Impacts of Aquaculture Extension on Pond Operators and the Rural Community

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In 1990-1993 in Kapasia sub-district in central Bangladesh ICLARM introduced low-input aquaculture for pond owners to adapt into their farming systems. Impacts on production, fish consumption and markets were assessed in 1998-1999. The percentage of ponds stocked increased from 1990 to 1998, but did not differ significantly between past participants (increased from 61% to 90%), neighboring pond operators or a control area. In 1992 participants produced 2 t/ha compared with 0.5 t/ha in 1990. In 1997-1998 the previous participants produced significantly more 2.2 t/ha, compared with 1.6 t/ha for other pond operators in Kapasia and 1.3 t/ha in the control area ($p<0.001$, t-test). Non-participants learnt of aquaculture from neighbors or mass media. Total production from ponds in the project area in 1998 was 4.2 times greater than in 1990. Without that project, production would probably have gradually increased 2.8 times. Local fish markets were surveyed in 1991 and 1999. The volume of fish traded increased 8 times. Carp from local ponds now dominate trade. Consequently the real price of carp has fallen, while that of indigenous fish has increased. Detailed participatory monitoring revealed much higher fish consumption than recall data. Pond owning households consumed 211 kg per household in 1998-1999 (just under 90 g/person/day), about 25% came from their own ponds. Small fish purchased or caught in flooded fields were mainly consumed, pond fish were sold for income.

Keywords: aquaculture, impact, consumption, markets.

1. INTRODUCTION

Bangladesh has many ponds, perhaps 1.3 million according to Bhuiyan (1999). Most were created when households excavated earth to raise their homesteads above normal flood levels. With the advent of large-scale production of carp fingerlings from private hatcheries since the late 1980s, and their distribution to potential small-scale customers throughout much of the country through complex networks of fry traders, there has been a major increase in pond fish production. This has helped to compensate for declining catches, particularly of carps, from inland openwaters. The Bangladesh Department of Fisheries (DOF 1997) reported a 145% increase in production from ponds between 1986-1987 and 1996-1997 to 0.35 million t or 27% of total fish production. This paper investigates the impacts of past aquaculture extension on fish farmers and fish consumption.

1.1 Aquaculture Extension in Bangladesh

In mid 2000 there are about ten substantial donor-funded freshwater aquaculture extension projects active in Bangladesh (DOF and ICLARM 2000). Most are projects of the DOF, many of these also work through the very large non-governmental organization (NGO) sector in Bangladesh, and some are operated directly by NGOs. Moreover DOF has its regular extension services and a number of NGOs also have their own extensive aquaculture programs. There is thus a wide range of national and area specific aquaculture extension activity involving a range of extension approaches and packages. This includes work to extend rice-fish culture, cage aquaculture, and training of extension staff, however the main focus of extension has been on polyculture of carp in the many small private ponds. There has been virtually no assessment of the practices of pond operators after extension and thus of the sustainability or impacts of aquaculture extension. This paper is based on a study which aimed to address this gap.

1.2 Earlier Extension in Kapasia

During 1990-1994 the International Center for Living Aquatic Resources Management (ICLARM) and DOF undertook action research on aquaculture extension and its impact on farming systems. The study area north of Dhaka comprised six unions (the smallest administrative unit comprising on average about ten villages) in Kapasia Upazilla (sub-district) in Gazipur District. Importantly the study included a control area – the adjacent Upazilla of Sreepur – which has received no specific aquaculture extension effort up to 2000. A benchmark survey (Ahmed 1992) found 1,045 ponds in the project area and that average pond fish production in both project and control areas was 0.55 t/ha. A baseline socio-economic and market survey in 1991 (Ahmed et al. 1993) described the

farming systems, by-product availability and use, assets, incomes and expenditure of pond owning households.

Although the project also worked to help local people develop fish nurseries and suggested that they stock fish in small seasonally flooded areas (*beels*), the main emphasis was on pond aquaculture. The operators of 418 ponds were trained in the basics of aquaculture. They were expected to adapt either monoculture of tilapia *Oreochromis niloticus*, or silver barb *Barbodes gonionotus* (locally known as Thai Shorputi), or polyculture of a mix of native and exotic carp species to their ponds using largely on-farm resources as feed and fertilizer. Detailed monitoring of participants in the first year revealed that carp polyculture and tilapia monoculture achieved production of just over 2 t/ha. Monoculture of silver barb was intended more for seasonal ponds and was adopted by many farmers, but this species was particularly affected by epizootic ulcerative syndrome and consequently average production was only 1.1 t/ha (Ahmed et al 1995).

On average pond operators have substantial land holdings, very few were functionally landless, about 30% are marginal and small farmers, about 40% are medium farm owners, and over 20% own large farms (Table 1). Pond size (small indicates up to 0.06 ha, and medium-large indicates above 0.06 ha) and landholding size are positively correlated ($r=0.34$, $p<0.001$). However, the past ICLARM participants' current landholding distribution matches the baseline distribution, indicating that the previous project did not target poorer pond owners or smaller ponds.

Table 1. Landholding and pond size distribution of households (% of households) by location.

Land area (ha)	Kapasia ICLARM participants		Kapasia non-ICLARM		Sreepur	
Pond ->	Small	Med-large	Small	Med-large	Small	Med-large
Landless (0-0.2 ha)	4	0	10	7	6	0
Marg-small (0.2-1 ha)	45	8	27	20	33	7
Med (1-3 ha)	40	42	43	47	36	41
Large (3+ ha)	11	51	20	27	24	52
Total households	47	53	30	30	33	27

2 METHODS

The earlier lists of project participants were reviewed to identify all 418 pond operating households trained by the earlier project. A revised census was made of all pond owning households in the same six unions revealing 1,641 households with ponds but who were not extension recipients. This represents an approximately 100% increase over the earlier census indicating faster growth in pond number (8% per year) than in the control thana (5% per year). A random sample of 100 past participants and 60 non-participants was made stratified by reported pond size. A control (without) sample of 60 households was also taken in the control area (Sreepur) based on a recent DOF list of pond owning households. Pond operation, farming system and socioeconomic data covering 1997-1998 were collected from each household by interview.

Sixty-nine past extension recipients were found to be stocking their ponds in 1998. Aquaculture practices, inputs and output were monitored each week, and household members were trained to record their fish consumption on each day for a week each month for 14 months of 1998-1999. Results from these surveys are presented in this paper. However, severe flooding in July-September 1998 affected a number of the monitored ponds and consequently average production in 1998-1999 was lower than that reported in 1997-1998.

3 AQUACULTURE SYSTEMS

The extension recipients of the past project have continued to follow improved aquaculture practices in respect to fingerling stocking, species composition and input use compared with control farmers. However, 10% of the past participants no longer cultivate fish (for example due to loss of access to ponds), overall 6-7% of other pond owning households in Kapasia and Sreepur do not cultivate fish. High stocking density had been the most obvious gap between past extension and current practice as reported by the participants. Ex-participants stock 5-

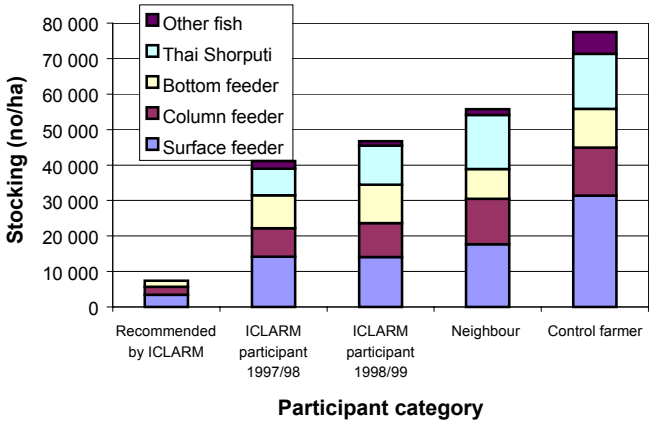

Figure 1. Kapasia stocking recommendation and current practice

times more fingerlings per ha than recommended, but others report stocking even more: 7-times more for neighboring non-ICLARM participants and 10-times more for control group farmers (Figure 1). Carp polyculture comprising 7-8 species has continued as the single technology type with most pond operators adding silver barb and a few adding tilapia in their stocking composition. Monoculture of silver barb and tilapia have not continued.

operators in Kapasia achieved only 1.6 t/ha. The ex-participants' production was 77% above the current fish production level of the control area farmers without extension support (1.3 t/ha), see Table 2.

The use of on-farm inputs (household bioresources such as cowdung, rice bran and green grass) has increased significantly irrespective of extension reception (Table 2). Chemical inputs have been reduced from the levels

Table 2. Input recommendation by ICLARM and current practice (kg/ha) in Kapasia, Gazipur

	Baseline (1990)	Recommended by project	Participants in 1991-1992 (carp polyculture) (N=82)	Ex-participants 1997-1998 (N=95)	Monitored ex-participants 1998-1999 (N=69)	Neighbor Farmers (Kapasia) (N=56)	Control farmers (Sreepur) (N=59)
Fingerlings (no/ha)	8,656	7,410	8,478*	41,160* [ab]	46,658*	55,750*[c]	77,493*
Chemical inputs							
Lime	0	500	208	76*	77*	33*	43*
Urea	46	362	(230	132*	149*	137*	69*
TSP	32	362	(	61*	66*	84*	31*
Organic inputs							
Cattle manure	1,181	10,400	4,954	12,592	15,586*	15,266*	15,781
Poultry manure	0	600	80	722	1,531*	407	391
Compost	0	5,000	12	182*	600*	69*	0
Feed inputs							
Bran	165	5,000	1,956	5,271	8,052	7,955	5,811
Oil cake	0	2,500	163	345*	299*	355*	183*
Grass/leaves	1	6,200	181	238*	213*	140*	283*
Fish production	618		2,071	2,250[a]	1,687	1,629	1,304

The 1991-1992 carp polyculture participants had much lower use of bran than monoculture of Thai sarputi (117 ponds), but these participants converted to carp polyculture with Thai sarputi after that year due to disease problems.
** significant difference from recommendation, t-test, $p<0.05$; [a] significant difference from control farmers, t-test, $p<0.001$; b significant difference from neighbors, t-test, $p<0.1$; [c] significant difference from control farmers, t-test, $p<0.1$.*
Source: FEEP surveys except for 1990 data - Ahmed et al. (1993) and 1991-1992 data – Ahmed et al. (1995).

Average annual fish production of 2.27 t /ha was achieved by past participants who cultured fish in 1997-98. This was about 10% more than production achieved during the previous extension project (2.1 t/ha in a 12-month period – average nine months of operation - for carp polyculture). Detailed monitoring in the flood affected 1998-1999 year revealed average production of only 1.7 t/ha in a 12-month period for 69 out of the same 100 past participants. By comparison in 1997-1998 other pond

Table 3. Cost and return from aquaculture (Tk/ha) in Kapasia, Gazipur in 1997-1998.

	Kapsia ex-participants 1997-1998 (N=95)	Kapasia monitored ex-participants 1998-1999 (N=69)	Kapasia other farmers 1997-1998 (N=56)	Sreepur control farmers 1997-1998 (N=59)
Stocking cost	24,669	24,138	19,084	21,393
% of total*	44	48	35	42
Other bought input cost	6,552	9,231	10,562	6,009
% of total	12	18	19	12
Imputed value of onfarm inputs	17,834	14,286	21,154	20,420
% of total	32	29	38	40
Hired labor including harvest	6,491	2,415	4,424	3,074
% of total	11	5	8	6
Total cash cost	36,771	35,783	34,151	30,106
Value of harvest	104,195	42,823	78,895	69,758
% consumed by hh and owner	41	58	56	41
Net return to household	67,424	6,969	44,744	39,652
Net return (Tk/dec)	273	148	181	160
Net return (Tk/ day hh labor)	171	61	103	63

**total cost excludes imputed value of household(hh) labor. Only households which actively cultivated fish in the survey years are included.*

recommended, although past participants use substantially more than the control farmers, but high levels of organic fertilizer presumably compensate for this. Nevertheless production levels are low compared to the fingerlings stocked, or rather too many small fingerlings are used for the sizes of pond. Hence stocking is a high proportion of total expenditure on their ponds for all categories of household (Table 3), but the other main input is on-farm resources even when valued with low imputed costs. On average there was little difference in the proportion of production reported to be consumed by the household between production levels associated with past extension (past participants in 1998-1999 consumed 50%).

The economic return from aquaculture is substantially different for the participants and non-participants. The gross return on investment (ratio of gross income to total costs) for carp polyculture was estimated to be about 200% for extension recipients and 150% for the non-participants, but the return could have been much more if the stocking density were lower. Diffusion of technology to non-participants in Kapasia (neighbors of extension recipients) appears to have happened, since they have intermediary pond management practice and yields.

Aquaculture practice was investigated in more detail in 1998-1999 for 69 of the same pond operating households that had earlier received extension in Kapasia. Inputs and fish caught were monitored on a weekly basis, resulting in more reliable data. Unfortunately 16 ponds were badly affected by severe floods that year and lost many of the stocked fish (although wild fish also entered these ponds). Tables 2 and 3 include summaries for these 69 ponds. Production averaged 75% of the previous year, use of inputs measured did not differ significantly from the levels reported the previous year, although use of oil cake was 50% more than reported in 1997-1998. Cash costs were similar to the previous year, but net returns were only about 10% of the previous ("normal") level, this is presumed to be mainly due to loss of fish.

Three categories of pond operation were distinguished through analysis and a workshop with the participants: farmers who consumed all they produced, who sold over 75% of fish produced, and those in between. Many of the farmers who did not sell fish had flood affected ponds, but the unaffected ones also had low production (Table 4). Overall the "subsistence" ponds had much higher stocking densities, higher on-farm input use per ha and lower purchased input use per ha than the other ponds. It is also notable that the pond operators who completely harvested each year tended to have high production levels and to be more commercially oriented, partial harvesting involved leaving stocked fish between years and generally less planned stocking and feeding/fertilizing.

Production functions were estimated for fish production in 1997-1998, when ponds were not affected by floods. Both value and physical unit based functions were estimated. For physical units the original inputs were converted to protein (feed) and nitrogen and phosphate (fertilizer) using figures in Lovell (1989) and Lin et al. (1997). Dummy variables were used for the sale strategy of the household (the same three categories developed for the monitored ponds) and for past extension experience. Table 5 indicates that smaller ponds are more intensively used and have higher production, and confirms a positive

Table 4. Production of monitored ponds according to harvest status.

	No sale (n=28)	1-74% sold (n=19)	75% + sold (n=22)
Complete harvest			
% ponds	7	16	41
Production (kg/ha)	263	7,275	3,279
Partial harvest			
% ponds	54	74	46
Production (kg/ha)	881	1,427	1,229
Flooded			
% ponds	39	11	14
Production (kg/ha)	1,069	1,164	1,662
All ponds			
Wild fish (%)	33	18	15
Production (kg/ha)	911	2,323	2,127

Table 5. Cobb-Douglas production functions for carp polyculture in Kapasia and Sreepur in 1997-1998.

Physical units		Value	
Dependent: fish production (kg/ha)		Dependent: fish produced (Tk/ha)	
Constant	+2.09	Constant	+5.98
Area (ha)	-0.46	Area (ha)	-0.50
Labor (days/ha)	+0.17	Labor (Tk/ha)	+0.09
Fingerlings (no/ha)	+0.23	Fingerlings (Tk/ha)	+0.26
Subsistence (1)*	-0.66	Subsistence (1)	-0.87
Extension (1)*	+0.66	Extenson (1)*	+0.35
Neighbor (1)*	+0.34	Neighbor (1)*	+0.28
Phosphate (kg/ha)	+0.06		
		Fertilizer (Tk/ha)	+0.06
Commercial (1)*	+0.26		
	$R^2 = 0.57$ $F_{(8,189)} = 33$; $p<0.001$		$R^2 = 0.52$ $F_{(7,183)} = 28$ $p<0.001$

Note: all units transformed to natural log. form except dummy variables. All coefficients significantly different from 0 at p<0.1
Dummy variables: Subsistence = 1 if household did not sell any fish from pond; Commercial = 1 of household sold over 75% of fish produced; Extension = 1 if previous recipient of ICLARM extension; Neighbor = 1 if live in same area (union) as ICLARM participants.

influence of extension that is not reflected only in the quantities or value of inputs used but presumably is connected with better management practices. Most of the

ponds have high feed rates (bran and oilcake), and neither feed nor nitrogen inputs were significant factors in the function. This is consistent with aquaculture science, for example: "phosphorous is often the first limiting nutrient to higher primary productivity in freshwater" (Lin et al. 1997).

4 CONSUMPTION PATTERNS OF FISH FARMERS

Other economic changes affecting the better off households in Kapasia (who tend to be the people owning ponds) mean that pond aquaculture for most households has not resulted in large increases in income. Increased incomes between 1990 and 1998 were mainly due to non-farm sources associated with improved communications and household members moving out of the thana (and even the country) for work and remitting incomes. Average household income has increased by 2.8 times between 1990 and 1997-1998 for the extension participants (compared with 1.9 times for non-participants in Kapasia and 2.3 times for Sreepur). Even for smaller farmers who benefited from extension their ponds contribute about 10% to overall net income from farming. Since the cumulated national general inflation between the surveys was about 30%, the purchasing power of pond owners (and presumably the few landowners who lack ponds) in this area has shown a huge increase for non-aquaculture related reasons.

On average all the pond operating households monitored ate fish almost every day in a month. Small pond owners ate fish on slightly fewer days than the medium and large pond owners. Pond owners in Kapasia are rich compared with rural households as a whole (average annual income per household from all sources of the medium farmers was Tk. 141,770 and that of the large farmers was Tk. 251,470 in 1997-1998) and they can afford to eat fish everyday. Even among marginal and small farmers average annual income was about Tk. 85,500 which is much higher than the annual average income of a Bangladeshi household of Tk.11,280 (BBS 1997).

Fish consumption was highest in October when fish from the floodplains were caught in maximum numbers (and in 1998 there were more wild fish available in the area due to high floods. Consumption was lowest in the month of June when the water level was rising and there were few fish to catch in the rivers or other waterbodies (Figure 2). Fish consumption has a positive correlation to wild fish catch and a negative or lagged correlation to water level.

On average the 69 surveyed households consumed about 17.58 kg of fish per month or 211 kg per household per year. There was no significant difference in consumption according to pond size (16.8 kg/household/month for small pond owners and 18.4 kg/household/month for medium-large pond owners). Small farm households consumed 14.84 kg/month or 83 g/person/day, medium farm households consumed 17.66 kg/month or 85 g/person/day, and large farm households consumed 22.17

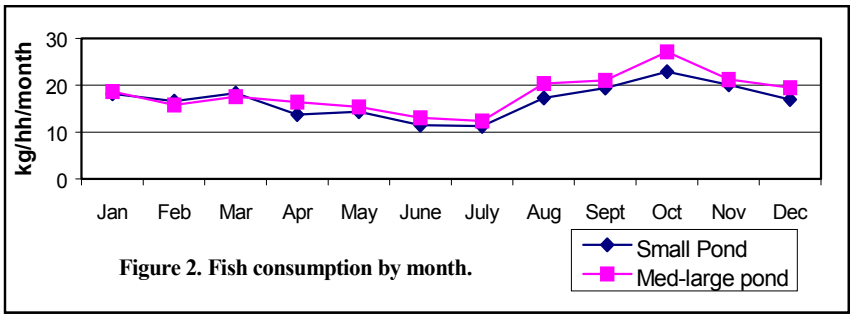

Figure 2. Fish consumption by month.

kg/month or 96 g/person/day. Thus large farm households consumed 49% more than small farmers on a household basis but only 15% more per person day. Large landowners on average have more people eating each day due to a larger household size plus tied laborers and servants.

Eighty-two species of fishes were consumed by all the 69 pond owning households during 25% of the days in the 12 month period, of which 43% by weight were cultured species. A small fish – jatpunti *Puntius sophore* (11% by weight) topped the list of individual species consumed, with the most prized cultured species – rui *Labeo rohita* (10%) next. However, 52 species combined contributed less than one third of the total amount consumed.

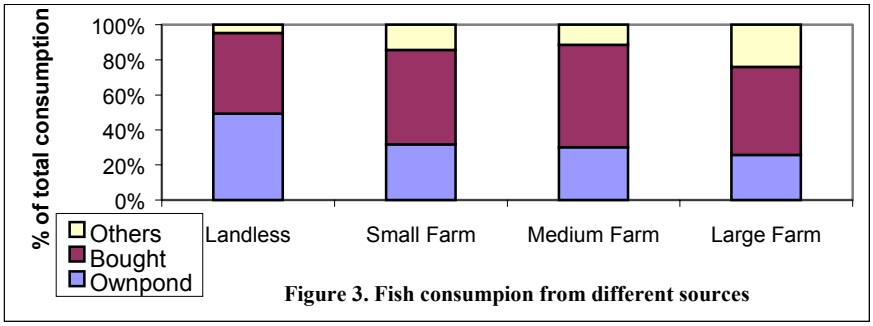

Figure 3. Fish consumpion from different sources

All the landed participant pond owners bought more than half of the total fish they consumed (Figure 3). About 25% of the fish consumed by large pond owners was caught from other waterbodies. Usually large pond owners own large fields and they excavate ditches to reserve water for irrigation during the dry season and also excavate earth for house building. During the monsoon when fields flood, fish from beels, canals and rivers enter into these fields and when water recedes after the monsoon fish become trapped in the ditches. During the monsoon the

owners fish in their fields and after the monsoon they catch fish from the ditches. This explains the greater amount of fish consumed from other waterbodies (their own ditches) by medium and large landowners. However, landless and small farm owners have very little access to these areas during the post-monsoon peak fishing season. They can only fish there when water levels are high.

Medium and large landowners consumed more cultivated species by quantity (respectively 7.8 kg/month and 9.5 kg/month) than small land owners (6.1 kg/month), and a slightly higher proportion of cultured species, but a smaller percentage came from their own ponds (Figure 3). When questioned they explained that they sell a large part of the fish they grow in their ponds in a lot and buy other (preferred and mainly higher value) fish through the year to eat. Also cultured fishes are not always liked by the rural rich people, thus the price of the main species grown (Silver Carp) is low.

Table 6. Daily nutrient consumption per household in 1998-1999.

	Energy		Protein		Animal protein		Calcium	
	Kcal	%	g	%	g	%	mg	%
Rice	13,750	86.5	334.9	57.9	0.0	0.0	3,940	40.4
Pond fish	145	0.9	23.2	4.0	23.2	11.3	390	4.0
Other big fish	165	1.0	26.3	4.5	26.3	12.8	442	4.5
Other small fish	401	2.5	63.0	10.9	63.0	30.7	4,007	41.1
Dal	536	3.4	38.6	6.7	0.0	0.0	112	1.1
Egg	153	1.0	11.8	2.0	11.8	5.7	53	0.5
Meat	300	1.9	60.0	10.4	60.0	29.3	30	0.3
Milk	437	2.8	20.9	3.6	20.9	10.2	783	8.0
Total	15,888	100.0	578.6	100.0	205.2	100.0	9,758	100.0

Consumption converted to components using Darnton-Hill et al (1988).

Overall fish were not a key energy source in household nutrition, but were the main source of animal protein at 55%, but own pond fish contributed only 11% of animal protein (Table 6). Small fish were also especially important as a source of calcium. Thus aquaculture is generating some income and food for households, but pond-owners are more dependent on capture fisheries for key nutients.

A simple demand function resulted in a poor fit and suggests that fish expenditure is not related with own fish production, and gave a very low elasticity of fish price (-0.01) compared with an elasticity of meat price of -0.73, however the fit of (1) was poor ($R^2 = 0.15$). For relatively wealthy households cultivating fish, market purchases probably depend more on preferences and the interplay of status and own-pond production than on prices.

LPPFish = 19.23 –3.44LFPr –4.47LMPr +0.39LPPExp – 0.23LPPExp2 +0.43ExpF +0.47ExpM –0.04LProd (1)

Where all terms are in natural log form and:
LPPFish = per person expenditure on fish (Tk)
LFPr = average fish price (Tk/kg)
LMPr = average meat price (Tk/kg)
LPPExp = per person total expenditure (Tk)
LPPExp2 = squared term of LPPExp
ExpF = LFPr and LPPExp
EXPM = LMPr and LPPExp
LProd = Total pond fish production (kg)

5 IMPACTS ON LOCAL MARKETS AND CONSUMERS

The objective of aquaculture extension at the macro level in Bangladesh has been to improve use of private ponds and to increase production to the extent that per capita availability of fish is higher despite population growth. It was expected that some of this production would reach poorer consumers. Fortunately in Kapasia a baseline market survey was carried out in November 1991 covering the thana market and 14 other markets. In February 1999 a repeat survey was conducted again covering the thana market and 14 other markets. From this changes in fish availability and market characteristics can be assessed comparing the time just before first harvests of fish from aquaculture with the situation some 5 years after extension work ended. Note that floods in 1998-1999 had pushed the catch of wild fish above the level of the mid-1990s, and had reduced the production from a number of ponds (although the escaped fish were then available for capture in flooded areas.

Local markets in general have grown in size to accommodate increasing numbers of buyers which reflects population growth (about a 15% increase between the two surveys) and growing market dependence (Table 7).

However, the number of fish sellers per market has

Table 7. Characteristics of sample markets in Kapasia.

Characteristic	1991	1999	% change
% markets with overall market area over 1600 sq m	54	94	+74%
% markets operate once a week	27	0	Na
Average number of buyers	1,700	2,567	+51%
Average number of fish sellers	9	52	+478%
Buyer/seller ratio	189	49	-76%
Average volume of fish in the market on a sitting day (kg)	91	801	+780
Average amount of fish per trader (kg/seller)	10.1	15.4	+52
Availability of fish in the market (g/buyer)	54	312	+478

increased by a much greater factor (5.8 times) reducing the number of potential customers per trader. Also the massive increase in volume of fish in the markets is due to there being many more traders each trading about 50% more than before. Most are professional fish traders (of whom 25% come from neighboring thanas), and in 1999 they reported average incomes from fish trading about 1.3 times higher than was reported in 1991. A few traders in 1999 (16%) were selling fish they had themselves harvested (either from their own or someone else's pond), in 1991 48% were selling their own openwater catch but in 1999 this had fallen to 29%, about 50% in both years sold fish they had bought.

With the introduction of aquaculture cultured species were found on sale in virtually all markets in 1999, when before they were present in less than a quarter (Table 8). Volumes of fish traded on the survey days had also changed from 39% of carps in 1991 (some of which were locally wild caught) to 80% cultured species (including all carp). With the increase in total volume in the markets this suggests a major impact of aquaculture.

Table 8. Types of fish marketed in Kapasia in 1991 and 1999.

Type of fish	% markets where recorded		% of volume of fish sampled	
	1991	1999	1991	1999
Indian major carps	27	93	29	50
Chinese carps	20	93	4	22
Common carp	13	87	6	4
Thai sharpunti	0	87	0	3
Tilapia	7	27	0	1
Airbreathers	80	87	10	2
Indigenous small fish	100	53	32	14
Small/large prawn	8	33	6	1
Hilsa	13	20	7	1
Marine fish	7	7	0	0
Other wild fish	40	67	6	2
Total (kg)	Na	Na	1,367	3,346

Associated with these changes have been changes in the relative prices of fish and in trader's margins. The consumer price of major carp has apparently hardly changed in the area over nine years, although the price of common carp increased by about 60%, similarly the price of small fish increased by about 68%, and prices of some types have increased by even higher proportions (Table 9).

By comparison the official national inflation between the two surveys was about 31%. So while the real prices of wild-caught fish have increased substantially, those of "chinese carp" (virtually all Silver Carp) and major carp have fallen, resulting in a major change in relative prices – Silver Carp are now 23% cheaper than small fishes in the local markets of Kapasia.

In the six unions studied in detail there were estimated to be about 41,000 households in 1999 (1991 census adjusted for population growth) compared with only 2,059 pond operating households (5%). Even allowing for some underestimation of small ponds and ditches most households cannot grow their own fish. Focus group discussions were held in each union with separate groups of landless and landed households without ponds to investigate the implications of these changes on poor and richer consumers.

In 1990 the small beels in the area were the main source of fish consumed by both categories of household and in-season about 75% of all households caught fish on roughly 50% of days. By 1999 at least 25% had stopped any fishing and the rest fished less frequently than before. Among the landless group 40% were marginal farmers in 1990 and consequently had some time and land on which to fish, now laboring is more profitable than fishing. Similar types of fish are still caught except that large catfish have disappeared from their catches. All groups reported a fall in daily catches, despite using the same gear types (traps, cast and push nets and rod-and-line), from 0.8-1 kg/person day in 1990 to 0.2-0.3 kg/person day in 1999. In 1990 these catches contributed 50% of landless and 25% of landed household fish consumption, by 1999 own catch contributed about 10% of consumption for both categories.

Table 9. Changes in price (Tk/kg) between 1991 and 1999 for main fish types.

Fish type	Purchase price (1999)	Inflation (% change 1991-1999)	Selling price (1999)	Inflation (% change 1991-1999)	Traders 1999 margin as % of 1991 margin
Indian major carps	47.9	1.7	58.9	-0.9	88
Chinese carps	28.5	26.7	35.2	17.3	72
Common carps	52.3	74.3	61.5	61.8	66
Airbreathers	54.1	157.6	65.2	22.9	13
Indigenous small fish	37.1	246.7	45.3	68.5	15
Small/large prawn	68.0	839.2	80.0	190.3	6
Hilsa	120.0	287.1	140.0	173.2	27
Other wild fish	63.8	85.6	78.8	58.8	53

Hence non-pond owners are now more dependent on the markets for fish, but they also reported reduced fish consumption – by about 50% for landed and by almost two-thirds for landless households. The focus groups imply that both landless and landed non-pond operating households have reduced the amount of fish they buy to about 60-63% of the earlier level. The composition of their consumption has also changed in favor of low priced and smaller cultivated fish – Silver Carp and Thai

Sharputi. The landed households have substituted meat (40% increase in reported consumption) for fish, but the landless households reported a more than 50% reduction in meat, dal and milk consumption (Table 10).

Table 10. Changes in fishing and fish consumption of non-pond owners.

	Landless		Landed	
	1990	1999	1990	1999
Never fish (%)	2%	29%	3%	25%
Go fishing 2+ x per week (%)	75%	38%	82%	56%
Catch (kg/day)	0.8	0.2	1.0	0.3
Consume (kg/day)	0.43	0.16	0.60	0.30
% bought	50%	89%	74%	91%
Meat consumption (kg/day)	0.10	0.04	0.10	0.14

6 OVERALL IMPACTS IN KAPASIA

Most of the increased supply of cultivated fish in the markets does appear to have been produced within the Thana given a four-fold increase in pond aquaculture production. The difference in average production between Kapasia and Sreepur indicates that a substantial part of this growth may be attributed to the earlier ICLARM project. Data from the earlier project suggests that smaller ponds were selected for extension and larger ones were left out of the extension, based on this calculation the large increase in number of ponds is mainly composed of very small ponds.

Had the trend for aquaculture development in the control area (Sreepur) occurred in Kapasia then the production of fish from ponds would have been only 192 t in 1998, reflecting both lower production and less growth in pond numbers (Figure 4). This implies that in 1998 about 44% of the higher aquaculture production in Kapasia could be attributed to the earlier extension project's influence over and above general extension activities within Bangladesh. Roughly 42% of the incremental growth in Kapsia pond fish production over what it would otherwise have been can be attributed to direct benefit to participants, the remainder being through demonstration effects on other people: pond operators with ponds in 1991, and induced growth in pond numbers. Moreover, these gains occurred earlier in Kapasia than the growth in pond production in Sreepur. There has also been a growth in stocking of carps in *beels* (small seasonally flooded depressions) which was started by the earlier project and is included in Figure 4.

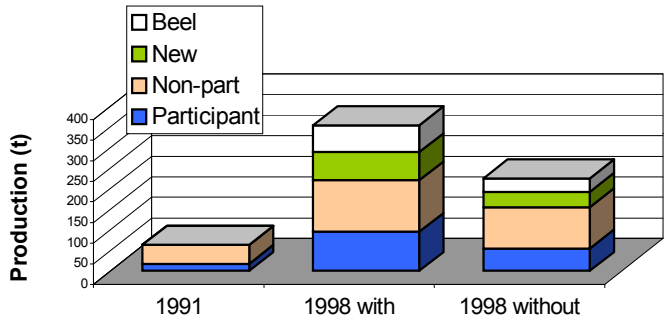

Figure 4. Total estimated fish production from aquaculture by source in Kapsia (6 unions)

Aquaculture has in quantity terms helped to compensate for loss of capture fisheries in the area. However, the beneficiaries have been households with land and diversified livelihoods who have achieved increases in real incomes mainly from non-aquaculture sources. They have gained either from producing fish or from their purchasing power in the markets where they can afford cultured fish and to buy the preferred wild fish despite increasing real prices. Similar people in neighboring thanas have also gained since part of the Kapasia fish production is sold outside the thana.

In 1998-1999 there were estimated to be some 41,000 households in the six unions of Kapasia studied, but only 2,059 were found to own ponds. Although the focus group estimates of changes in fishing effort and catch are not precise they do indicate a massive fall in capture fish catch in the area – from about 90 kg per household per year in 1990 to about 8 kg per household per year in 1999. This implies a loss of some 3,000 t of fish catch from floodplains and small beels per year which is much more than aquaculture has been able to replace.

An increasing landless population means that a large number of people who can no longer catch as much fish as before and who have no pond, now buy fish (mainly cultured species) but cannot afford as much fish as they once ate.

7 CONCLUSIONS

We conclude that:

1. These past aquaculture extension recipients have continued their practices and achieve at least as good yields as they did when they received regular advice.
2. Neighbors from the same areas also achieve higher production than do control farmers indicating a demonstration effect.
3. Smaller ponds are used more intensively including excess use of on-farm resources.
4. Pond operators who are more commercially oriented achieve better returns relative to costs.
5. The returns from pond aquaculture appear to have induced digging more ponds.
6. Yields are variable and affected by floods.

7. Pond aquaculture had minimal impact on participant household incomes as new opportunities for non-farm income arose after extension.
8. Pond owning households tend to have relatively high incomes and prefer to buy or catch indigenous (non-cultured) small fish while selling cultured fish.
9. People without ponds are now more dependent on purchase of cultured fish in local markets rather than catching fish from seasonal common property floodplains.
10. Relative prices of cultured species have fallen compared with wild (non-cultured) species.
11. The sustained increase in production from aquaculture has failed to compensate for the loss to landless people of access to and catches from local capture fisheries due to drainage and enclosure.

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