemented in a few selected village units, the main objective of the extension program was to assist farmers to adopt fish culture in small waterbodies (ponds/ditches). The extension program provided farmers with services such as farm visits, technical advice, training and demonstration for three main technologies: 1) polyculture of Indian, Chinese and common carps; 2) Nile tilapia (*Oreochromis niloticus*) culture; and 3) silver barb (*Puntius gonionotus*) culture. Results show that the farmers responded positively with respect to stocking density, species ratio and input use, although these were not as per recommendations. Nevertheless, by adopting new aquaculture practices, the farmers were able to produce more fish (9.89 $kg \cdot 40\ m^{-2}$) than the baseline production (2.2 $kg \cdot 40\ m^{-2}$), as well as earn a higher income per unit of pond area. Average net profit-cost ratio was estimated at 2.44. The study concluded that targetting farmers who already have waterbodies (ponds and ditches) through extension services can push up aquaculture production and benefits significantly. Fish disease and floods were identified as major risk factors.

Introduction

Aquaculture in small waterbodies (e.g., ponds, ditches and roadside canals) has tremendous potential within the existing farming systems of Bangladesh as evidenced in various studies (Mahbubullah 1983; Khan 1985; Gupta 1991; Ahmed 1992). The government of Bangladesh seeks to determine the possibility of realizing this potential as well as to determine the likely socioeconomic impact of widespread adoption of fish farming in the rural areas. With these considerations in mind, a project entitled "Socioeconomic Impact of Fish Culture Extension Program on the Farming Systems of Bangladesh" was implemented by the International Center for Living Aquatic Resources Management in collaboration with the Government of Bangladesh since June 1990.

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The main objectives of the project were to assist farmers adopt fish culture in small waterbodies in and around their homesteads; and to assess the socioeconomic impact of improving fish culture techniques on rural households and on the community.

A target area comprising several village units (union) of Kapasia thana (sub-district) in Gazipur district, and representing the general agroecological and socioeconomic condition of farmers in the country was chosen for implementing an extension program in order to assist the farmers in adopting fish culture on the farms. A control area, comprising two unions of Sreepur thana in the same district, was also included under the project for comparison of project impact (Ahmed et al. 1993).

Fig. 1 summarizes the methodology for extension of aquaculture technology, and variables included for assessment of its impact in the project area (Ahmed et al. 1993). A diagnostic survey of the waterbodies was undertaken in the two thanas (Fig. 2) as part of benchmark data-gathering efforts. The survey identified the existing status as well as problems and potentials of aquaculture in the area's small waterbodies based on complete enumeration of small waterbodies in six out of 20 unions in the two thanas (Ahmed 1992). In the four selected unions of Kapasia thana, the survey enumerated 634 waterbodies of which 44% were individually owned and 40% were jointly owned. The remaining waterbodies (16%) were non-private (institutional and *Khas*, public or government owned) (Ahmed 1992). Among the owners/operators of these waterbodies, 387 were enlisted as possible cooperators in the project activities based on their "expression of interest." After participating in a training program, 257 farmers prepared and stocked their ponds for fish culture operations during July 1991 to June 1992.

Extension Methods

The extension program included provision of services such as farm visits, technical advice, training and demonstration to be carried out by an extension assistant based in each union and supervised by two extension officers. Four union assistants were engaged in four target unions.

Important features of the extension program were:

- Organization of outreach training program at the community level to improve farmers' understanding of the technical aspects of aquaculture;
- Assessment of farm resource-base through extensive consultation with the farmers and emphasizing low-external input and low-cost technologies;
- Assistance to farmers in identifying alternative seed, feed and fertilization materials including sources of supply;
- Regular contact and advisory assistance to farmers throughout pond preparation, stocking, rearing and marketing phases; and
- Provision of no credit ties between farmers and extension workers.

The project did not follow the high input approach for purposes of ease of adoption and less reliance on external support for inputs, and thereby integrat-

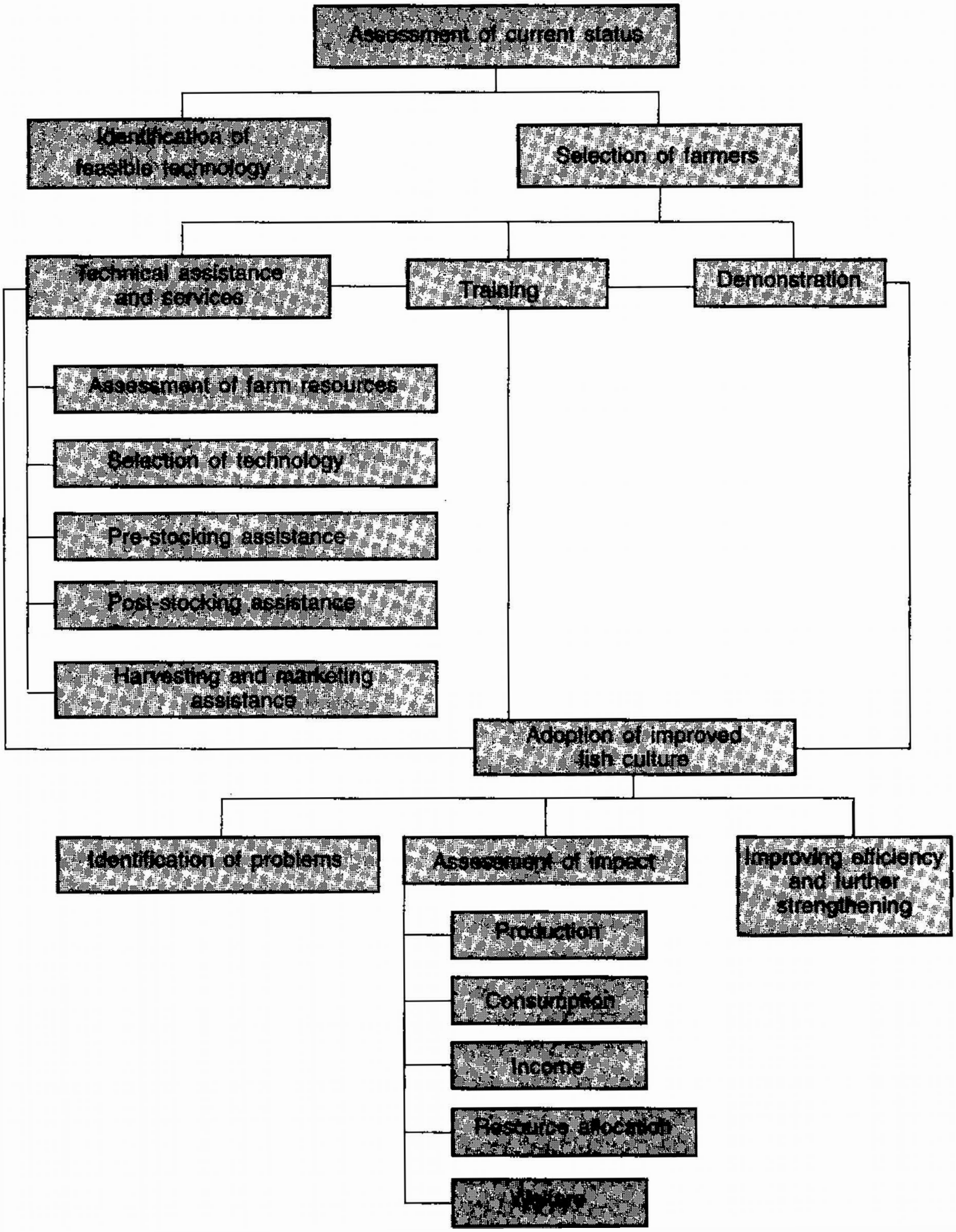

Fig. 1. Methodology for aquaculture extension and assessment of its impact under the project "Socioeconomic Impact of Fish Culture Extension Program on the Farming Systems of Bangladesh."

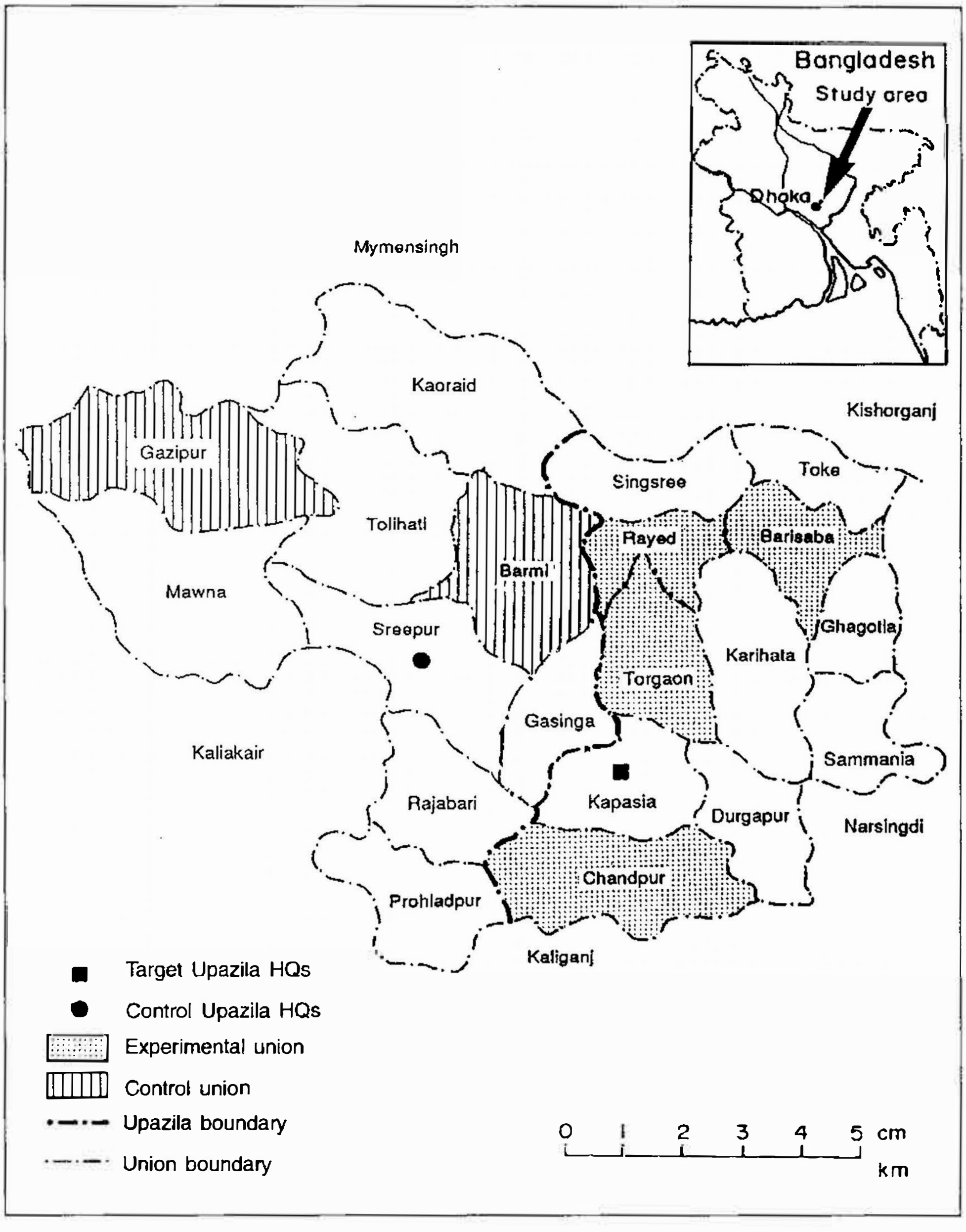

Fig. 2. Map of the study area (Kapasia and Sreepur)

ing fish culture into the agricultural production systems of the farm households through use of on-farm feed, water and labor resources (Lightfoot et al. 1992). While credit is considered a part of the extension package in most cases of transfer of technology, particularly to resource-poor farms, the project did not include any such provision. The premise was that if low-cost technologies are introduced, farmers would be able to finance the improvements themselves by diverting existing resources or by credit sought through established sources. The project stressed that farmers should be self-reliant and use existing supply channels where possible. Most of the inputs such as inorganic fertilizers, lime and supplementary feed (e.g., rice bran, oil cake and grass/aquatic vegetation) were to a large extent already available at the farm. Farmers have a long tradition of using these inputs in diverse farm activities (Ahmed et al. 1993). It was also assumed that low levels of input needs and possibilities of substitution of on-farm wastes and byproducts 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.

The aim of the extension program was to work with all rural households within the study area who were able to practice fish culture, and not with any specific socioeconomic group. A household socioeconomic survey revealed that the principal owner or operator of the waterbodies belonged to the landed class ranging from marginal farmers to rich land owners, who constituted 60% of the total households in the study area (Ahmed et al. 1993). A package of flexible aquaculture technologies was developed to allow a wide range of socioeconomic groups to become fish farmers and improve their fish production in the long run. Close contact between extension staff and farmers was emphasized to allow farmers' conditions to be appraised and technologies to be adapted accordingly. Likewise, the use of available on-farm resources, byproducts and wastes was emphasized (Ahmed and Rab 1992). Farmers were not recommended high doses of external commercial inputs so as not to make them dependent on external capital resources. During the training and consultation programs, the farmers were made aware of the importance and benefits of fish farming. Techniques of pond preparation, fingerling stocking and transportation, including available fish culture technologies for silver barb (*Puntius gonionotus*), Nile tilapia (*Oreochromis niloticus*), and polyculture of different carps were discussed with the farmers. During the post-stocking rearing period, field assistants paid regular fortnightly visits to the farmers' ponds to monitor input use, fish health, growth and appearance. Under the continuous supervision of extension officers, extension staff also assisted the cooperator farmers in procuring fingerlings from public and private seed fish suppliers and local traders who distribute fingerlings on a commercial basis.

The project concentrated on extending three pond culture technologies: 1) polyculture of carps such as Indian major carps - catla *(Catla catla)*, rohu (*Labeo rohita)*, mrigal *(Cirrhinus mrigala)*; 2) polyculture of exotic carps - silver carp (*Hypophthalmichthys molitrix*), mirror carp (*Cyprinus carpio* var. *specularis*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*); and 3) monoculture technologies such as Nile tilapia and silver barb. Monoculture technologies were designed and developed for seasonal ponds and ditches. Silver barb and Nile tilapia can survive in shallow, turbid waters and grow to table size even in 3-4 months rearing (Gupta et al. 1992; Gupta and Rab 1994). This paper discusses the results of the extension program in terms of use of inputs, production, and costs and benefits at the farmer level in the project target area.

Data Sources

Prior to the start of extension activities for pond fish culture in the target unions of Kapasia thana, a pond record-keeping book was prepared to document data on input-output and other relevant variables. The book was used to record use of inputs from pond preparation to fish harvest for each of the ponds operated by the cooperator farmers. Extension staff assisted the farmers in maintaining these records. As mentioned earlier a total of 257 ponds came under extension services during the 1991-92 production cycle, and record-keeping books were maintained for each of them. However, farmers who did not harvest during the reference period (May 1991-June 1992) were excluded from the analysis. Finally, 215 books were analyzed.

Results

Use of Inputs

At the time the extension program was initiated, aquaculture was an irregular practice among the farmers in the target extension areas (Ahmed 1992). Irregular stocking and occasional harvesting of fish was the dominant practice among pond operators. Only 33% of the pond operators stocked fingerlings in their ponds in 1990-91, and among them, almost 97% were practicing polyculture of Indian major carps, such as, catla, rohu and mrigal. Stocking of exotic species like silver carp, mirror carp, grass carp and Nile tilapia were negligible. Culture of silver barb was totally absent. Proper stocking density and species ratio of fingerlings were not maintained (Ahmed et al. 1993).

Input-output records of the ponds under extension indicated that among the suggested technologies, monoculture technology was adopted by 43% of the operators of which majority (36%) stocked silver barb, and only 7% stocked Nile tilapia. The remaining 57% of the farmers adopted polyculture technologies. The average size of the waterbodies which adopted monoculture technologies was significantly smaller than the polyculture waterbodies (Table 1). Empirical evidence suggests that the farmers did not follow the technologies as suggested. Many of the monoculture farmers stocked a small proportion of carps. Similarly, a few of the polyculture farmers stocked silver barb and Nile tilapia.

Stocking density among farmers who stocked only silver barb was about 5% higher than the suggested, and 13.7% higher for those who stocked other species with silver barb. The density was within the suggested limit in the case of Nile tilapia. Among carp farmers, stocking density was almost as suggested but 56.8% higher in the case of carps with silver barb (Table 1). Species composition (Table 2) in the case of carps was almost as suggested; in the case of carps with silver barb and Nile tilapia, the composition was 51% Indian carps, 18% exotic carps, 26% silver barb and 5% Nile tilapia. Species composition in case the of silver barb with other species was 83% silver barb and 17% other species (mostly carps).

Table 1. Number of cooperator farmers, average area of waterbodies and stocking density of fingerlings by technology type in Kapasia thana, Gazipur district, Bangladesh, 1991-92.

Technology	% of cooperator farmers (n=215)	Average area of the waterbodies (m^2)	Suggested stocking density (per 40 m^2)	Actual stocking density (per 40 m^2)
Silver barb				
Monoculture	36.3	372	60-65	68
		(340)		(18)
Silver barb with other species	18.1	540		74
		(393)		(11)
Nile tilapia				
Monoculture	7.0	232		81
		(103)	80-85	(10)
Nile tilapia with other species	0.5	162		80
		(-)		(-)
Carp polyculture				
Only carps	29.8	1,262		31
		(726)	25-30	(6)
Carps with silver barb and Nile tilapia	8.3	1,169		47
		(627)		(21)

Note: Figures in parentheses are standard deviations.

Table 2. Species composition in the ponds of polyculture farmers in Kapasia thana, Gazipur district, Bangladesh, 1991-92.

Species	Suggested stocking rate (%)	Actual stocking rate (%)	
		Carps only	Carps with other species
Catla	25	33.2	22.4
Silver carp	15	5.6	2.4
Rohu	30	34.5	23.2
Mrigal	10	15.3	5.3
Grass carp	5	2.9	1.7
Mirror carp, common carp	15	-	5.4
Nile tilapia	-	-	5.4
Silver barb	-	-	26.1

Before the launching of the extension program, use of inputs such as feed and fertilizer in fishponds was limited (Ahmed et al. 1993). As a result of the extension program, various inputs were channeled to fishponds; cattle dung, poultry droppings, inorganic fertilizers and lime were used to fertilize ponds; rice bran, oil cake, grass and termites were used as feeds. All the farmers used cattle dung and inorganic fertilizers. About 89% and 29% used lime and poultry droppings, respectively, for fertilization of ponds. A few (1%) also used compost as fertilizer. All the farmers used rice bran as supplementary feed; while 47% used oil cake, 20% used grass, and 6% used termites (Table 3).

The farmers, irrespective of technology, used less than the suggested amount of feeds and fertilizers. Nile tilapia farmers used cattle dung, inorganic fertilizers and rice bran at 3%, 70% and 55% less than the suggested levels, respectively. Silver barb farmers used cattle dung, lime and inorganic fertilizers in higher quantity than the suggested amount. Poultry droppings, compost, oil

Table 3. Distribution of cooperator farmers who used corresponding inputs by technology type in Kapasia thana, Gazipur district, Bangladesh, 1991-92.

Inputs	Number of users prior to the extension[a] (n=140)	Number of users during post extension period[b] (n=215)			
		Nile tilapia (n=16)	Silver barb (n=117)	Carps (n=82)	All (n=215)
Cattle dung	93 (66)	16 (100)	117 (100)	82 (100)	215 (100)
Compost	- (0)	- (0)	1 (0.4)	2 (2.4)	3 (1.4)
Lime	24 (17)	16 (100)	106 (90.6)	70 (88.44)	192 (89.3)
Inorganic fertilizer	41 (29)	16 (100)	117 (100)	8 (100)	215 (100)
Rice bran	67 (48)	16 (100)	117 (100)	82 (100)	215 (100)
Poultry droppings	4 (3)	6 (37.5)	25 (21.4)	32 (39.0)	63 (29.3)
Oil cake	2 (1)	- (0)	47 (40.2)	54 (65.9)	100 (47.0)
Grass	- (0)	- (0)	5 (4.3)	38 (46.3)	43 (20.0)
Termite	- (0)	1 (6.3)	11 (9.4)	- (0)	12 (5.6)

Note: Figures in parentheses represent percentage of n.
[a]Source: Ahmed et al. 1993
[b]Record-keeping data

Table 4. Suggested and actual use (kg·40 m^{-2}) of major inputs by technology type in Kapasia thana, Gazipur district, Bangladesh, 1991-92.

Inputs	Nile tilapia (n=16)		Silver barb (n=117)		Carps (n=82)	
	Suggested	Used	Suggested	Used	Suggested	Used
Cattle dung	20	20	15	17	30	20
Poultry droppings	-	1	-	0	3	0
Compost	-	-	-	0	2	0
Lime	-	1	1	1	1	1
Inorganic fertilizer	2	1	1	1	3	1
Rice bran	60	27	40	17	20	8
Oil cake	-	-	-	0	10	1
Grass	-	-	-	0	25	1

cake and grass were also used by these farmers. Rice bran, the crucial supplementary feed for silver barb was used at 58% less than the suggested amount. However, carp polyculture farms used inputs of all varieties at quantities much less than the suggested (Table 4).

Production Performance

Among the ponds under study, only 39% were harvested fully during the year under consideration. For the fully harvested ponds, actual fish production during the observed rearing period was reported; for the partially harvested ponds, total production was estimated by summing up actual harvest and estimated biomass on the date of last harvest (Ahmed and Rab, in press). Average production (kg·40 m^{-2}) of fish by technology was highest (8.94 kg·40 m^{-2}) for Nile tilapia with the lowest rearing period (7.95 months). Average production of carps (8.34 kg·40 m^{-2}) was lower than the average production of Nile tilapia, and higher than the average production of silver barb (4.58 kg·40 m^{-2}). Rearing period, however, was higher for carps than silver barb (Table 5). The pre-extension production of fish in these ponds (mainly Indian carps) was only 2.2 kg·40 m^{-2} (Ahmed 1992).

Epizootic ulcerative syndrome (EUS), an infectious disease, was the major damaging factor for fish productivity in the extension target area in the year under consideration. Fish production was significantly affected by the disease. Average production recorded less than half in disease-affected ponds. Floods also affected fish production. The productivity difference between flood-affected and flood-free ponds was significant in silver barb ponds (Table 5).

Soil type and water quality of the ponds also affected fish production. In the case of silver barb and carp, productivity differences were significant between ponds with red/sandy soil and clayey soil. In Nile tilapia ponds, this was inconclusive. Water quality had similar effects on production. Irrespective of technology, average production was lower in ponds with clayey turbid waters than in ponds with clear/plankton turbid water. (Table 5)

Costs and Benefits

The average total cost was highest for silver barb (BDT 77·40 m-^{2}), followed by Nile tilapia (BDT 59·40 m^{-2}) and carps (BDT 58·40 m^{-2}). The proportion of cash cost (cost of commercial inputs) to total cost of production was 76%, 73% and 44.5% for carps, silver barb and Nile tilapia, respectively. However, in absolute terms, the highest cash cost (BDT 57·40 m^{-2}) was for silver barb followed by carps (BDT 44·40 m^{-2}) and Nile tilapia (BDT 26·40 m^{-2}) (Table 5).

The breakdown of total operating costs for fingerlings and fish feed was 43% and 22% in carp polyculture, 53% and 23% in silver barb, and 29% and 44% in Nile tilapia, respectively. Inorganic fertilizers, lime and organic fertilizers accounted for 8.8%, 5.6% and 13% (in Nile tilapia); 6%, 7.4% and 8% (in silver barb); and 9%, 7.6% and 12.6% (in carps) of total costs, respectively.

Table 5. Average fish production (kg·40 m^{-2}) and productivity differences due to disease, floods, soil and water quality by technology type in Kapasia thana, Gazipur district, Bangladesh, 1991-92.

	Nile tilapia (n=16)		Silver barb (n=117)		Carps (n=82)	
	Average production	No. of ponds	Average production	No. of ponds	Average production	No. of ponds
Effect of disease						
Disease affected	-	-	2.52 (1.34)	46	4.14 (1.94)	33
Disease free	8.94 (5.18)	16	5.91 (2.20)	71	9.04 (2.92)	49
Effect of floods						
Flood affected	2.04 (0.00)	1	0.90 (0.60)	5	3.56 (1.58)	2
Flood free	9.40 (5.02)	15	4.70 (2.50)	112	8.51 (3.19)	80
Effect of soil quality						
Red/sandy soil	10.50 (6.44)	4	3.99 (2.18)	43	6.85 (1.88)	28
Clayey soil	8.42 (4.91)	12	4.91 (2.66)	74	9.18 (3.53)	54
Effect of water quality						
Clayey turbid water	8.58 (5.22)	7	4.01 (2.23)	48	7.45 (1.88)	26
Plankton turbidity	9.22 (5.45)	9	4.94	69	8.59 (3.53)	56
All ponds	8.94 (5.18)	16	4.58 (2.53)	117	8.34 (3.25)	82
Average rearing period (months)	7.95	-	8.14	-	9.11	-
Annual production	13.49	-	6.75	-	11.04	-

Note: Figures in parentheses are standard deviations of respective mean.

The proportion of harvesting cost was higher (6%) in polyculture of carps, followed by silver barb (3.2%) and Nile tilapia (1.1%). In actual practice, harvesting cost would be much higher. The estimated proportions are low as the farmers did not go for major harvests in most cases (Table 6).

Average gross income was highest in carps although average physical production was highest for Nile tilapia. This was due to the higher average market price for carps. On average, taking all the technologies together, gross income amounted to BDT 234·40 m^{-2}, while the net income of the farmers was BDT 166·40 m^{-2}. The net income accrued to the farmers was 2.43 times the total cost of production (including non-cash costs). Average net income of carp farmers was almost triple (2.92 times) that of silver barb farmers, and more than double (2.12 times) that of Nile tilapia farmers. Cost of production in silver barb culture was 34% higher than carp polyculture, and 32% higher than Nile tilapia culture,

Table 6. Costs and returns (BDT·40 m^{-2}) in the ponds of cooperator farmers in Kapasia thana, Gazipur district, Bangladesh, 1991-92.

Items	Technology type			All (%) (n=215)
	Nile tilapia (n=10)	Silver barb (n=117)	Carps (n=82)	
Cash cost:				
Fingerlings	17.02	40.59	24.81	32.82
	(12.91)	(31.40)	(8.83)	(25.53)
Lime	5.17	5.71	4.35	5.15
	(2.28)	(3.96)	(2.77)	(3.49)
Inorganic fertilizer	3.27	4.66	5.21	4.77
	(1.31)	(3.17)	(4.25)	(3.56)
Rice bran	-	1.25	0.74	0.96
	(0)	(4.35)	(2.56)	(3.59)
Oil cake	-	1.83	5.0	2.91
	(0)	(3.38)	(0.66)	(5.07)
Piscicide	-	0.15	0.19	0.15
	(0)	(0.31)	(0.35)	(0.32)
Harvesting cost	0.66	2.45	3.44	2.70
	(2.12)	(7.63)	(8.60)	(7.77)
Total cash cost	26.12	56.63	43.76	49.45
	(13.55)	(33.79)	(16.17)	(28.50)
Noncash cost:				
Cattle dung	6.83	6.07	7.03	6.49
	(4.25)	(2.56)	(2.72)	(2.80)
Poultry droppings	0.73	0.29	0.24	0.30
	(1.58)	(0.81)	(0.44)	(0.78)
Rice bran	25.00	14.24	6.55	12.10
	(9.85)	(8.76)	(5.13)	(9.23)
Total noncash cost	32.57	20.59	13.82	18.9
	(12.50)	(10.20)	(6.71)	(10.48)
Total cost	58.69	77.23	57.58	68.36
	(17.76)	(36.73)	(19.04)	(31.38)
Gross income	252.52	168.56	324.34	234.46
	(146.38)	(93.02)	(125.72)	(133.78)
Net income	193.83	91.34	266.75	166.11
	(144.18)	(87.71)	(124.49)	(133.72)
Net income excluding noncash costs	226.40	111.93	280.58	185.01
	(145.48)	(92.16)	(125.80)	(138.02)

Note: Figures in parentheses are standard deviations of respective mean.

but among the technologies, silver barb culture was the least profitable. Net income, excluding costs of external/purchased inputs, was much higher for all technologies than net income excluding total costs (including non-cash costs).

Discussion

Analysis of results indicated that the cooperator farmers responded positively to technology adoption *vis-à-vis* input use. Fingerling stocking behavior and input use pattern improved positively and significantly due to extension services, however, there have been some deviations between observed and suggested stocking density, species composition and input use. Nevertheless, farmers were able to produce a higher amount of output which was on average four times higher than the baseline production (Ahmed et al. 1993; Ahmed et al., in press).

Moreover, composition of farmed fish changed from Indian major carps to inclusion of Chinese and common carps as well as silver barb and Nile tilapia. Despite higher productivity of carps, silver barb and Nile tilapia appear to be more popular in small and seasonal ponds, as carps do not perform well in these types of waterbodies.

EUS, to a great extent, and floods, to some extent, affected production. (Ahmed et al., in press) Early preventive measures such as liming to the affected ponds and salt bath to the infected fish minimized the damage. In most of the affected ponds, fish losses were partial. Silver barb was badly affected by the disease. Some carp ponds were also affected by the disease. None of the Nile tilapia ponds were affected by the disease (Ahmed and Rab 1995). In addition, flood, soil and water quality had worsened production. Lack of a marketing infrastructure, and the nonavailability of some critical inputs such as piscicides, chemicals and fingerlings of desired species were the principal constraints to fish culture. Farmers had to depend on the local markets and neighboring households to sell their products. Professional fishers who harvest and purchase fish from the pond owners were not always available and their services were costly (25% or more of total catch). For large-scale harvests, farmers need either to secure the services of these fishers or to procure a net. Given the scale of production, it is neither desirable nor economically feasible for the farmers to own nets individually. On the other hand, since the farmers have no access to urban markets, due to inadequate transport and communications and lack of storage facilities, they are compelled to sell their harvest at a lower price.

Farmers could not always follow the recommended methods of pond cleaning such as pond drying, intensive netting and poisoning due to high costs. Piscicides and chemicals, though easier to apply, were, however, more expensive and scarce. Fingerlings of desired species were not locally available. It took considerable effort and money to procure fingerlings from distant hatcheries/nurseries. For the sustainable development of aquaculture it is necessary to transfer hatchery techniques and nursery operations at the farmer level.

References

Ahmed, M. 1992. Status and potential of aquaculture in small waterbodies (ponds/ditches) in Bangladesh. ICLARM Technical Report 37, 35 pp.

Ahmed, M. and M.A. Rab. 1992. Feasibility of adopting aquaculture to increase resource productivity in existing Bangladesh farming systems. Naga, the ICLARM Quarterly 15(4):21-22.

Ahmed, M. and M.A. Rab. 1995. Factors affecting outbreaks of epizootic ulcerative syndrome in farmed fish in Bangladesh. Journal of Fish Diseases 18:263-271.

Ahmed, M., M.A. Rab and M.P. Bimbao. Aquaculture technology adoption in Kapasia thana, Bangladesh: some preliminary results from farm record-keeping data. ICLARM Technical Report. (In press).

Ahmed, M., M.A. Rab and M.P. Bimbao. 1993. Household socioeconomics, resource use and fish marketing in Bangladesh. ICLARM Technical Report 40, 76 pp.

Gupta, M.V. 1991. Low input technologies for rural aquaculture development in Bangladesh. Aquaculture and Schistosomiasis: 26-35. Board on Science and Technology for International Development, National Research Council, National Academy Press, Washington, D.C.

Gupta, M.V., M. Ahmed, M.P. Bimbao and C. Lightfoot. 1992. Socioeconomic impact and farmers' assessment of Nile tilapia (*Oreochromis niloticus*) culture in Bangladesh. ICLARM Technical Report 35, 50 pp.

Gupta, M.V. and M.A. Rab. 1994. Adoption and economic viability of silver barb (*Puntius gonionotus*) culture in Bangladesh. ICLARM Technical Report 41, 39 pp.

Khan, M.S. 1985. Culture fisheries of Bangladesh: the issue of unused ponds. In: Small scale fisheries in Asia: socioeconomic analysis and policy (ed. T. Panayotou), pp. 261-268. International Development Research Centre, Ottawa.

Lightfoot, C., M.V. Gupta and M. Ahmed. 1992. Low external input sustainable aquaculture for Bangladesh - an operational framework. Naga, The ICLARM Quarterly 15(3):9-12.

Mahbubullah. 1983. Socioeconomic factors affecting the utilization of village-ponds for fish culture. BIDS (mimeo).

Manuscript received 12 March 1993; accepted 18 January 1995.