ICLARM Technical Reports 37

Status and Potential of Aquaculture in Small Waterbodies (Ponds and Ditches) in Bangladesh

Mahfuzuddin Ahmed

ICLARM
INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
MANILA, PHILIPPINES

Status and Potential of Aquaculture in Small Waterbodies (Ponds and Ditches) in Bangladesh

Mahfuzuddin Ahmed

1992

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
MANILA, PHILIPPINES

Status and Potential of Aquaculture in Small Waterbodies (Ponds and Ditches) in Bangladesh

MAHFUZUDDIN AHMED

1992

Printed in Manila, Philippines

Published by the International Center for Living Aquatic Resources Management, MC PO Box 2631, 0718 Makati, Metro Manila, Philippines with financial assistance from the International Fund for Agricultural Development (IFAD), Rome, and the Danish International Development Agency (DANIDA), Copenhagen.

Citation:
Ahmed, M. 1992. Status and potential of aquaculture in small waterbodies (ponds and ditches) in Bangladesh. ICLARM Tech. Rep. 37, 36 p.

ISSN 0115-5547
ISBN 971-8709-28-2

Cover: An unused waterbody in Gazipur district of Bangladesh with potential for fish farming. Photo by M. Ahmed.

ICLARM Contribution No. 838.

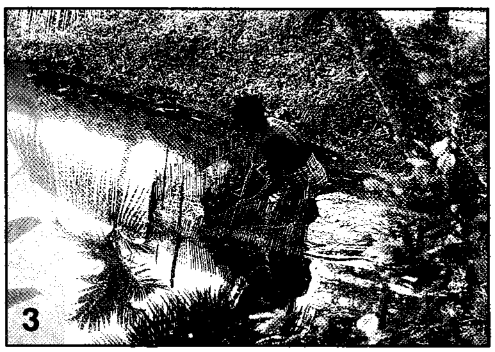
This report is Benchmark Survey Report Series No. 1. Government of Bangladesh-ICLARM Project on Socioeconomic Impact of Fish Culture Extension Program on the Farming Systems of Bangladesh.

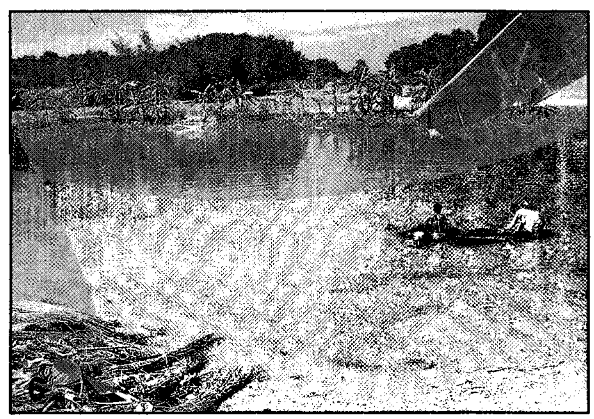
CONTENTS

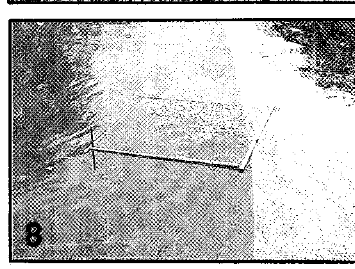
LIST OF TABLES

LIST OF FIGURES

Aspects of Small Waterbody Aquaculture in the Government of Bangladesh-ICLARM Collaborative Project Area, Gazipur District, Bangladesh







Photos by M. Ahmed.

1. A small waterbody lying in derelict condition, which can be easily rehabilitated for fish farming practices. **2.** A freshly cleaned small waterbody (pond) to be used for fish farming through the efforts of the project. **3.** Organic manure being applied to augment fish growth in farmed ponds in the project area. **4.** Happy household members with silver carp catch from farmed ponds after one year of culture. **5.** Fingerlings harvested from a farmer-operated small nursery pond for sale to neighboring farmers for growout operations in the project area. **6.** Small waterbody used for bathing and washing cattle. **7.** Jute retting, an important use of waterbodies. **8.** Pond being brought under improved aquaculture practice in the project area.

ABSTRACT

A survey of 1,300 ponds and ditches, averaging about 1,200 m^2, in two areas of Bangladesh was made in 1991 to determine their potential use for aquaculture.

Nearly 50% of these small waterbodies were individually owned and operated. The remainder, which covered 70% of the waterbody area, was under multiple and public (*khas*) ownership, often regarded as hindrances to adoption of improved aquaculture practices. Some 65% were being used for aquaculture, but less than 1% of them used good husbandry methods.

Nearly three-quarters of the waterbodies could retain 0.9-1.2 m depth of water during the dry season and were useful for fish farming, although most are subject to other uses also, especially bathing and washing.

In nearly all farmed waterbodies, carps (*Labeo rohita, Catla catla* and *Cirrhinus mrigala*) were used with average yields of 270-280 $kg \cdot ha^{-1}$. Productivity of ponds decreased with increasing pond size and with increasing numbers of owners of the pond.

A few of the pond operators reported that lack of understanding among the co-owners (29%) and inadequate working capital (33%) were the main impediments to adoption of aquaculture in small waterbodies. However, no major structured alterations would be necessary in ponds currently used for or having potential for fish culture to initiate better fish farming methods.

Very few of the pond operators received extension advice, although most would invest in aquaculture if pond extension services were available.

It appears that the prospects to improve aquaculture in small waterbodies in Bangladesh are bright, especially if short-cycle species are used in the smaller or seasonal waterbodies.

Status and Potential of Aquaculture in Small Waterbodies (Ponds and Ditches) in Bangladesh

INTRODUCTION

In Bangladesh, the fisheries sector accounts for 3% of GDP, 8% of gross value added of the agricultural product, 71% of animal protein intake and more than 11% of export earnings. About 8% of the population depends on fisheries for its livelihood and about 73% of the households are involved in subsistence fishing in floodlands (areas that intermittently get flooded during monsoon rains). Although some surveys have claimed that per caput daily consumption of fish has either stabilized or improved, a widening of gap in the consumption of fish between urban and rural areas has been evident over time (World Bank 1991). This indicates deteriorating nutritional standards in rural households. The Government of Bangladesh (GOB) has recognized the importance of the fisheries sector to the national economy and has set a target of doubling fish production by the year 2000.

Between the two broad categories of fisheries environment, namely, inland and marine, the former is dominant in terms of its contribution to total national fish production. During 1988-89, inland fisheries contributed 72.3% of the total fish production of 840,000 t, of which 50.5% was from inland capture and 21.8% from inland culture. There has been a declining trend in the production from inland capture fisheries in recent years. Stocks have declined due to factors such as construction of dams, drainage and irrigation schemes, and pollution from agricultural and other sources, siltation of rivers and "haors" (natural depressions), and excessive fishing pressure. The share of inland capture fisheries thus declined from 62.6% of total catch in 1983-84 to 50.4% in 1988-89 (World Bank 1991). A sizeable amount of the current efforts of the government is being directed toward improving and sustaining production from the inland capture fisheries through openwater stocking programs and management measures.

However, in view of the low production levels that are being obtained currently (704 $kg \cdot ha^{-1} \cdot year^{-1}$) from aquaculture (World Bank 1991), there is a clear need to increase fish production from several thousand small waterbodies (mainly homestead ponds and ditches) in the countryside through improved fish culture practices. Inland aquaculture production grew by about 10% per annum during the last five years, most of which was attributable to simple expansion of production in previously unutilized/underutilized waterbodies. Further improvement of fish production is also viewed as a major means of increasing the fish consumption and purchasing power of the rural households (Chowdhury et al. 1987). Aquaculture forms part of a major development strategy in Bangladesh with many local and foreign NGO programs supporting aquaculture development.

In view of the possibility of increasing fish production through aquaculture, a project entitled 'Socioeconomic Impact of Fish Culture Extension Program on the Farming Systems of Bangladesh' has been undertaken jointly by the International Center for Living Aquatic Resources Management (ICLARM) and the GOB, with financial assistance from the International Fund for Agricultural Development (IFAD) and the Danish International Development Agency (DANIDA). The overall objective of the project is to examine the likely impact of the introduction of improved fish culture practices on rural households and communities. The project intends to provide extension assistance to pond operators in selected unions (village units) for adoption of modern fish culture methods: stocking,

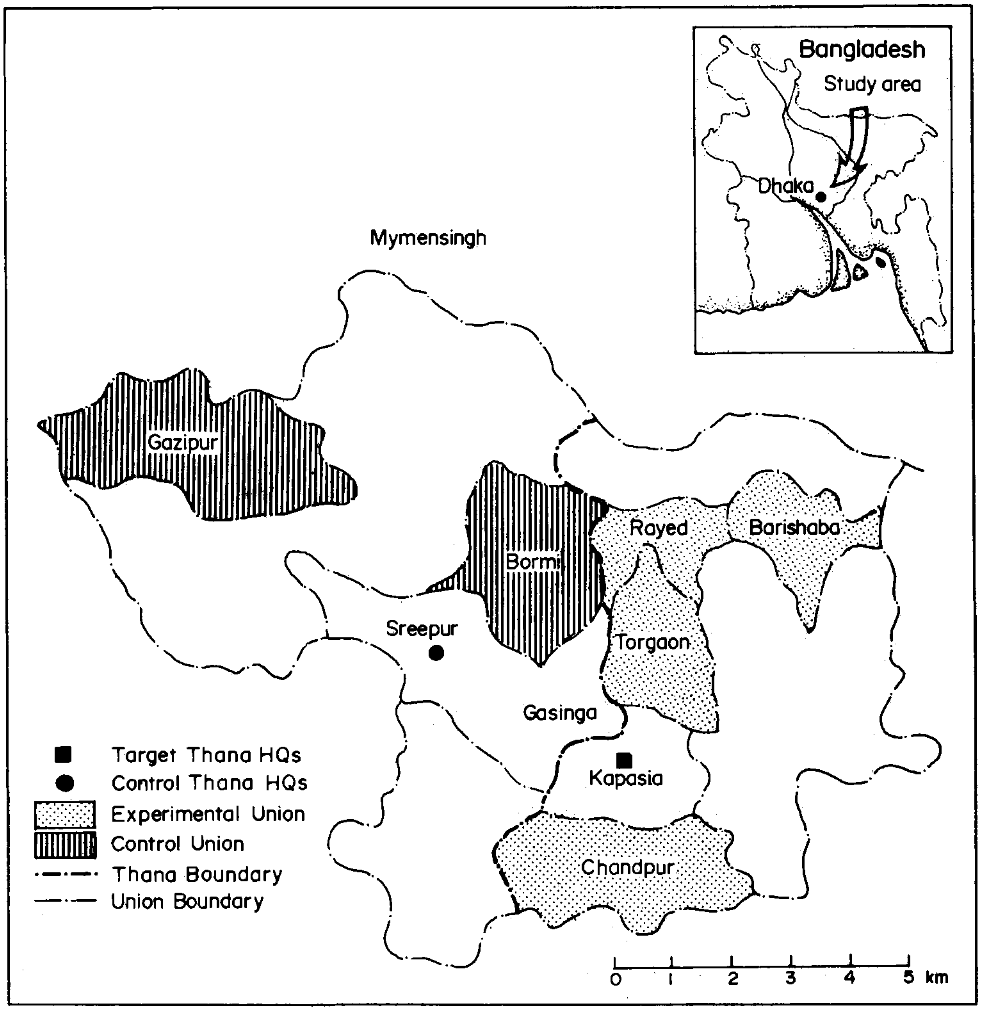


Fig. 1. Map of the study area (Kapasia and Sreepur).

feeding and fertilization. The project also aims to develop a viable and sustainable extension methodology for fish culture in small waterbodies.

This report describes a survey of small waterbodies (ponds and ditches) conducted to help formulate the extension program and to generate benchmark data regarding use and productivity of the small waterbodies of the project area. Ponds are here defined as closed waterbodies bigger than 80 m^2, generally constructed around the homesteads and having near-rectangular shapes. Waterbodies less than or equal to 80 m^2, with irregular shapes were referred to as ditches. The project area covers six selected unions from two thanas (subdistricts), namely, Kapasia and Sreepur under the district of Gazipur. The selected unions are Barishaba, Chandpur, Rayed and Torgaon from Kapasia thana and Bormi and Gazipur from Sreepur thana (Fig. 1).

Data Collection

Fig. 2 shows the design for conducting the socioeconomic survey and monitoring activities. The survey enumerated all the seasonal and perennial ponds and ditches having a land area (inclusive of water area) of 2 decimals (80 m^2) or more, irrespective of their current status of use. A total of 634 ponds and ditches (hereinafter called waterbody) in

Kapasia and 670 waterbodies in Sreepur were surveyed. For each union, a map showing the location of the ponds and ditches was prepared during the survey (Appendix I, Figs. 1-6). Basic information such as pond characteristics, pattern of ownership and utilization of the waterbodies, physical and socioeconomic problems of fish culture, and present level of aquaculture technology, extension services and production from the waterbodies were obtained through the use of a predesigned questionnaire (Appendix II). During the course of data collection, each of the individual waterbodies was physically identified and their sizes (length and width) were measured. Each of the waterbodies was given an identification number. Most of the data on production and species composition were based upon the recollection of farmers and refer to the year 1989-90.

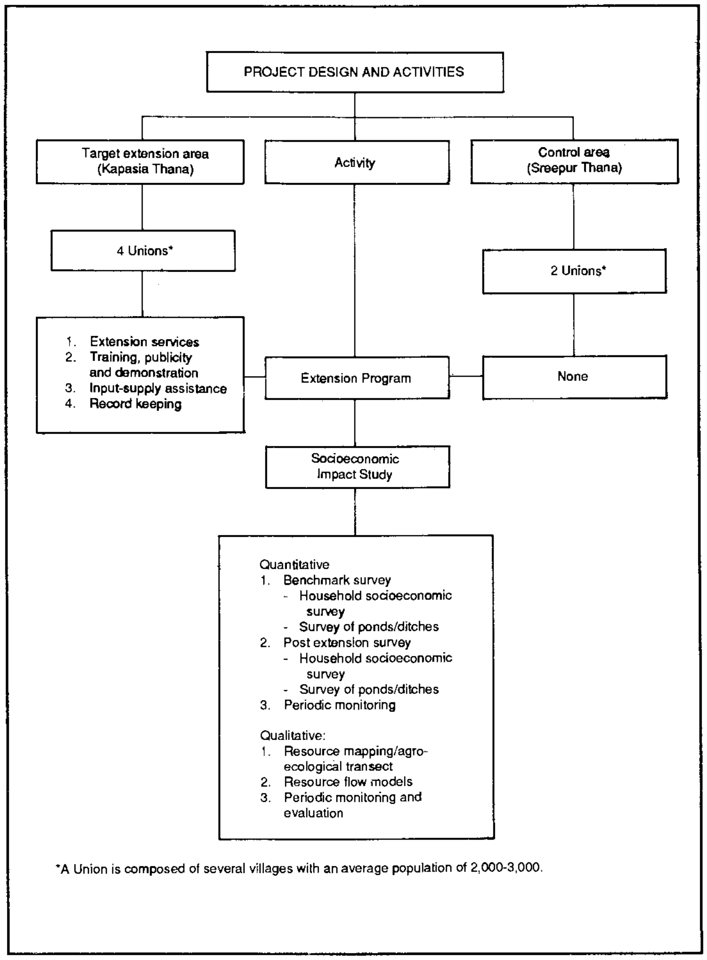


Fig. 2. Design of the fish culture extension impact study.

Data collection in the four unions of the target thana began in the first week of February 1991 and continued until the end of the month. The same procedure was carried out in the two unions of the control thana during the second half of March 1991 and continued up to the middle of April 1991. In each of the target unions, data were collected by one field investigator assisted by one field assistant (extension staff). In each of the control unions, the same procedure was carried out by two field investigators. Research officers closely supervised the entire data collection process. A few (5%) of the pond operators were re-interviewed to check for consistency of the data, especially with regard to production data.

Survey data were checked, verified and coded by the field investigators and research officers. Data consistency was also checked by computer. Data processing and tabulations were done on computer using the SPPSS/PC package.

Analytical Framework

Survey data were analyzed by using simple statistical techniques, such as frequency distribution, simple mean and percentages. Simple cross tabular techniques were applied to interpret data. Most of the analyses were done by type of waterbody, e.g., ponds and ditches. Contrary to ponds, ditches are normally not systematically maintained and are usually the unintentional by-products of some other activity, such as road building and elevation of homestead land. Ponds were further categorized as small, medium and large which were defined on the basis of water areas ranging from less than 600 m^2, 601-1,200 m^2 and above 1,200 m^2, respectively.

GENERAL PROFILE OF THE STUDY AREA

Household Characteristics

Kapasia and Sreepur, both under the district of Gazipur, are typical of the more than 450 thanas of Bangladesh, having total land areas of 352 and 462 km^2, respectively. Average population density though higher in Kapasia (712 persons per km^2) than in Sreepur (517 persons per km^2), was lower than the national average (800 persons per km^2). The total number of household per km^2 was also higher in Kapasia (124) than in Sreepur (88) (Table 1). However, the average family size was almost the same (about six) for both the thanas (Table 1). The literacy rate in Kapasia (23%) is higher than that of Sreepur (17%).

The two thanas have more or less a similar distribution of farm-size classes and other household characteristics (Table 1). Nonfarm households (families with less than 200 m^2 of cultivated area) and small farms (households having a farm holding of 200-6,100 m^2) comprised the majority of the households (61% in Kapasia and 59% in Sreepur) in both thanas. In the unions studied, they comprised more than 70% of the total households. While the proportion of nonfarm households to total households was higher in Sreepur (20%) than in Kapasia (16%), small farms constituted 43% in Kapasia as compared to 38% in Sreepur. The proportion of medium farms (households having farm holdings of 0.61-3.03 ha) was equal in both the thanas. Large farms (households having farm holdings of more than 3.03 ha) account for only 2% in Kapasia and 3% in Sreepur (Fig. 3).

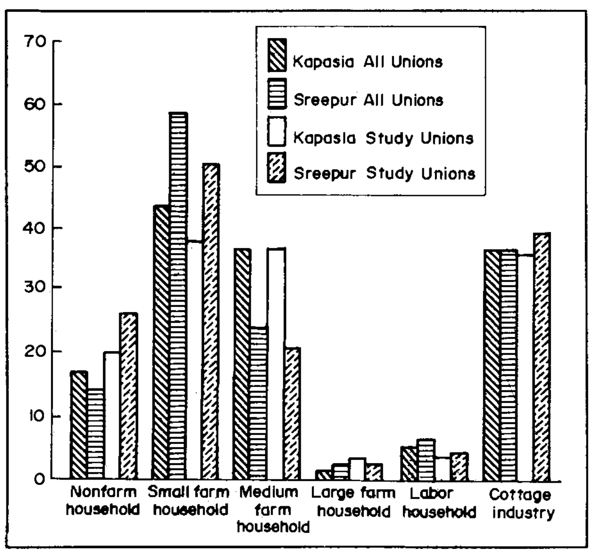


Fig. 3. Proportion of households in Kapasia and Sreepur under different farm and occupation categories.

Table 1. Key information about the unions and thanas studied (Kapasia and Sreepur).

Information categories	All unions of Kapasia	Kapasia					All unions of Sreepur	Sreepur		
		Barishaba	Chandpur	Rayed	Torgaon	Total		Bormi	Gazipur	Total
Area (km^2)	352	40	36	36	34	146	462	51	46	97
Population ('000s)	251	28	20	19	24	90	239	37	25	62
Population density (No.·km^{-2})	713	689	555	538	692	616	517	729	547	639
Total No. households[a]	43,690 (100)	4,791 (100)	3,672 (100)	2,944 (100)	4,226 (100)	15,633 (100)	41,044 (100)	5,791 (100)	4,858 (100)	10,649 (100)
No. of nonfarm households	7,256 (17)	800 (17)	435 (12)	224 (8)	752 (18)	2,211 (14)	8,403 (20)	1,581 (27)	1,148 (24)	2,729 (26)
No. of farm households[b]	36,434 (83)	3,991 (83)	3,237 (88)	2,720 (92)	3,449 (82)	13,397 (86)	32,641 (80)	4,210 (73)	3,710 (76)	7,920 (74)
- small (0.02-0.6 ha)	19,050 (44)	2,820 (59)	2,165 (59)	1,669 (57)	2,558 (61)	9,212 (59)	15,693 (38)	2,973 (51)	2,405 (50)	5,378 (51)
- medium (0.61-3.03 ha)	16,381 (37)	1,042 (22)	970 (26)	910 (31)	846 (20)	3,768 (24)	15,328 (37)	1,088 (19)	1,103 (23)	2,191 (21)
- large (>3.03 ha)	1,003 (2)	129 (3)	102 (3)	141 (5)	90 (2)	462 (3)	1,620 (4)	149 (3)	202 (4)	351 (3)
No. of households with cottage industries	2,520 (6)	115 (2)	366 (10)	238 (8)	345 (8)	1,064 (7)	1,498 (4)	216 (4)	321 (7)	537 (5)
No. of agricultural labor households[c]	15,983 (37)	1,807 (38)	1,536 (42)	987 (34)	1,516 (36)	5,846 (37)	4,768 (36)	2,139 (37)	2,141 (44)	4,280 (40)
Literacy rate (%)	23	16	24	22	29	23	17	20	13	16

[a]Figures in parentheses indicate percentages.
[b]Households with less than .02 ha of cultivated land are treated as nonfarm households.
[c]Households whose main part of income comes from working as agricultural wage labor are considered as agricultural labor households.
Source: The Bangladesh Census of Agriculture and Livestock: 1983-84, Bangladesh Bureau of Statistics, September 1988.

Again, 36-40% of the households derive a major portion of their income from work as agricultural laborers. This reveals that, among the farm households (having a farm holding of more than 0.02 ha), there exists a group of households whose major income was derived from work outside the farm; agricultural wage labor (Fig. 3). Furthermore, between 4 and 7% of the households are engaged in cottage industries in both thanas. However, there are differences between unions in the same thana; for example the proportion of such households ranged from as low as 2% in Chandpur to as high as 10% in Rayed, both in Kapasia thana (Table 1).

As shown in Table 1, there were variations of the household characteristics among the study unions in both the thanas. Among the four unions studied in the target thana (Kapasia) the average proportion of nonfarm households to total households was 14%, ranging between 8% (Rayed) and 18% (Torgaon). On the other hand, in the two unions studied in the control thana (Sreepur), 27 and 24% of the households in Bormi and Gazipur, respectively, were nonfarm households, the average being 26%. The proportion of medium and large farms was highest (31 and 5%, respectively) in Rayed union of Kapasia thana. Again, medium and large farms represented a higher proportion in the Gazipur union than in the Bormi union of Sreepur thana.

Also shown in Table 1, the proportion of agricultural laboring households was highest in Chandpur (42%) and lowest in Rayed (34%) in Kapasia thana. In Sreepur thana, however, agricultural laboring households were higher in Gazipur (44%) than in Bormi (37%). Amongst the unions of both thanas, there was variation with respect to literacy (Table 1).

Cropping Pattern and Cropping Intensity

The net and gross temporary (seasonal) cropped areas were higher in Sreepur than in Kapasia (Table 2). However, cropping intensity, defined as the ratio of gross temporary cropped area to net temporary cropped area per annum was found higher in Kapasia (1.53) than in Sreepur (1.41). Irrigation coverage was only 9.3% of the net cultivated area in Kapasia as compared to 16.9% in Sreepur. Among the major crops *Aus* (rainfed) rice, *Amon* (wet season nonirrigated) rice, and *Boro* (dry season irrigated) rice were notable in both thanas. Cash crops, such as jute, sugarcane and cotton accounted for more than 20% of total net temporary cropped area in both thanas. Minor crops like vegetables, spices, oil seeds and pulses were also cultivated in both thanas. Cultivation of wheat was almost absent in both thanas.

Table 2. Cropping pattern, cropping intensity and extent of irrigation in Kapasia and Sreepur.

Information categories	All unions of Kapasia[a]	Study unions of Kapasia[b]				All unions of Sreepur[b]	Study unions of Sreepur[b]	
		Barishaba	Chandpur	Rayed	Torgaon		Bormi	Gazipur
Net temporary cropped area (ha)	20,859	2,437	1,795	2,133	2,074	25,108	2,997	3,088
Gross cropped area (ha)	31,812	3,571	2,297	3,047	3,147	35,304	4,031	5,366
Cropping intensity[c]	1.53	1.47	1.28	1.43	1.16	1.41	1.35	1.74
% of irrigated land	9.30	9.80	5.60	7.40	11.70	16.90	25.20	4.60
% of land under different crops:								
Aus	44.14	40.00	5.60	48.86	44.30	48.09	36.77	79.63
Aman	43.25	30.66	37.26	35.93	36.00	40.61	41.55	70.47
Boro	22.05	26.34	32.61	24.31	39.85	15.78	44.06	3.55
Wheat	0.49	0.36	0.02	0.02	1.11	0.70	0.02	1.78
Pulses	4.40	4.92	0.83	4.25	6.01	3.33	1.31	2.85
Cash crop	25.29	34.38	8.16	27.41	19.96	23.00	29.31	8.81
Oil seeds	3.09	6.86	0.49	4.29	2.90	2.27	1.22	1.04
Vegetable	3.90	3.92	5.21	2.67	3.92	3.54	1.86	0.90
Species	4.82	5.58	3.74	4.76	5.07	2.78	1.32	2.41
Others	1.10	-	-	-	-	0.60	-	-

Sources:
[a]The Bangladesh Census of Agriculture & Livestock, 1983-84, Bangladesh Bureau of Statistics, September 1988.
[b]Unpublished data, Thana Statistical Office, Kapasia and Sreepur, Gazipur.
[c]Ratio of gross cropped area to net cropped area.

Comparison of cropping intensity among unions revealed that in Kapasia thana, Torgaon union has the lowest (116) cropping intensity (Table 2). In the study unions of Sreepur, cropping intensity was found higher in Gazipur (174) than Bormi (135). In all the unions, except the Gazipur union of Sreepur thana *Aus, Amon, Boro* and cash crops (e.g., jute) were cultivated. In Gazipur union, *Aus* and *Amon* were the major crops, whereas *Boro* and cash crops were cultivated to a very limited extent. Irrigation coverage was also lowest in the Gazipur union of Sreepur thana and the Chandpur union of Kapasia thana. Bormi union under Sreepur thana with an irrigation coverage of 25% of land area ranked highest among all the study unions in terms of percentage area of land under *Boro* (Table 2).

WATERBODY CHARACTERISTICS AND USE

Distribution of Waterbodies

Table 3 shows the distribution of waterbodies in the six unions studied in Kapasia and Sreepur. Ponds constituted 89 and 94% of the total count of waterbodies in Kapasia and Sreepur, respectively. Table 3 also shows the distribution of ponds by different size-classes. Among the three size-classes of ponds, small ponds (less than 600 m^2 water area) represented 33% in Kapasia and 44% in Sreepur. Thus, including the ditches, small waterbodies represented 44% of the total waterbodies in Kapasia and 50% of the total waterbodies in Sreepur.

Table 4 shows the area of available small waterbodies. The total water area occupied by the 634 waterbodies in Kapasia is 77.16 ha, while that occupied by the 670 waterbodies in Sreepur was 75.75 ha.

The density of waterbodies (no./m^2) varied widely between the two study unions as well as among the unions within each thana. It may be observed from Table 4 that the concentration of waterbodies was more pronounced in the unions of Sreepur than in Kapasia. On average, there were only 4.34 ponds per km^2 in Kapasia as compared to

Table 3. Frequency and percentage distribution of small waterbodies in the study unions of Kapasia and Sreepur.

	Kapasia					Sreepur		
Type of waterbody	Barishaba	Chandpur	Rayed	Torgaon	Total	Bormi	Gazipur	Total
Pond	99 (91)	233 (88)	115 (86)	118 (94)	565 (89)	217 (96)	411 (93)	628 (94)
- small (0-600 m^2)	21 (19)	99 (37)	27 (20)	64 (51)	211 (33)	92 (41)	205 (46)	297 (44)
- medium (601-1,200 m^2)	30 (28)	46 (17)	38 (29)	29 (23)	143 (23)	26 (11)	110 (25)	136 (20)
- large (above 1,200 m^2)	48 (44)	88 (33)	50 (38)	25 (20)	211 (33)	99 (44)	96 (22)	195 (29)
Ditch	10 (9)	33 (12)	18 (14)	8 (6)	69 (11)	10 (4)	32 (7)	42 (6)
All types	109 (100)	266 (100)	133 (100)	126 (100)	634 (100)	227 (100)	443 (100)	670 (100)

Figures in parentheses represent percentage of total.

Table 4. Availability of pond waterbodies in Kapasia and Sreepur.

	Total area (ha)	Waterbody areas as % of total area	Density of waterbody (no.·km^2)	Average no. of households per waterbody	Per household water area (m^2)	Per capita water area (m^2)
KAPASIA	77.16	0.53	4.34	24.66	48.80	8.44
Unions						
Barishaba	22.72	0.57	2.73	43.95	46.80	8.12
Chandpur	26.33	0.73	7.39	13.80	70.80	13.20
Rayed	19.38	0.53	3.69	22.14	26.40	4.00
Torgaon	8.73	0.26	3.71	33.54	20.40	3.60
SREEPUR	75.75	0.78	6.91	15.89	70.40	12.00
Unions						
Bormi	31.45	0.62	4.45	25.51	53.60	8.50
Gazipur	44.30	0.96	9.63	10.97	90.00	17.73

6.91 ponds in Sreepur. The density of waterbody (number of waterbody per km^2) was highest (9.63) in Gazipur union of Sreepur thana and lowest (2.73) in Barishaba union of Kapasia thana .

Again, on average there were more households per waterbody in Kapasia (25) than in Sreepur (16). The average number of households per waterbody was the highest (44) in Barishaba union of Kapasia thana and lowest (11) for Gazipur union of Sreepur thana (Table 4). Per household and per caput availability of waterbody area were larger in Sreepur (70.40 and 12 m^2) than those in Kapasia (48.80 and 8.44 m^2). In terms of per caput as well as per household availability of waterbodies there are wide variations between the two thanas and among the unions within each thana.

Size of Waterbodies

Table 5 shows the average size of waterbodies in the study unions. The average size of ponds and ditches in the target thana (Kapasia) was 1,347 m^2 and 156 m^2, respectively. In the control area (Sreepur), the figures were, respectively, 1,199 m^2 and 108 m^2. The average size of waterbodies considering both ponds and ditches together was found to be 1,217 m^2 in the target extension area and 1,130 m^2 in the control area. The average size of waterbodies did not vary significantly between the thanas under consideration, but variations among unions in both thanas were notable (Table 5). Among the four unions from the target thana (Kapasia), the average size of ponds and ditches in Barishaba (2,084 m^2) was almost double from that of Chandpur (990 m^2) and almost three times that of Torgaon (693 m^2). Similarly, in the control thana (Sreepur), the average size of the waterbodies of Bormi (1,385 m^2) exceeded that of Gazipur (1,000 m^2).

Operator Status of the Waterbodies

Four distinct categories of operator status - single owner operator, joint owner operator, single lease operator and joint lease operator - are shown in Table 6. The category

Table 5. Average size of ponds and ditches (m^2) in Kapasia and Sreepur.

Type of waterbody	Kapasia					Sreepur		
	Barishaba	Chandpur	Rayed	Torgaon	Total	Bormi	Gazipur	Total
Pond	2,279	1,104	2,075	728	1,347	1,444	1,069	1,199
					(0.1726)			(0.2101)
- small	480	277	399	300	320	333	348	343
					(0.0148)			(0.0133)
- medium	947	899	933	868	912	874	876	876
					(0.0184)			(0.0171)
- large	3,898	2,142	2,917	1,662	2,668	2,625	2,831	2,727
					(0.2239)			(0.3268)
Ditch	158	185	094	0172	156	113	106	108
					(0.0156)			(0.0037)
All types	2,084	990	1,457	693	1,217	1,385	1,000	1,130
	(0.2998)	(0.0994)	(0.1646)	(0.0575)	(0.1672)	(0.1644)	(0.2222)	(0.2051)

[a]Figures in parentheses represent standard deviation of area m^2.
[b]The differences in average sizes of waterbodies between the two thanas are not significant (P=0.1), but those among the individual unions are signficant (P=0.5).

Table 6. Frequency and percentage distribution of ponds and ditches by operator status in Kapasia and Sreepur.

Type of waterbody	Operator status					
	Single owner operator	Joint owner operator	Single lease operator	Joint lease operator	Others[b]	Total
Pond	273	188	12	22	70	565
	(48)	(33)	(2)	(4)	(12)	(100)
- small	158	48	2	1	2	211
	(75)	(23)	(1)	(0)	(1)	(100)
- medium	71	52	3	3	14	143
	(50)	(36)	(2)	(2)	(10)	(100)
- large	44	88	7	18	54	211
	(21)	(42)	(3)	(9)	(26)	(100)
Ditch	54	12	-	-	3	69
	(78)	(17)	(-)	(-)	(4)	(100)
All (Kapasia)	327	200	12	22	73	634
	(52)	(32)	(2)	(3)	(12)	(100)
Pond	336	248	10	6	28	628
	(54)	(39)	(2)	(1)	(4)	(100)
- small	213	80	-	-	4	297
	(72)	(27)	(-)	(-)	(1)	(100)
- medium	68	63	-	-	5	136
	(7)	(46)	(-)	(-)	(4)	(100)
- large	55	105	10	6	19	195
	(28)	(54)	(5)	(3)	(10)	(100)
Ditch	30	10	-	-	2	42
	(71)	(24)	(-)	(-)	(5)	(100)
All (Sreepur)	366	258	10	6	30	670
	(55)	(39)	(1)	(1)	(4)	(100)

[a]Figures in parentheses represent percentage of total.
[b]Others include institutional (school, college, *masjid*, village club, etc.) and *khas* pond.

'others' includes waterbodies managed by institutions (e.g., schools and mosques) and illegal occupants. The term "operator" refers to the person under whose control the waterbody was held during the survey period, irrespective of ownership. As shown in Table 6, most of the waterbodies (84 and 94% in Kapasia and Sreepur) were owner operated. Single and joint owner operators account for almost 52 and 32% in Kapasia and 55 and 39% in Sreepur, respectively. Single, as well as joint lease operators on the other hand, contributed only 1.9 and 3.5% in Kapasia and were very few in Sreepur, only 1.5 and 0.9%. Waterbodies held by the 'Others' were 11.5% in Kapasia and 4.5% in Sreepur.

The average size of ponds operated under lease agreements was larger than that of the owner operated ponds (Table 7). This holds true for both thanas. The average size of individually operated ponds was the smallest of all categories in both thanas. The largest ponds were operated by the single lease holders in Kapasia and by the joint lease holders in Sreepur. The average size of ponds operated by joint lease holders in Sreepur was 1.27 ha and that of ponds operated by single lease holders in Kapasia was only 0.37 ha (Table 7).

Ownership Pattern

The distribution of ponds, if viewed in terms of ownership, gives some interesting insights. As shown in Table 8, 44% of the waterbodies in Kapasia and 50% of the waterbodies in Sreepur were individually owned. About 29% of the waterbodies in Kapasia and 35% in Sreepur had between two and five owners. Waterbodies with more than five owners constituted 11 and 9% of the total in Kapasia and Sreepur, respectively. Waterbodies owned under the name of institutions were almost equal (3%) in both upazilas. Around 13% of the waterbodies in Kapasia and 4% of the waterbodies in Sreepur were *Khas* property (i.e., public property under the ownership of Government).

Thus, there is multiple (joint) ownership of 40 and 44% of the total existing waterbodies in Kapasia and Sreepur, respectively. On the other hand, nonprivate (institutional and *Khas*) ownership extended to as much as 16% of the total waterbodies in

Table 7. Average size (m^2) of waterbodies by operator status in Kapasia and Sreepur.

	Operator status					
Type of waterbody	Single owner operator	Joint owner operator	Single lease operator	Joint lease operator	Others	Total
Pond	751	1,386	3,691	2,573	2,776	1,347
- small	296	395	283	324	385	320
- medium	902	910	1,026	931	943	912
- large	2,141	2,208	5,807	2,971	3,340	2,668
Ditch	133	169	-	-	526	156
All (Kapasia)	649	1,313	3,691	2,572	2,684	1,217
Pond	730	1,320	3,520	12,746	2,439	1,199
- small	331	377	-	-	334	343
- medium	898	873	-	-	883	876
- large	2,090	2,307	3,522	12,746	3,292	2,727
Ditch	101	134	-	-	81	108
All (Sreepur)	618	1,274	3,522	12,746	2,282	1,130

Table 8. Frequency and percentage distribution of waterbodies by ownership status in Kapasia and Sreepur.

Type of waterbody	Ownership status: Single owner operator	Joint (2-5 owners)	Joint (more than 5)	Institu-tional	Khas	Total
KAPASIA						
Pond	231	169	69	19	77	565
	(41)	(30)	(12)	(3)	(14)	(100)
-small	149	52	7	2	1	211
	(71)	(25)	(3)	(1)	(0)	(100)
-medium	58	56	14	6	9	143
	(41)	(39)	(10)	(4)	(6)	(100)
-large	24	61	48	11	67	211
	(11)	(29)	(23)	(5)	(32)	(100)
Ditch	51	13	2	-	3	69
	(74)	(19)	(3)	(-)	(4)	(100)
All (Kapasia)	282	182	71	19	80	634
	(44)	(29)	(11)	(3)	(13)	(100)
SREEPUR						
Pond	305	224	56	17	26	628
	(49)	(36)	(9)	(3)	(4)	(100)
-small	208	74	11	4	-	297
	(70)	(25)	(4)	(1)	(-)	(100)
-medium	60	62	9	4	1	136
	(44)	(46)	(7)	(3)	(1)	(100)
-large	37	88	36	9	25	195
	(19)	(45)	(19)	(5)	(13)	(100)
Ditch	29	10	1	2	-	42
	(69)	(24)	(2)	(5)	(-)	(100)
All (Sreepur)	334	234	57	19	26	670
	(50)	(35)	(9)	(3)	(4)	(100)

Figures in parentheses represent percentage of total.

Kapasia and 7% of the total waterbodies in Sreepur. Multiple-owned and nonprivate waterbodies accounted for even larger pond and ditch areas (Table 8). Nonprivate (institutional and *Khas*) waterbodies occupied 37% of the total waterbody area, but 16% of waterbodies by number in Kapasia. Similarly, in Sreepur, nonprivate ponds occupied 24% of the total area but only 7% of the total number of waterbodies (Table 9). This is because relatively large-sized ponds had multiple owners or were institutional and public properties. Table 9 also shows the average size of ponds/ditches by ownership status. It shows that as the number of owners increased the average size of ponds/ditches also increased. Under the present system of management, multiple owner and *Khas* waterbodies have many of the characteristics of common property resources, which may explain their relative underutilization or inefficient use for aquaculture (Khan 1990).

Status of Aquaculture in the Waterbodies

The distribution of waterbodies used for various types of aquaculture is shown in Table 10. The waterbodies were broadly categorized as being farmed, farmable, or derelict. Farmed waterbodies were further classified as i) only stocked - irregularly stocked without fertilization and feeding, ii) irregularly stocked with occasional feeding and fertiliza-

Table 9. Average size (m^2) of ponds and ditches by ownership status in Kapasia and Sreepur.

	Ownership status					
Type of waterbody	Single	Joint (2-5 owners)	Joint (more than 5)	Institu- tional	Khas	Total
KAPASIA						
Pond (N=565)	634	1,165	1,889	1,764	3,292	1,347
- small (N=211)	290	396	370	385	324	320
- medium (N=143)	921	900	914	877	954	912
- large (N=211)	2,082	2,065	2,395	2,499	3,651	2,668
Ditch (N=69)	132	137	344	-	526	156
All (Kapasia)(N=634)	544	1,092	1,846	1,764	3,189	1,217
	(20)	(26)	(17)	(4)	(33)	(100)
SREEPUR						
Pond (N=628)	642	1,278	1,643	1,307	6,018	1,199
- small (N=297)	332	363	427	334	-	343
- medium (N=136)	880	863	936	931	688	876
- large (N=42)	1,797	2,341	2,191	1,907	6,232	2,727
Ditch (N=42)	102	121	202	81	-	108
All (Sreepur) (N=670)	595	1,229	1,413	1,178	3,189	1,130
	(26)	(38)	(12)	(3)	(21)	(100)

Figures in parentheses indicate percentage of total area of waterbodies in each ownership category.

tion, iii) regularly stocked but with no regular feeding and fertilization, and iv) used for well managed semi-intensive aquaculture nature (regular stocking, feeding, fertilization and harvesting). Waterbodies with dikes, bottoms in good condition with at least 0.9 m usable depth, readily available for stocking with minimum effort (e.g., cleaning of aquatic vegetation and repairs to dikes) were termed as farmable ponds. Ponds that became very shallow over the years, clogged with vegetation, having damaged dikes or deep bottom mud were considered derelict. Such ponds can be made farmable only after major renovation: excavations and other earthworks and removal of excessive aquatic vegetation.

From Table 10 it is clear that many waterbodies were not used for fish culture at all. Nevertheless, it can be seen that in Kapasia 66% of the ponds and 25% of the ditches were farmed at different levels. Moreoever, there were more than 22% farmable ponds and 25% farmable ditches in Kapasia. In the same thana, there were only 11% derelict ponds and as high as 50% derelict ditches. Together, they constituted about 16% of the total waterbodies from the four unions studied in Kapasia. Similarly, in Sreepur, 70% of the waterbodies (72% of the ponds and 36% of the ditches) were found to be farmed at the time of this survey. Another 18% of the waterbodies were farmable while about 12% of the waterbodies were derelict.

Nevertheless, the status of existing waterbodies in terms of well-managed aquaculture is very dismal. It is to be noted from Table 10 that among 634 waterbodies in Kapasia, only four (0.6%) were used for well-managed aquaculture (regular stocking, feeding and fertilization), while 8.5% practiced regular stocking with occasional feeding. Thus, a large number of waterbodies (52%) were farmed with irregular stocking, with or without occasional feeding and with no fertilization (Table 10). The status of aquaculture practices in Sreepur was also similar. Well-managed aquaculture was virtually absent from both thanas. In summary, aquaculture still appears to be in a state of infancy in the rural area of Bangladesh.

Ownership is an important determinant of the status of aquaculture in the existing waterbodies. Private and individually owned waterbodies have much better farming

Table 10. Frequency and percentage distribution of ponds and ditches by culture status in Kapasia and Sreepur.

Type of waterbody	Cultured: Only stocking (mostly irregular)	Irregular stocking with occasional feeding	Regular stocking with occasional feeding	Regular stocking feeding and fertilizing	Total	Not cultured: Farmable	Derelict	Total
KAPASIA								
Pond	145	170	52	4	371	129	65	565
	(26)	(30)	(9)	(1)	(66)	(23)	(11)	(100)
- small	42	69	24	-	135	63	13	211
	(20)	(33)	(11)	(-)	(64)	(30)	(6)	(100)
- medium	35	52	10	1	98	31	14	143
	(24)	(36)	(7)	(1)	(69)	(22)	(10)	(100)
- large	68	49	18	3	138	35	38	211
	(32)	(23)	(9)	(1)	(65)	(17)	(18)	(100)
Ditch	5	10	2	-	17	17	35	69
	(7)	(14)	(3)	(-)	(25)	(25)	(51)	(100)
All (Kapasia)	150	180	54	4	388	146	100	634
	(24)	(28)	(9)	(1)	(61)	(23)	(16)	(100)
SREEPUR								
Pond	226	103	123	2	454	117	57	628
	(36)	(16)	(20)	(0)	(72)	(19)	(9)	(100)
- small	96	56	52	-	204	51	42	297
	(32)	(19)	(18)	(-)	(61)	(17)	(14)	(100)
- medium	62	21	21	1	105	24	7	136
	(46)	(15)	(15)	(1)	(77)	(18)	(5)	(100)
- large	68	26	50	1	145	42	8	195
	(35)	(13)	(26)	(1)	(74)	(22)	(4)	(100)
Ditch	10	5	-	-	15	5	22	27
	(24)	(12)	(-)	(-)	(36)	(12)	(52)	(100)
All (Sreepur)	236	108	133	2	469	122	79	670
	(35)	(16)	(18)	(0)	(70)	(18)	(12)	(100)

Figures in parentheses represent percentages of total.

systems, than jointly owned and *Khas* waterbodies (Table 11). However, waterbodies under institutional ownership also use good farming methods, because institutions (e.g., schools and mosques) usually lease such properties to private operators.

Level of Water Retention

In Bangladesh, ponds capable of retaining 0.9-1.2 m water level during the dry season were normally considered farmable year-round. Table 12 shows that this applies to about 66% of the ponds and 4% of the ditches in Kapasia, with corresponding figures 73 and 2% in Sreepur. Taking ponds and ditches together, almost 70% of the waterbodies in Kapasia and 76% in Sreepur were capable of retaining a minimum of 0.9-1.2 m water level during the dry season (Table 12). This confirms that the overwhelming majority of waterbodies, especially ponds, have the potential for year-round fish culture.

Another important finding of the survey was that ponds that could not retain the specified minimum depth of water throughout the year were the ones that are mostly unused or derelict (Table 13).

Table 11. Culture status of waterbodies by type of ownership in Kapasia and Sreepur.

Culture status of waterbody	Ownership status: Single	Joint (2-5 owners)	Joint (more than 5)	Institu-tional	*Khas*	Total
KAPASIA						
Farmed						
- only stocking	62	38	23	8	19	150
(mostly irregular)	(22)	(21)	(32)	(42)	(24)	(24)
- irregular stocking with	91	55	13	4	17	180
occasional feeding	(32)	(30)	(18)	(21)	(21)	(28)
- regular stocking with	37	9	2	2	4	54
occasional feeding	(13)	(5)	(3)	(11)	(5)	(8)
- regular stocking, feeding	-	2	1	-	-	4
and fertilizing	(-)	(1)	(1)	(-)	(-)	(1)
Farmable	60	51	20	4	11	146
	(21)	(28)	(28)	(21)	(14)	(23)
Derelict	31	27	12	1	29	100
	(11)	(15)	(17)	(5)	(36)	(16)
Total	282	182	71	19	80	634
	(100)	(100)	(100)	(100)	(100)	(100)
SREEPUR						
Farmed						
- only stocking	111	91	18	7	9	236
(mostly irregular)	(33)	(39)	(32)	(37)	(34)	(35)
- irregular stocking with	60	32	10	4	2	108
occasional feeding	(18)	(14)	(17)	(21)	(8)	(16)
- regular stocking with	63	42	8	5	5	223
occasional feeding	(19)	(18)	(14)	(26)	(19)	(18)
- regular stocking, feeding	2	-	-	-	-	2
and fertilizing	(-)	(-)	(-)	(-)	(-)	(-)
Farmable	49	45	18	2	8	122
	(15)	(19)	(32)	(11)	(31)	(18)
Derelict	49	24	3	1	2	79
	(15)	(10)	(5)	(5)	(8)	(12)
Total	334	234	57	19	26	670
	(100)	(100)	(100)	(100)	(100)	(100)

Figures in parentheses indicate percentages of total number of waterbodies under each ownership category.

Table 12. Frequency and percentage distribution of ponds and ditches capable of retaining a minimum of 0.9-1.2 m water during the dry season in Kapasia and Sreepur.

Type of waterbody	Kapasia: Bari-shaba (N=109)	Chand-pur (N=226)	Rayed (N=133)	Torgaon (N=126)	Total (N=634)	Sreepur: Borml (N=227)	Gazipur (N=443)	Total (N=670)
Pond	58	189	74	97	418	154	338	492
	(53)	(71)	(56)	(77)	(66)	(68)	(76)	(73)
- small	11	73	20	51	155	65	148	213
	(10)	(27)	(15)	(40)	(24)	(29)	(33)	(32)
- medium	21	37	27	26	111	15	100	115
	(19)	(14)	(20)	(21)	(16)	(7)	(23)	(17)
- large	26	79	27	20	152	74	90	164
	(24)	(30)	(20)	(0)	(24)	(33)	(20)	(24)
Ditch	2	9	6	7	24	2	12	14
	(2)	(3)	(5)	(6)	(4)	(1)	(3)	(2)
All types	60	198	80	104	442	156	350	506
	(55)	(74)	(60)	(83)	(70)	(69)	(79)	(76)

Figures in parentheses represent percentage of N (N = total no. of waterbodies).

Other Uses of Waterbodies

Table 14 depicts the utilization of the study area waterbodies for purposes other than fish farming. It is evident that bathing and washing were common in both thanas. In Sreepur, almost 91% of the waterbodies were used for bathing and washing and in Kapasia somewhat less (78%). In both thanas, irrigation and jute retting were the next common uses. Ponds were used as drinking water sources and for growing water hyacinth for feeding livestock to a limited extent in both thanas.

Table 15 shows the extent of nonaquaculture utilization of waterbodies and their levels of farming. The use of ponds for bathing and washing was common, irrespective of the farming levels. Other uses of ponds were limited where regular stocking, feeding and fertilizing were practiced. This holds true for both the thanas. In conclusion, the data show that the most important uses, i.e., bathing and washing, were not compromised by the current fish farming practices. However, the utility of derelict ponds for irrigation and jute retting may be diminished as fish farming is adopted.

Table 13. Distribution of ponds by culture status and minimum water retention in Kapasia and Sreepur.

	Minimum water level in ponds	
Culture status of waterbody	0.9-1.2 m & above	below 0.9-1.2 m
KAPASIA		
Farmed		
- only stocking		
(mostly irregular N=150)	133	17
- irregular stocking with occasional	(89)	(11)
feeding (N=180)	152	28
- regular stocking with occasional	(84)	(16)
feeding (N=54)	50	4
- regular stocking, feeding and	(93)	(7)
fertilizing (N=4)	4	-
	(100)	(-)
Farmable (N=146)	90	56
	(62)	(38)
Derelict (N=100)	13	87
	(13)	(87)
Total (N=634)	442	192
	(62)	(38)
SREEPUR		
Farmed		
- only stocking	208	28
(mostly irregular N=236)	(88)	(12)
- irregular stocking with occasional	86	22
feeding (N=108)	(79)	(20)
- regular stocking with occasional	117	6
feeding (N=123)	(95)	(5)
- regular stocking, feeding and	2	-
fertilizing (N=2)	(100)	(-)
	86	36
Farmable (N=122)	(70)	(30)
	7	72
Derelict (N=79)	(9)	(91)
Total (N=670)	506	164
	(76)	(24)

Figures in parentheses represent percentages of N.

Table 14. Pattern of waterbody utilization for purposes other than fish culture by size and type of waterbody in Kapasia and Sreepur.

Type of waterbody	Types of pond use: Bathing & washing	Drinking	Irrigation	Jute retting	Stocking of hyacinth	Others
Pond (N=565)	47	5	184	107	16	96
	(83)	(1)	(33)	(19)	(3)	(17)
- small (N=211)	169	2	59	15	4	19
	(80)	(1)	(28)	(7)	(2)	(9)
- medium (N=143)	121	-	38	28	3	21
	(85)	(-)	(27)	(20)	(2)	(15)
- large (N=211)	181	3	87	64	9	56
	(86)	(1)	(41)	(30)	(4)	(27)
Ditch (N=69)	25	-	33	8	2	3
	(36)	(-)	(48)	(12)	(3)	(4)
All (Kapasia) (N=634)	496	5	217	115	18	99
	(78)	(1)	(34.23)	(18)	(3)	(16)
Pond (N=628)	575	8	158	172	4	18
	(92)	(1)	(26)	(27)	(6)	(3)
- small (N=297)	260	3	70	67	4	4
	(88)	(1)	(24)	(23)	(1)	(1)
- medium (N=136)	130	1	45	49	-	2
	(96)	(1)	(33)	(36)	(-)	(1)
- large (N=195)	185	4	43	56	-	12
	(95)	(2)	(22)	(29)	(-)	(6)
Ditch (N=42)	32	-	5	20	-	-
	(76)	(-)	(12)	(48)	(-)	(-)
All (Sreepur) (N=670)	607	8	163	192	4	18
	(91)	(1)	(24)	(29)	(1)	(3)

Figures in parentheses represent percentages of corresponding N (N = no. of waterbodies). Due to multiple responses, the row total may exceed N.

Table 15. Pattern of waterbody utilization for purposes other than pond fish culture by culture status in Kapasia and Sreepur.

Culture status of waterbody	Utilization of waterbody: Bathing & washing	Drinking	Irrigation	Jute retting	Stocking of hyacinth	Others
KAPASIA						
Farmed						
- only stocking (mostly irregular N=150)	138	2	53	23	3	21
	(92)	(1)	(35)	(15)	(2)	(14)
- irregular stocking with occasional feeding (N=180)	148	1	26	25	1	38
	(82)	(1)	(14)	(14)	(1)	(21)
- regular stocking with occasional feeding (N=54)	53	1	19	5	- -	6
	(98)	(2)	(5)	(9)	(-)	(11)
- regular stocking, feeding and fertilizing (N=4)	3	-	-	-	-	1
	(75)	(-)	(-)	(-)	(-)	(25)
Farmable (N=146)	112	1	62	28	4	17
	(77)	(1)	(42)	(19)	(3)	(12)
Derelict (N=100)	42	-	57	34	10	16
	(42)	(-)	(57)	(34)	(10)	(16)
All (N=634)	496	5	217	115	18	99
	(78)	(1)	(34)	(18)	(3)	(16)
SREEPUR						
Farmed						
- only stocking (mostly irregular N=236)	230	1	78	77	1	5
	(97)	(0)	(33)	(33)	(0)	(2)
- irregular stocking with occasional feeding (N=108)	101	2	20	16	-	4
	(94)	(2)	(19)	(15)	(-)	(4)
- regular stocking with occasional feeding (N=123)	118	5	19	25	-	4
	(96)	(4)	(15)	(20)	(-)	(3)
- regular stocking, feeding and fertilizing (N=2)	2	-	-	-	-	-
	(0)	(-)	(-)	(-)	(-)	(-)
Farmable (N=117)	104	-	21	30	1	4
	(89)	(-)	(18)	(26)	(1)	(3)
Derelict (N=57)	52	-	25	44	2	1
	(91)	(-)	(44)	(77)	(4)	(2)
All (N=670)	607	8	163	192	4	18
	(91)	(1)	(24)	(29)	(1)	(3)

Figures in parentheses represent percentages of corresponding N (N = no. of waterbodies). Due to multiple responses, the row total may exceed N.

FISH PRODUCTION OF SMALL WATERBODIES

The conventional approach used for measuring productivity is the ratio of output to associated inputs. In this study, our interest was to measure the production of fish per unit area of waterbody. From the disaggregated data, fish productivity per unit of waterbody was calculated following the formula given below:

$$Q_p = \frac{\sum_{i=1}^{n} Q_{ij}}{\sum_{i=1}^{n} L_i}$$

where Q_p = average production in a particular community group, union, upazila, etc.; Q_{ij} = fish output of the jth class/group/union by the ith farmer of a particular group; and L_i = size of waterbody in hectare of the ith farmer of the class/group.

Culture of Different Fish Species and Production by Species

Polyculture is practiced in the waterbodies farmed with irregular stocking or regular stocking, feeding and fertilization. Table 16 gives the choices of species. Indian major carps (*Labeo rohita, Catla catla* and *Cirrhinus mrigal*) are so far the most preferred species for stocking. In Kapasia and Sreepur, respectively, 92% and 96% of the total number of farmed waterbodies were stocked with Indian major carps. Chinese carps and tilapia (*Oreochromis* spp.) were farmed in 27 and 37% of the waterbodies in Kapasia and in 43

Table 16. Percentage distribution of farmed ponds and ditches by type of species reared in Kapasia and Sreepur.

	Kapasia			Sreepur		
Type of species	Ponds N=371	Ditches N=17	Total N=388	Ponds N=454	Ditches N=15	Total N=469
A	94	59	92	96	87	96
	(348)	(10)	(358)	(437)	(13)	(450)
B	27	24	27	43	40	43
	(102)	(4)	(106)	(196)	(6)	(202)
C	35	24	35	53	40	52
	(130)	(4)	(134)	(198)	(6)	(246)
D	36	65	37	44	47	44
	(133)	(11)	(144)	(240)	(7)	(205)
E	0	0	0	-	-	-
	(1)	(0)	(1)	(-)	(-)	(-)
F	24	59	28	12	7	12
	(97)	(10)	(107)	(54)	(1)	(55)
G	5	18	6	11	-	10
	(20)	(3)	(23)	(48)	(-)	(48)

[a]Figures in parentheses represent number of ponds. Due to multiple responses column totals may exceed N.
[b]A = Indian major carps, B = Chinese carps, C = Common carp, D = Tilapia, E = Shorputi, F = Air-breathing fish and G = Other wild fish.

and 44% of the waterbodies in Sreepur. The main tilapia species was *O. mossambicus* or hybrids of *O. mossambicus* and *O. niloticus.* Common carp (*Cyprinus carpio*) were farmed in 35% of the waterbodies in Kapasia and in 52% of the waterbodies in Sreepur. Culture of silver barb, otherwise called Thai shorputi (*Puntius gonionotus*) was almost absent from both the thanas. Some experimental farming trials using Thai shorputi had given good results in some parts of the country, but fingerlings of this species were not available to the farmers in the study area at the time of survey.

The airbreathing fish, popularly known as live fish (category used to describe those species which can be kept alive after capture and sale for several days prior to consumption, e.g., catfish, climbing perch and snakehead) and other indigenous species were also stocked in a number of waterbodies. The analysis of the species selection pattern thus reveals that the waterbodies in the study areas were used mostly for polyculture giving primary importance to Indian major carps (Table 16). However, this is expected to change in the future. Chinese and common carps are already included in the polyculture system because of simple and easier hatchery and nursery technologies as well as their high growth performances. Similarly, farming of tilapia and Thai shorputi are expected to expand to relatively smaller ponds and seasonal waterbodies as they are being found suitable for short-cycle fish farming.

Though a fraction of total available ponds and ditches in the two thanas had not been stocked with any species, a wide variety of species were harvested from both farmed and nonfarmed (farmable and derelict) waterbodies. Table 17 shows the average per hectare production (in kg) according to species. The average per hectare production of Indian carps was highest followed by airbreathers and other wild species in both thanas. The production of airbreathing fish and other wild species was quite high as many of the waterbodies, especially the farmable and derelict waterbodies that were occupied by these wild fish during the monsoon from adjacent flooded lands. Moreover, the average

Table 17. Annual production ($kg \cdot ha^{-1}$) of various species by type of waterbody in Kapasia and Sreepur. Production is defined as total harvest over all units of each waterbody type, whether stocked or not.

	Species group							
Type of waterbody	Indian carps	Chinese carps	Common carp	Tilapia	Shorputi	Air-breathing fish	Others	Total
KAPASIA								
Pond	275	24	19	22	1	99	95	535
- small	397	49	64	144	4	302	209	1,169
- medium	326	28	18	30	1	146	130	679
- large	249	20	14	5	-	64	74	426
Ditch	128	14	9	196	7	856	487	1,697
All (Kapasia)	273	24	19	24	1	109	101	551
SREEPUR								
Pond	282	44	31	36	1	41	104	539
- small	530	72	60	121	-	117	228	1,128
- medium	450	49	48	26	-	46	127	746
- large	196	37	22	22	1	26	75	379
Ditch	216	26	-	60	-	406	386	1,096
All (Sreepur)	281	44	31	36	1	44	106	542

production of airbreathers and other wild species was higher for ditches than ponds (Table 17). On the other hand, the average per hectare production of exotic species (tilapias, common carp, Chinese carps), is minimal so far.

The average productivity of different species by farming levels is shown in Table 18. There was a sharp difference between farmed and nonfarmed waterbodies in terms of species concentration. The average production of Indian carps and exotic carps was higher for the farmed ponds in both thanas. In the farmable and derelict ponds the average production of airbreathers and other wild fish was higher than in the farmed waterbodies. Similarly, in the case of ditches the average production of airbreathers and other indigenous fish was also higher than the ponds under various status of aquaculture. One interesting fact that has emerged from the analysis is that the production of carps and exotic fish became dominant with improvement of farming practices.

Productivity Differences by Union

Table 19 shows variation in average productivity by union and pond size. In this respect there existed little difference between the two thanas but there were differences

Table 18. Annual production ($kg \cdot ha^{-1}$) of various species by farming level in Kapasia and Sreepur. Production is defined as total harvest over all units of each waterbody type, whether stocked or not.

Culture status	Species group							
	Indian carps	Chinese carps	Common carp	Tilapia	Shorputi	Live fish	Others	Total
KAPASIA								
Pond	275	24	19	22	1	99	95	535
Farmed								
-only stocking (mostly irregular)	295	11	19	27	1	40	56	449
-irregular stocking with occasional feeding	403	51	35	33	1	65	64	652
-regular stocking with occasional feeding	812	76	41	48	2	85	193	1,257
-regular stocking, feeding and fertilizing	1,305	15	124	-	-	42	315	1,801
Farmable	25	13	-	5	-	201	137	381
Derelict	18	-	-	-	-	180	132	330
Ditch	128	14	9	196	7	856	487	1,697
All (Kapasia)	273	24	19	24	1	109	101	551
SREEPUR								
Pond	282	44	31	36	1	41	104	539
Farmable								
- only stocking (mostly irregular)	399	57	26	17	-	20	98	617
- irregular stocking with occasional feeding	291	54	56	77	-	46	95	619
- regular stocking with occasional feeding	269	56	58	83	2	32	84	584
- regular stocking, feeding and fertilizing	-	-	-	-	-	49	21	70
Farmable	73	4	1	1	-	91	140	310
Derelict	113	-	-	7	-	69	140	329
Ditch	216	26	-	60	-	406	386	1,096
All (Sreepur)	281	44	31	36	1	44	106	542

Table 19. Average annual production (kg·ha^{-1}) by type of waterbody in selected unions of Kapasia and Sreepur.

	Kapasia					Sreepur		
Type of waterbody	Bari-shaba	Chand-pur	Rayed	Torgaon	Total	Bormi	Gazipur	Total
Pond	588	487	423	787	535 (879)	372	586	539 (809)
- small	1,360	1,026	1,338	1,182	1,170 (1,582)	1,074	1,149	1,127 (1,416)
- medium	943	454	590	876	679 (974)	439	818	746 (988)
- large	492	416	315	550	425 (724)	283	507	379 (569)
Ditch	2,153	1,482	2,599	1,017	1,697 (2,132)	1,032	1,114	1,096 (1,519)
- retaining water (0.9-1.2 m)	2,624	2,871	3,723	945	2,259 (2,664)	-	1,204	1,204 (894)
- not retaining water (0.9-1.2 m)	2,032	1,219	2,038	1,433	1,477 (1,878)	1,032	1,437	1,360 (1,761)
All types	599 (1,019)	510 (866)	443 (701)	790 (1,114)	551 (909)	374 (546)	660 (961)	542 (815)

Figures in parentheses represent standard deviations.

among unions within the same thana. In Kapasia, the productivity of waterbodies was the highest in Torgaon union (790 kg·ha^{-1}) and lowest in Rayed union (443 kg·ha^{-1}). In Sreepur, the productivity of waterbodies differed significantly between the two study unions. Productivity was nearly twice as high in Gazipur than in Bormi (Table 19).

A comparison of the productivities of ponds and ditches gives some important indications of their potentials. In Kapasia, the average per hectare productivity of ditches was almost three times (1,697 kg·ha^{-1}) higher than that of ponds (535 kg·ha^{-1}) and in Sreepur, the productivity of ditches (1,094 kg·ha^{-1}) was twice that of ponds. The higher productivity of ditches needs clarification. Ditches remain connected to open waters (flooded lands) year-round especially during the monsoon. When monsoon waters start receding, fish from the formerly inundated areas take shelter in the ditches. Hence the ditches act as aggregating grounds for fish that have grown naturally in the floodwaters and can produce more fish than enclosed ponds. Moreover, as shown earlier in Table 17, the bulk of the catch from the ditches comprises airbreathers and miscellaneous small fish of floodland origin. Table 19 also shows that ditches capable of holding water year-round had higher productivity in Kapasia, while the reverse holds true in Sreepur. The productivity of ponds declines as pond size increases. This holds true throughout the study area. Under the existing management practices, the average pond productivity ranged from 379 kg·ha^{-1} for large ponds (1,200 m^2 and above) ponds to 1,170 kg·ha^{-1} for small ponds (up to 600 m^2).

Production by Ownership and Culture Status

Ownership pattern and operator status play an important role in the adoption of aquaculture and hence, production from small waterbodies. Table 20 shows the average annual production according to ownership. The productivity of ponds decreased as the number of owners increased. Conversely, the productivity of ditches increased as the number of owners increased. However, productivities of institutional and *Khas* ponds were lower than the ponds held under private ownership. Again, single owner operators ranked first with respect to fish productivity (Table 20). The productivity of lessee operated ponds was also lower than the owner operators in the study thanas (Table 21). Table 22 shows the expected relationship between improvement of farming levels and productivity.

Table 20. Average annual production ($kg \cdot ha^{-1}$) by type of waterbody and ownership status in Kapasia and Sreepur.

Type of waterbody	Ownership status: Single	Joint (2-5 owners)	Joint (more than 5)	Institu-tional	*Khas*	Total
KAPASIA						
Pond	713	680	591	480	297	535
- small	1,215	1,138	691	494	2,624	1,170
- medium	628	813	756	285	334	679
- large	370	552	570	517	293	425
Ditch	1,902	1,925	2,034	-	424	1,697
All (Kapasia)	765	691	598	480	298	551
SREEPUR						
Pond	756	624	435	536	170	539
- small	1,117	1,195	624	2,043	-	1,127
- medium	767	719	923	505	291	746
- large	410	525	371	425	170	379
Ditch	1,042	1,136	1,235	1,544	-	1,096
All (Sreepur)	760	626	437	543	170	542

Table 21. Average annual production ($kg \cdot ha^{-1}$) by type of waterbody and operator status in Kapasia and Sreepur.

Type of waterbody	Operator status: Single owner operator	Joint owner operator	Single lease	Joint lease	Others	Total
KAPASIA						
Pond	789	538	185	305	336	535
- small	1,205	1,078	1,500	803	-	1,170
- medium	652	749	1,108	440	402	679
- large	685	450	97	294	332	425
Ditch	1,947	1,352	-	-	323	1,697
All (Kapasia)	792	546	185	305	336	551
SREEPUR						
Pond	745	558	327	100	246	538
- small	1,137	1,102	-	-	-	1,127
- medium	778	701	-	-	-	746
- large	483	456	327	100	246	379
Ditch	1,097	1,220	-	-	2,717[a]	1,096
All (Sreepur)	748	561	327	100	250	542

[a]Only one case was reported.

Table 22. Average annual production (kg·ha^{-1}) by type of farming level and type of waterbody in Kapasia and Sreepur.

Type of waterbody	Culture status: Cultured – Only stocking (mostly irregular)	Irregular stocking with occasional feeding	Regular stocking with occasional feeding	Regular stocking feeding and fertilizing	Not cultured – Farmable	Derelict
KAPASIA						
Pond	449	652	1,256	1,801[a]	381	330
- small	1,053	1,348	1,992	-	835	717
- medium	682	760	951	799	565	441
- large	380	476	1,184	1,857[a]	217	293
Ditch	2,182	2,799	3,767	-	1,645	1,405
All (Kapasia)	452	664	1,270	1,801[a]	400	389
SREEPUR						
Pond	618	619	584	70[a]	311	329
- small	1,259	1,375	1,472	-	542	740
- medium	915	757	786	-	410	238
- large	444	352	428	70	247	96
Ditch	1,235	1,796	-	-	865	958
All (Sreepur)	620	624	584	70[a]	312	371

[a]Average of two ponds where harvesting was made during reporting year.

CONSTRAINTS TO FISH CULTURE

Factors Affecting Fish Culture

The perceptions of the respondents with regard to factors affecting fish culture in farmable ponds are presented in Table 23. Lack of adequate water was cited by 26% of those with access to farmable ponds as an impediment to fish culture in Kapasia. Lack of

Table 23. Response of operators of farmable ponds regarding factors affecting fish culture in Kapasia and Sreepur.

Factors	Unions of Kapasia: Barishaba (N=26)	Chandpur (N=75)	Rayed (N=20)	Torgaon (N=25)	Total (N=146)	Unions of Sreepur: Bormi (N=52)	Gazipur (N=70)	Total (N=122)
Lack of adequate water during dry season	15 (58)	12 (16)	9 (45)	2 (8)	38 (26)	- (-)	9 (13)	9 (7)
Extreme turbidity of water	- (-)	1 (1)	- (-)	4 (16)	5 (3)	1 (2)	4 (6)	5 (4)
Natural production adequate	4 (15)	1 (1)	4 (44)	- (-)	9 (6)	- (-)	8 (11)	8 (7)
Lack of understanding among the shareholders	4 (15)	19 (25)	3 (33)	8 (32)	34 (23)	29 (56)	15 (21)	44 (36)
Risk of theft	3 (12)	6 (8)	3 (33)	- (-)	12 (8)	6 (12)	17 (24)	23 (19)
Inadequate supply of fry fingerlings	- (-)	2 (3)	3 (33)	7 (28)	12 (8)	- (-)	6 (9)	6 (5)
Inadequate cash	1 (4)	22 (29)	2 (22)	9 (36)	34 (23)	33 (63)	18 (26)	51 (42)
Others	14 (54)	33 (44)	6 (30)	14 (56)	67 (469)	7 (13)	24 (34)	31 (25)

Figures in parentheses represent percentages of N in the corresponding column. Column totals may exceed N due to multiple response.

cooperation among the cosharers and inadequate cash resources were also reported by 23% of the respondents as the reasons for not farming fish in the same thana. In Sreepur, lack of cooperation among the cosharers, risk of theft and inadequate financial resources were identified by 36, 19 and 42% of the operators, respectively, as the most important factors constraining adoption of fish farming in farmable ponds. Inadequate supply of fingerlings and risk of theft were shown as two minor factors affecting fish production in Kapasia.

Changes Needed to Encourage and Improve Small Waterbody Aquaculture

Almost 45% of respondents in Kapasia and 68% in Sreepur reported that no changes were necessary to encourage adoption or improvement of aquaculture in the farmed and farmable ponds and ditches (Table 24). However, 25% of the respondents in Kapasia identified the need to repair dikes while only 8% felt this was important in Sreepur. The clearing of aquatic weeds and repair of dikes were seen to be necessary in 9 and 6% of the ponds, respectively, in Kapasia and Sreepur.

Table 24. Response of the pond/ditch operators on the changes required for adoption or encouragement of fish culture in the farmable and farmed ponds in Kapasia and Sreepur.

	Percentages of operator and potential operators citing needs for change	
Changes needed	Kapasia (N=534)	Sreepur (N=591)
Only cleaning of aquatic weeds	14	6
Only repair of dikes	25	8
Both cleaning of aquatic weeds and repair of dikes	9	6
No reform/development necessary	45	68
Others	7	12
Total	100	100

Incidence of Ulcerative Disease

Ulcerative disease (popularly known as viral infection) has been a common phenomenon in recent times among fish in the ponds and ditches of Bangladesh. It affects mainly the airbreathers, barbs and some species of carp. About 79% of the waterbodies in Sreepur and 66% of the waterbodies in Kapasia were affected by the disease (Table 25). Barishaba union of Kapasia and Gazipur union of Sreepur thana were worst affected. The least affected union was Chandpur (60%). This shows that the extent of ulcerative disease was quite severe in both the thanas and posed a potential risk to investment in aquaculture. However, the disease usually occurred during the cold and dry months (November-January) and was most prevalent among certain floodwater-dependent species. Hence, risks of production failure can be minimized either by farming nonvulnerable species (e.g., tilapia) or by harvesting prior to onset of dry season.

Table 25. Incidence of ulcerative fish disease in Kapasia and Sreepur.

Name of the union	Affected by disease	Not affected by disease	Total
Barishaba	80	29	109
	(73)	(27)	(100)
Chandpur	151	107	266
	(57)	(43)	(100)
Rayed	82	51	133
	(62)	(38)	(100)
Torgaon	81	44	126
	(64)	(34)	(100)
All (Kapasia)	394	240	634
	(62)	(38)	(100)
Bormi	160	67	227
	(70)	(30)	(100)
Gazipur	348	95	443
	(79)	(21)	(100)
All (Sreepur)	508	162	670
	(76)	(24)	(100)

Figures in parentheses represent percentages of total number of ponds.

Willingness to Invest

About 93% of operators in Kapasia and 86% in Sreepur showed a willingness to make additional investments in fish culture (Table 26). Respondents who were not willing to do so identified one of the following constraints as the main reason:

- the use of the pond/ditch for other purposes;
- the expiration of near-expiration of the lease contract;

Table 26. Response of pond operators about their willingness and unwillingness to invest in pond fish culture in Kapasia and Sreepur.

Factors	Kapasia	Sreepur
A. Willing to invest	581	579
	(92)	(86)
B. Not willing to invest	53	93
	(8)	(14)
- Pond/ditch is used for other purpose	4	16
	(8)	(17)
- Unable to invest since lease contract has expired or about to expire	23	5
	(43)	(5)
- Lack of family member(s) to provide supervision	9	8
	(17)	(9)
- Lack of consensus among the cosharers	11	29
	(21)	(31)
- Lack of capital	5	34
	(9)	(37)
- Others	1	1
	(2)	(1)

Figures in parentheses represent percentages of totals.

- the lack of available family member(s) to provide necessary supervision;
- the lack of consensus among the cosharers; and
- the lack of capital.

STATUS OF EXTENSION SERVICES

In response to the question relating to the types of extension services received by the operators, only 32 (8%) out of 388 operators of farmed waterbodies in Kapasia and 33 (7%) out of 469 operators of waterbodies in Sreepur reported that they received some services (Table 27). Again, amongst those respondents who received extension services, 84% (27 out of 32) in Kapasia and 82% (27 out of 33) in Sreepur received only advice. Training, provision of critical inputs, credit (cash or kind) were rarely made available to the waterbody operating farmers in both upazilas. Therefore, the important point to be noted here is that a large majority of the pond operators (92% in Kapasia and 93% in Sreepur) never received any kind of extension service. This poor state of extension services explains why better aquaculture technologies have not been introduced yet to the farmers.

POTENTIAL FOR IMPROVED POND FISH CULTURE

It is evident from the above analyses that the prospect for improved fish culture in the small waterbodies in the study area is bright. The survey revealed that 85% of the waterbodies (including 65% farmed and 20% farmable) were readily available for fish

Table 27. Types and extent of extension assistance received by the operators of the farmed ponds in Kapasia and Sreepur.

Types of extension assistance received	Kapasia	Sreepur
Yes	32 (8)	33 (7)
- Training	2 (6)	4 (12)
- Advice	27 (84)	27 (82)
- Free input support	2 (6)	- (-)
- Credit (in kind)	3 (9)	1 (3)
- Credit (in cash)	4 (13)	4 (12)
- Others	1 (3)	1 (3)
No	356 (92)	436 (93)
Total	388 (100)	469 (100)

Figures in parentheses represent percentages of total.

culture without any major changes or investments. To introduce modern fish culture methods, the operators will incur running costs (i.e., variable costs of inputs) in which most of them (89%) were willing to invest. Among the respondents who were not willing to invest, few reported cash constraints. Lack of consensus among the cosharers emerged as an important reason for the unwillingness to invest in fish culture by some. The present study revealed that multiple ownership waterbodies had poor aquaculture status. It was also found that the productivity of the ponds declined as the number of operators/owners increased. Hence, adoption of modern methods of fish culture was hampered not so much by cash constraints as by difficulties in management of the jointly operated ponds. Khan (1990), citing an example of quick adoption of fish farming in villages near demonstration projects, reported that multiple ownership has not been much of a deterrent as it is usually thought to be.

Again, availability water throughout the year was not a problem with the majority of waterbodies. Almost 72% of these small waterbodies were perennial, i.e., capable of retaining a minimum water level of 0.9-1.2 m during the dry season. The remaining waterbodies became dry for 2-3 months during the dry season. This confirms that overwhelming majority of waterbodies have the potential for year-round fish culture. On the other hand, waterbodies that are seasonal can support farming of species, such as *O. niloticus* and Thai shorputi (*P. gonionotus*) in short production cycles.

Current average annual production in the farmed waterbodies is very low in both upazilas (551 $kg{\cdot}ha^{-1}$ in Kapasia and 542 $kg{\cdot}ha^{-1}$ in Sreepur). Available evidence from farm level data on aquaculture suggests that it is possible to increase annual per hectare production to more than 2,500 kg easily under well-managed semi-intensive culture system. That is, it is possible to increase fish production in the waterbodies more than fourfold through adoption of various semi-intensive culture techniques in farmed and farmable waterbodies.

Polyculture that combines Indian major carps (e.g., rohu, catla and mrigal), with common carp (*C. carpio*) and Chinese carps are able to produce as much as 3.5 $t{\cdot}ha^{-1}{\cdot}year^{-1}$ using on-farm inputs (e.g., rice bran, cattle dung and other manures) and modest doses of inorganic fertilizers and supplementary feeding (Table 28). Similarly, for seasonal and small waterbodies alternative technologies such as farming tilapia and shorputi can produce 2-3 t for 8-10 months of production operations per annum and are quite attractive but inexpensive (Table 28). These technologies can easily be adopted by farmers (Gupta et. al 1992).

As fish farming expands and techniques improve, large demands for fry and fingerlings will be created. At present, farmers rely on naturally available fry and fingerlings, the supply of which is unreliable and highly seasonal. Procurement of fingerlings from distant hatcheries is not a viable option for smallholder farmers. Dissemination of nursery technology to farmers can help solve the problem of availability of fingerlings and make the local aquaculture self-sustaining. Thus, extension services, technical assistance and training should be made available to the farmers on pond preparation, procuring of stocking materials and poststocking management of both nursery and growout ponds.

CONCLUSION

There is an enormous potential for increasing fish production from the large number of small waterbodies in the study area through the adoption of available low-input aquaculture technologies. The two thanas studied are representative of most thanas in rural Bangladesh. Therefore, these conclusions apply to much of rural Bangladesh.

Table 28. Estimated annual requirement of inputs and production of fish under different culture technologies (per 40 m^2 of water area).

Items	Carp (year-round culture)	Tilapia (6-8 months culture)	Shorputi (6-8 months culture)
Inputs			
A. Pond preparation			
1. Lime (kg)	1.00	1.00	1.00
2. Cowdung (kg)	12.00	4.00	4.00
3. Urea (kg)	0.25	0.10	0.10
4. TSP (kg)	0.25	0.10	0.10
B. Stocking (No.)	25-30	80-85	60-65
C. Poststocking fertilizing			
1. Urea (kg)	1.25	0.75	0.25
2. TSP (kg)	1.25	1.25	0.50
3. Lime (kg)	1.00	0.00	1.00
4. Cowdung(kg)	30.00	20.00	15.00
5. Chicken/duck mannure (kg)	2.50	0.00	0.00
6. Compost (kg)	20.00	0.00	0.00
D. Poststocking feed			
1. Rice/wheat bran (kg)	20.00	60.00	40.00
2. Oil cake (kg)	10.00	0.00	0.00
3. Grass/vegetation (kg)	25.00	0.00	0.00
Expected output (fish) (kg)	15.00	12.00	8.00

Estimate based on available profiles of various proven aquaculture technologies.

The technologies mentioned in the preceding section are flexible in terms of production inputs and management requirements. Moreover, they do not preclude the use of ponds for washing and bathing (the single most important use of ponds other than fish culture at present) to any significant extent. The overwhelming majority of the ponds and ditches are readily available for improved fish culture with a minimum of investment, mostly operating expenses. Availability of water throughout the year does not seem to be a problem in the area, as most ponds are capable of retaining minimum water levels required for year-round fish culture. Moreover, for ponds and ditches that are seasonal in nature, species such as *O. niloticus* and *P. gonionotus* can be raised, the technologies for which are presently available and affordable even by relatively poor and marginal farmers.

Surplus and underutilized on-farm resources and by-products can also be used for feeding and fertilization of small waterbodies. Future research should try to determine the degree to which such resources are presently utilized at the farm level and the extent to which those resources could be profitably harnessed for fish culture purposes. Such research should also investigate whether or not the integration of improved aquaculture practices into the existing farming systems will improve the economic efficiency of resource use at the farm level, so that economic incentives of adoption of aquculture enterprise can be assessed.

Half of the currently available waterbodies (over 70% in terms of total waterbody area) are essentially common property resources because of their multiple ownership and use by the public. They have lagged behind individually owned waterbodies in terms of adoption of aquaculture and levels of production, more efficient future use of such resources for production of food and generation of income should be sought. This will be difficult. One major constraint identified by farmers to adoption of improved fish culture is conflict amongst multiple owners and joint operators. Some early studies (Mahbubullah 1983; Khan 1990) supported the view that joint ownership is an unfavorable factor for increased investment in ponds. Similarly, many of the public waterbodies are subject to conflicting use by the community and held under insecure tenurial arrangements (e.g., leasing and extra-legal occupancy). As long as such situations prevail, the investment potential of these waterbodies will remain poor. Hence, further research will have to address the possibilities for overcoming these problems. New institutional arrangements are needed to retain joint-access without compromising increased productivity.

ACKNOWLEDGEMENTS

This report is an outcome of a survey on small waterbodies (ponds and ditches) undertaken as part of a collaborative project between the International Center for Living Aquatic Resources Management (ICLARM) and the Government of Bangladesh (GOB) entitled "Socioeconomic Impact of Fish Culture Extension Program on the Farming Systems of Bangladesh". The Bangladesh Agricultural Research Council (BARC), the Department of Fisheries (DOF) and the Fisheries Research Institute (FRI) were the three main collaborating agencies of GOB. Financial assistance came from IFAD and DANIDA.

Four field investigators supervised by one senior research officer and two research officers were involved in the data collection. Project extension workers also provided assistance during the data collection. Project senior research officer Mr. Abdur Rab provided substantial assistance to the preparation of the report, while data processing and analyses were done with the assistance of research officers Messrs. Aynul Islam and Mujibur Rahman. The survey work benefitted from the comments and suggestions made on design and methodologies by Dr. M.V. Gupta and Dr. Clive Lightfoot and Ms. Mary Ann P. Bimbao of ICLARM.

REFERENCES

BBS. 1988. The Bangladesh census of agriculture and livestock, 1983-84. Bangladesh Bureau of Statistics, Dhaka.

Chowdhury, A.M., M.A. Mannan, M.A. Hakim, A.J.M. Ahmad, A.T.M.A. Hossain and M.R. Nabi. 1987. Socioeconomic impact of land use conflicts and multiple ownership on the management of fish ponds in Bangladesh. Rural Development Academy, Bogra, Bangladesh.

DOF. 1986. Water area statistics of Bangladesh. Fisheries Information Bulletin. Vol. 3, No. 1. Bangladesh Fisheries Resources Survey System, Department of Fisheries, Dhaka.

Gupta, M.V., M. Ahmed, M.P. Bimbao and C. Lightfoot. 1992. Socioeconomic impact and farmer's assesment of Nile tilapia (*Oreochromis niloticus*) culture in Bangladesh. ICLARM Tech. Rep. 35, 50 p.

Khan, M.S. 1990. Multiple use of ponds, p. 45-51. *In* S. Haque, A.A. Rahman and G.R. Conway (eds.) Environmental aspects of agricultural development in Bangladesh. Bangladesh Center for Advanced Studies, Dhaka, Bangladesh and the International Institute for Environment and Development, London.

Mahbubullah. 1983. Socioeconomic factors affecting the utilization of village ponds for fish culture. BIDS-CDR Research Center, Feni, Noakhali, Bangladesh.

World Bank. 1991. Bangladesh fisheries sector review. Report No. 8830-BD. World Bank.

APPENDIX I
Maps of Study Unions

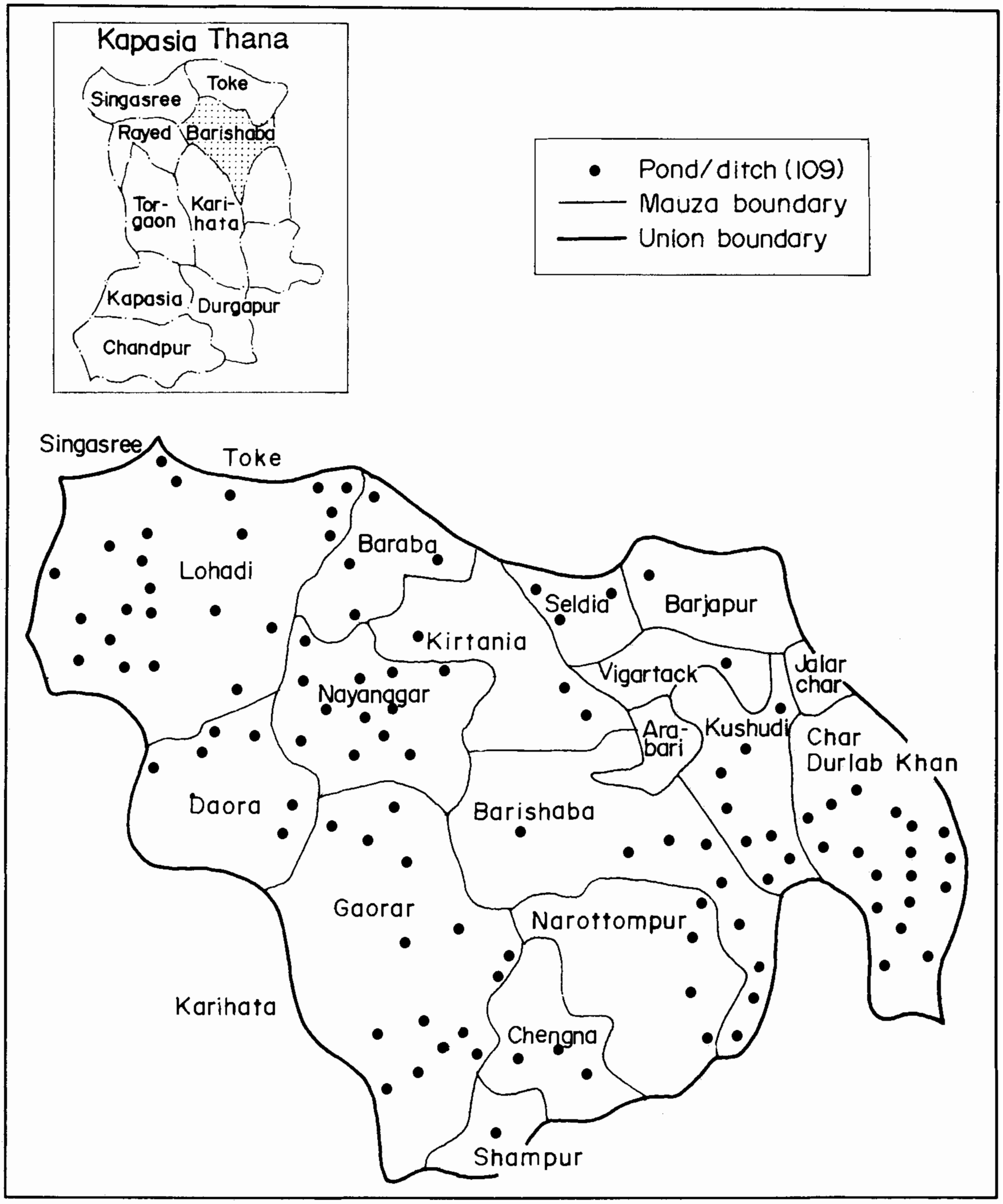


Fig. 1. Map of Barishaba union showing location of ponds/ditches.

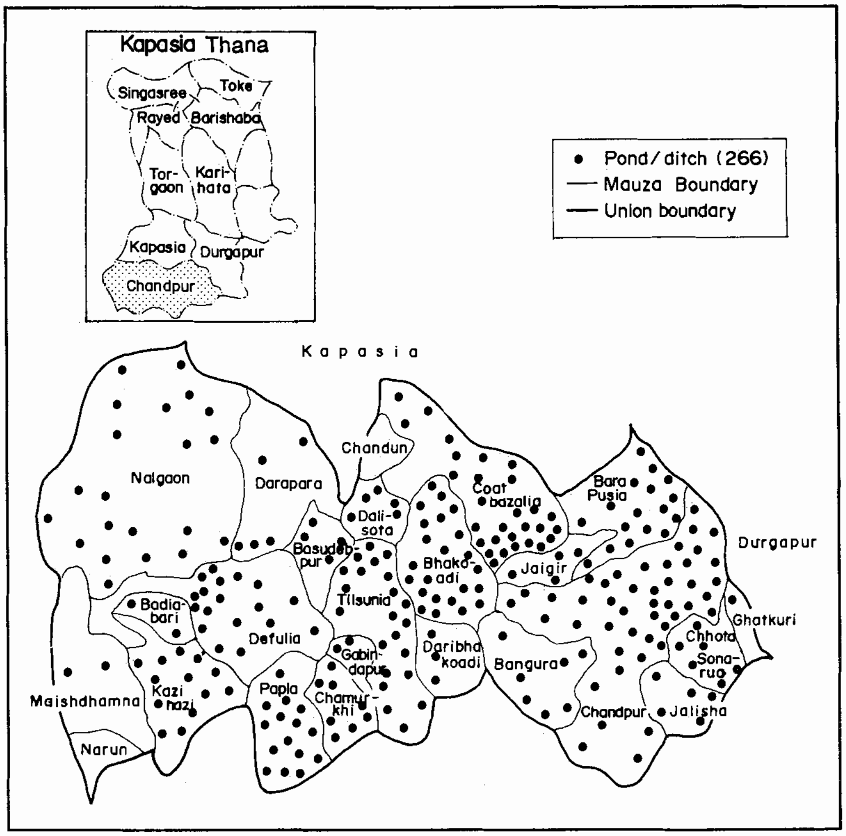


Fig. 2. Map of Chandpur union showing location of ponds/ditches.

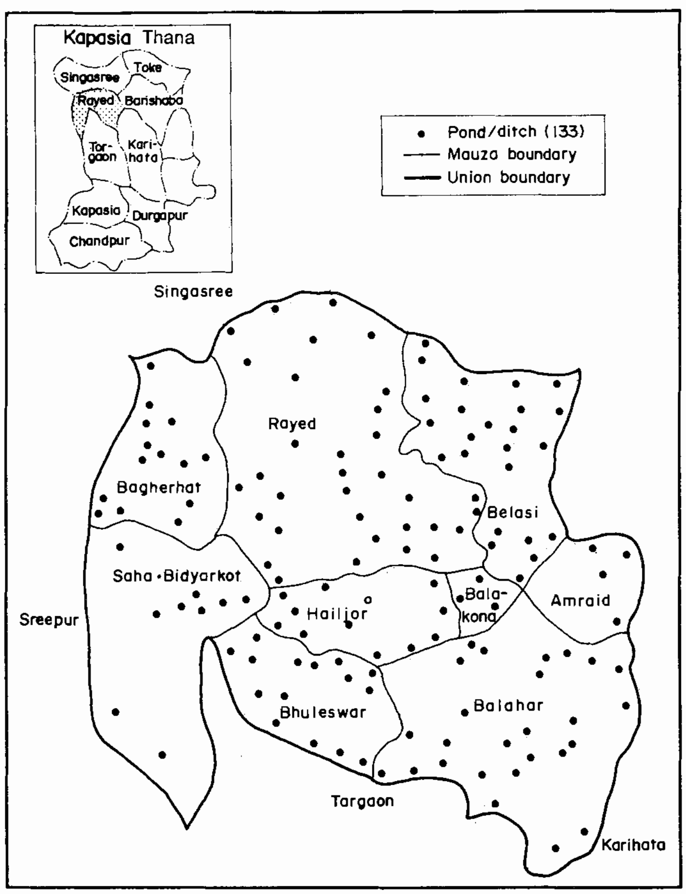


Fig. 3. Map of Rayed union showing location of ponds/ditches.

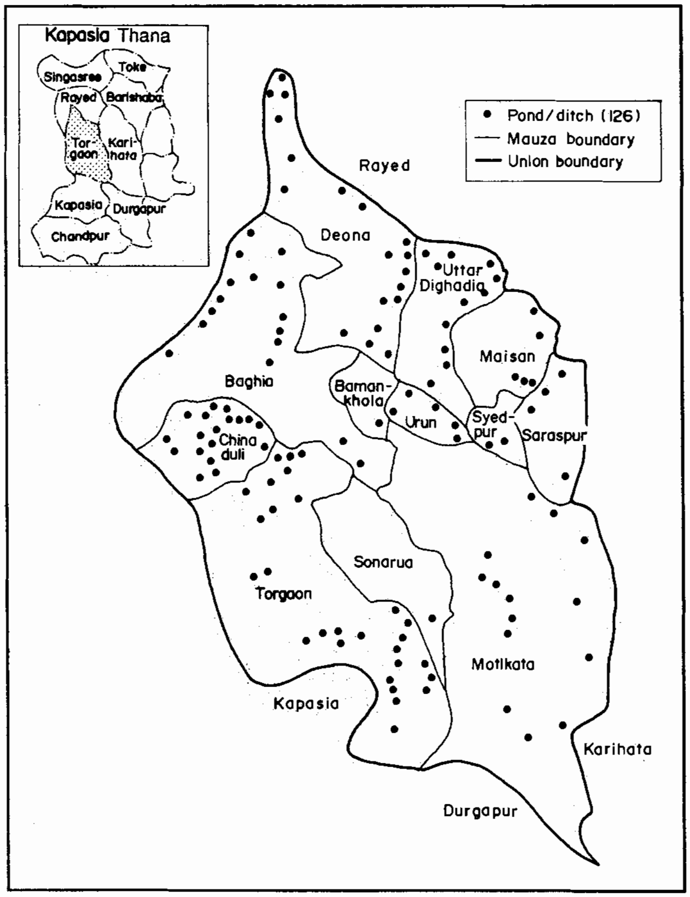


Fig. 4. Map of Torgaon union showing location of ponds/ditches.

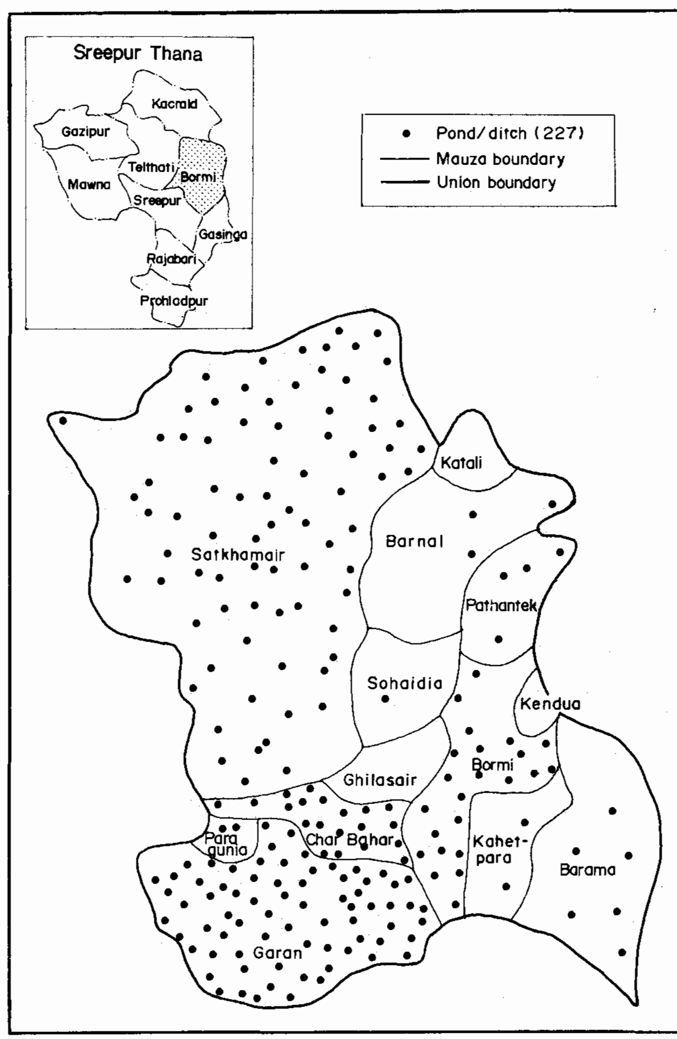


Fig. 5. Map of Bormi union showing location of ponds/ditches.

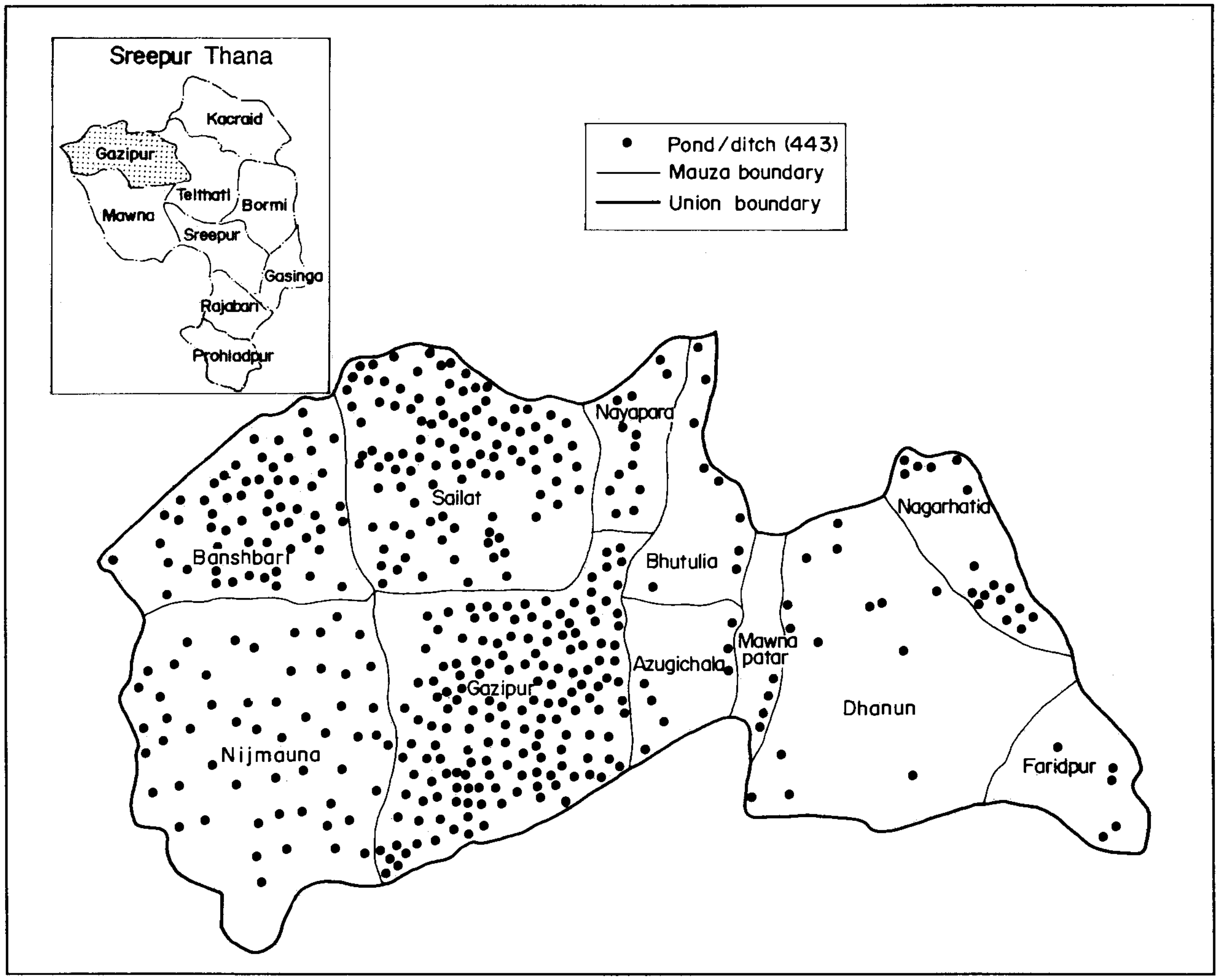


Fig. 6. Map of Gazipur union showing location of ponds/ditches.

APPENDIX II
Small Waterbody Survey Questionaire

Respondent's Identity: Name:________________________________
(To be asked to the person under whose disposal the pond is presently held. In case of multiple operators, ask the dominant/active operator)

Father's/Husband's name ____________________ Para ________________
Village ________________ Union __________________________

1. Pond/Ditch identification number: (Pond-1, Ditch-2) [| | | | |] 1- 6

2. Pond/Ditch property type: [ ] 7

   a) Single owned 1
   b) Jointly owned (2-5 owners) 2
   c) Jointly owned (6-9 owners) 3
   d) Jointly owned (above 10) 4
   e) Institutional 5
   f) Khas (Govt) 6
   g) Others (specify) 7

3. Operator's/Farmer's status [ ] 8

   a) Single owner operator 1
   b) Joint owner operator 2
   c) Single-lease Operator 3
   d) Joint-lease Operator 4
   e) Others (specify) 5

4. Area of the Pond/Ditch (in decimal)

   a) Area including bank (decimal) [| | |] 9 - 12

   b) Area excluding bank (decimal) [| | |] 13- 16

5. Is there at least 3-4 feet water available in the pond/ditch during dry season? (Yes - 1, No - 0) [ ] 17

6. Classification of pond/ditch on the basis of current fish culture status: 18

   a) Only stocking (regular/irregular), without feeding and fertilizing; even harvesting is irregular 1

   b) Irregular stocking with irregular feeding and fertilizing 2

   c) Regular stocking with irregular feeding and fertilizing 3

   d) Package culture (stocking, regular feeding, fertilizing and harvesting, follows scientific pond management) 4

   e) Culturable pond: Pond dikes, pond bottom and depth are in good condition and are readily available for stocking with minimum effort, i.e., cleaning of aquatic vegetation, repairing of partially broken dikes 5

   f) Derelict pond: Ponds that are very shallow and full of aquatic vegetation, decayed dikes and heavy bottom mud can be called derelict ponds. Ponds that can be made available only after undertaking major re-excavation and earthwork and removal of excessive aquatic vegetation 6

   (If the pond/ditch is derelict then ask question No. 9)

7. If the pond/ditch is culturable or cultured what improvement is needed? 19

   a) Only cleaning of aquatic vegetation 1
   b) Only repairing of dikes 2
   c) Both repairing of dikes and cleaning of aquatic vegetation 3
   d) No improvement is needed 4
   e) Others (Specify) 5

8. If the pond/ditch is culturable, what factors are responsible for not culturing fish (Yes-1, No-0)

   a) Lack of adequate water during dry season 20
   b) Extreme turbidity of water 21
   c) Natural harvest is abundant 22
   d) Shareholders are unwilling to invest 23
   e) Risk of theft 24
   f) Lack of availability of fry fingerling and other inputs 25
   g) Lack of adequate cash 26
   h) Others (specify) 27

9. If the pond/ditch is derelict, what reforms will be needed to bring it under cultivation [ ] 28

a) Major earthwork 1
b) Re-excavation (including major earthwork) 2
c) Others (specify) 3

10. Except fish culture, other uses of pond/ditch (Yes-1, No-0)

a) Bathing and washing [ ] 29
b) Drinking [ ] 30
c) Irrigation [ ] 31
d) Jute retting [ ] 32
e) Stocking water hyacinth for animals [ ] 33
f) Others (specify) [ ] 34

11. How much of the following species of fish were harvested during last year (in kg)?

a) Indian major carps (catla, rohu, mrigal)				35- 37
b) Chinese carps (grass carp, silver carp, bighead carp)				38- 40
c) Common carp				41- 43
d) Tilapia				44- 46
e) Shorputi				47- 49
f) Airbreathing fish (mudfish, catfish, climbing perch, etc.)				50- 52
g) Other wild fish (specify)				53- 55

12. What types of species of fish are being cultured in your pond/ditch?

a) Indian major carps (catla, rohu, mrigal) [ ] 56
b) Chinese carps (grass carp, silver carp, bighead carp) [ ] 57
c) Common carp [ ] 58
d) Tilapia [ ] 59
e) Shorputi [ ] 60
f) Airbreathing fish (mudfish, catfish, climbing perch, etc.) [ ] 61
g) Other wild fish (specify) [ ] 62

13. Were the fish of your pond affected by ulcerative fish disease (epizootic ulcerative syndrome) during last two years? (Yes-1, No-0) [ ] 63

14. a) If the pond/ditch is currently under culture, did you receive any extension assistance? (Training, advice, — 64

b) If the answer in (14.a) is yes, what type of assistance did you receive? (Yes-1, No-0)

1) Training — 65
2) Advice — 66
3) Free input support — 67
4) Credit (in kind) — 68
5) Credit (in cash) — 69
6) Others (specify) — 70

15. a) Are you willing to invest capital to culture fish in your pond if necessary extension services are available? (Yes-1, No-0) — 71

b) If the answer in (15.a) is 'No', what is the main reason? — 72

1) Pond/ditch is used for other purposes
2) Unable to invest since lease contract has expired or is about to expire
3) Lack of family member to provide supervision
4) Lack of consensus among the shareholders
5) Lack of capital
6) Others (specify)

Signature of data collector ______________________

Date: ______________________

Signature of verifier ______________________

Date: ______________________

TITLES OF RELATED INTEREST

- **A model to determine benefits obtainable from the management of riverine fisheries of Bangladesh.** M. Ahmed. 1991. ICLARM Tech. Rep. 28, 133 p. US$6 surface; $10 airmail; P135.
- **Socioeconomic impact and farmers' assessment of Nile tilapia *(Oreochromis niloticus)* culture in Bangladesh.** M.V. Gupta, M. Ahmed, M.P. Bimbao and C. Lightfoot. 1992. ICLARM Tech. Rep. 35, 50 p. US$3 surface; $5 airmail; P65.
- **Status and potential of aquaculture in small waterbodies (ponds and ditches) in Bangladesh.** M. Ahmed. 1992. ICLARM Tech. Rep. 37, 36 p. US$2.50 surface; $4.50 airmail; P60.

HOW TO ORDER

Enquirers from the USA should order from our exclusive distributor, the **International Specialized Book Services**, 5804 N.E. Hassalo Street, Portland, Oregon 97213-3644, to whom payment should be directed using the ***airmail*** price. Interested persons in Canada and Central and South America may also find ISBS a convenient source.

Enquirers from Europe may order from **S. Toeche-Mittler GmbH**, Versandbuchhandlung, Hindenburgstrasse 33, D-6100, Federal Republic of Germany, using the ***airmail*** price.

Enquirers elsewhere should address orders and payment (payable to ICLARM) in US$ by international money order, bankdraft or Unesco coupons to: The Editor, ICLARM, MC P.O. Box 2631, 0718 Makati, Metro Manila, Philippines. We can accept US$ checks only if from a US-based bank due to high clearance fees of other banks.

Airmail is strongly recommended due to delays of up to six months and occasional losses experienced with surface mail.