Integration of Aquaculture into the Farming Systems of the Floodprone Ecosystems of Bangladesh: An Evaluation of Adoption and Impact

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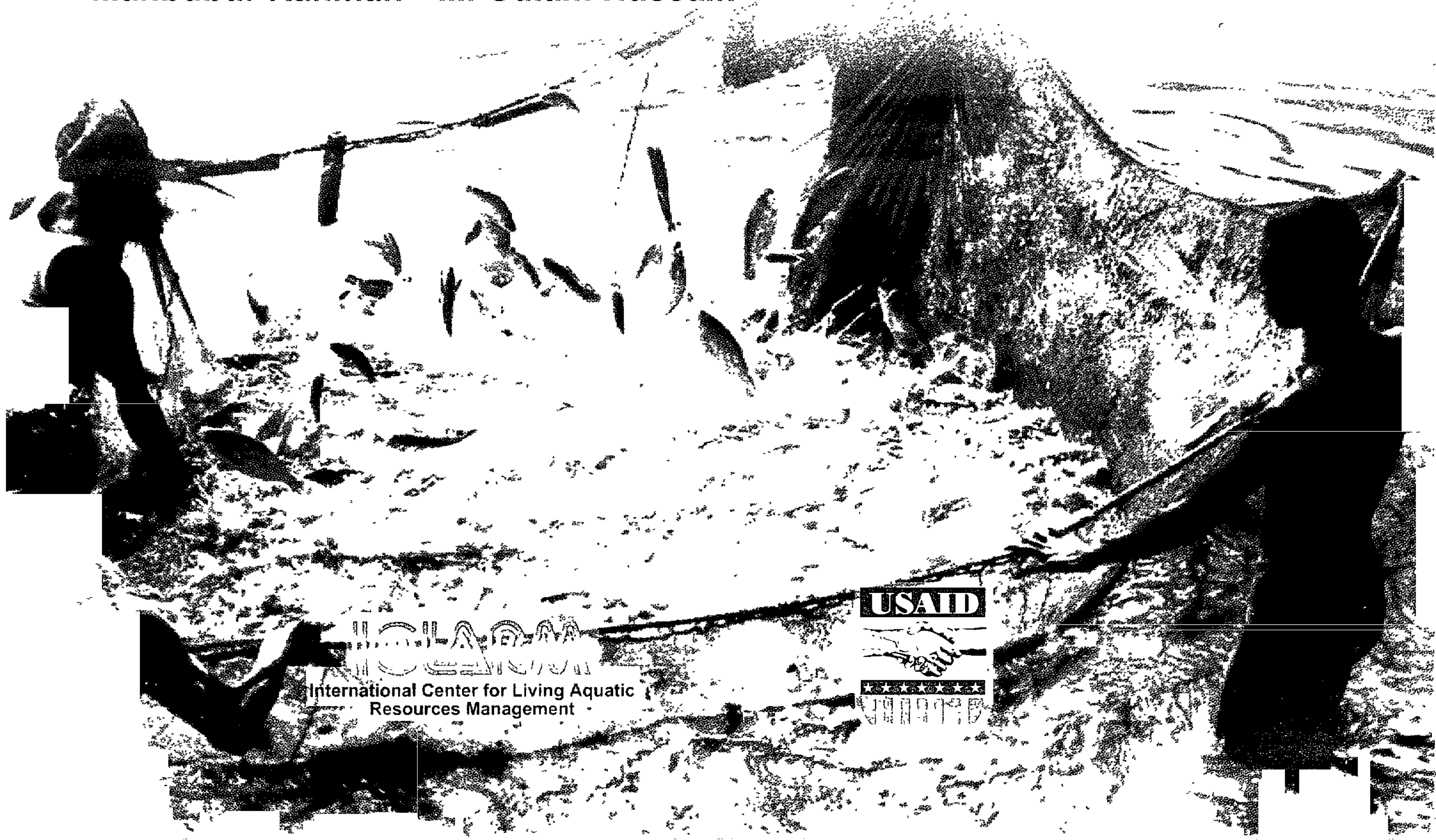

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Modadugu V. Gupta[1]
M. Abdul Mazid[2]
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Mahbubur Rahman[3]
M. Gulam Hussain[2]

[1]International Center for Living Aquatic Resources Management, Makati City, Metro Manila, Philippines
[2]Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh
[3]Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh

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MODADUGU V. GUPTA
M. ABDUL MAZID
MD. SHAHIDUL ISLAM
MAHBUBUR RAHMAN
M. GULAM HUSSAIN

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ICLARM is one of the 16 international research centers of the Consultative Group on International Agricultural Research (CGIAR) that has initiated the public awareness campaign, Future Harvest.

CGIAR

FUTURE HARVEST

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FOREWORD

Fish is an important source of animal protein to rural households in many countries of Asia, providing as much as 30-70% of the total animal protein intake. With the widening gap between the supply and the increasing demand for fish, the world is looking to aquaculture as a means of bridging the gap. The decline in fish production from natural aquatic resources is affecting rural households the most, at times leading to malnutrition in low-income households. One of the solutions to the problem could be the development of sustainable aquaculture practices that can be incorporated into the existing farming systems. This report presents the results of studies undertaken for incorporating low-external input aquaculture practices into the farming systems of a complex floodprone ecosystem in Bangladesh and the impacts of integration on income, nutrition and resource use in rural households. The study has clearly indicated that multi-purpose ponds which were hitherto underutilized or unutilized because of risk of flooding, could be made productive through proper management and incorporation into the existing farming systems. Farmers with minimal external inputs were able to increase fish production and consumption by 5 to 8 times.

Research for developing and promoting improved farming practices should include work to assess the adoption and impact of the results and provide feedback to further research. This assessment can provide information on how the technologies fit into the complex farming systems practiced by the farmers. Properly managed adoption studies can contribute to improving efficiency of research, technology transfer, assessment as to what extent adoption of a technology is constrained by lack of inputs, credit, dissemination of knowledge, etc. and policy formulation. However, adoption studies have received very little attention in the past and this has led to criticism that much of the farming systems research is done by researchers without taking into consideration the needs and perspectives of target farmers. ICLARM gives importance to the assessment of the impact of its research. The present report describes one such study which we conducted with our partners in the Bangladesh Fisheries Research Institute (BFRI), the Bangladesh Agricultural Research Institute (BARI) and farmers in five agroecological regions of Bangladesh.

The results of the impact assessment presented in this report indicated that the technology by itself will not benefit the resource-poor marginal farmers, unless they have access to resources through institutional support (inputs, credit, training, etc.). Otherwise, only the relatively resource-rich farmers will benefit from the technological developments.

Meryl J Williams
Director General
International Center for Living Aquatic
Resources Management

ABSTRACT

Fish plays a vital role in the nutrition of people of Bangladesh accounting for over 57% of animal protein intake. The decline in fish catches from open waters due to increased fishing pressure and other natural causes and human interventions has resulted in declining availability and intake of fish, especially among low-income rural households. The majority of households in rural Bangladesh have multipurpose homestead ponds and ditches, which have the potential for increasing production and availability of fish to rural households. However, the challenge is to develop and adapt low external input aquaculture practices that can be incorporated into the existing farming systems without competing for resources with other farm enterprises.

From 1990 to 1994, the International Center for Living Aquatic Resources Management (ICLARM) in collaboration with the Bangladesh Fisheries Research Institute (BFRI) and the Bangladesh Agriculture Research Institute (BARI) undertook a study in 5 of the 30 agroecological regions of the country, to incorporate aquaculture into the farming systems of Bangladesh. At the end of the study, a survey was carried out at one of the five farming system research sites to: (i) document the socioeconomic profile of farmers owning or operating aquatic resources; (ii) assess the waterbody characteristics and aquaculture status before and after farming systems research intervention; (iii) determine the bioresource use by fish farmers; (iv) quantify economic benefits from incorporation of aquaculture into the farming systems; and (v) assess farmers' perception on incorporating aquaculture into the farming system. The respondents were divided into two categories: (i) research farmers, those who participated in on-farm research and (ii) adopters, those who adopted the aquaculture technologies after seeing the results of research.

Fifty-four percent of the farmers surveyed listed farming as their principal occupation, while for the rest it was secondary. On average, the farmers owned 1.621 ha of land, of which the pond/ditch area constituted 0.116 ha. Over 50% of the ponds were formed as a result of excavation of soil for house building and only 29% of the ponds were excavated specifically for the purpose of fish culture.

Before research intervention, the average annual fish production from ponds in the area was 23.4 kg per pond (292 $kg{\cdot}ha^{-1}$), of which 14.7 kg was consumed by the household and the rest was given away. After research intervention, fish production on average increased to 198.3 kg per pond (2 574 $kg{\cdot}ha^{-1}$) among research farmers and 96.8 kg (1 320 $kg{\cdot}ha^{-1}$) among adopters, in 6-9 months rearing. On average, the households consumed a total of 62 kg of fish produced (excluding fish purchased and caught from wild). The households on average had 6-7 family members which works out to per capita consumption of 9.25 kg per annum which is much higher than national per capita consumption of 7.9 kg.

Operating costs for fish production amounted to Tk 2 971* per pond of 752 m^2, which was about 6% of the gross annual income of the households surveyed. Gross benefit from fish culture in perrenial ponds per farmer on average amounted to Tk 9 590 per pond (Tk 102 862 per ha) in the case of research farmers and Tk 3 869 (Tk 56 059 per ha) in the case of adopters. Before research intervention, contribution of fish culture to farm and household income was 4.6% and 2.8%, respectively, which after research intervention has increased fivefold to 21.5% and 13.5%, respectively.

The impact on resource utilization and effects on other farm enterprises of incorporating aquaculture into the farming system was assessed. The results showed that the farmers were able to divert some of their on-farm resources and labor for aquaculture without affecting other farm enterprises.

Before research intervention, only 13.1% of the ponds in the study area were under traditional fish culture. Demonstration of increased benefits from incorporation of aquaculture into the farming systems has resulted not only in all the ponds in the area coming under aquaculture, but in excavation of new ponds.

* US$1 = Tk39.

The study indicated that the farmers who adopted aquaculture were the economically better off segment of the population with larger landholdings, higher income and literacy, indicating that in addition to technological innovations, an institutional approach is vital if the resource-poor are to benefit from technological advancements.

1. INTRODUCTION

Farming is the main economic activity in Bangladesh, a country with a population of 114 million people. It accounts for 35% of gross domestic product and 68.5% of all employment. About 14 million families are involved in farming, of which 90% are at subsistence or below subsistence level. Small-scale and marginal farmers (with landholding of less than 1 ha) constitute more than 70% of farm households and operate in 29% of land holdings (BBS 1994). About 8.7% households are landless and nearly 50% are near landless (those owning less than 0.2 ha). The majority of farmers depend on their farms for their livelihood. In order to be self-sufficient, these small farms grow a number of crops, thereby integrating various farming activities.

Fish has traditionally been a staple of the Bangladeshi diet. It plays a vital nutritional role especially in the diet of low-income rural households, accounting for about 57% of animal protein intake and 8.7% of total protein intake (BBS 1994). In the past, rural households obtained their fish intake mostly from subsistence fishing in open access aquatic resources. However, with the reduction in fish catches from open waters as a result of increased fishing pressure, and other natural causes and human interventions, the availability and consequently per capita intake of fish has declined especially in rural households. This is resulting in a widening gap in fish consumption between rural and urban households (World Bank 1991).

Although this development is discouraging, the potential for increasing production and availability of fish in rural areas through aquaculture is vast (Khan 1990; Gupta 1992a, b; Ahmed 1992). The majority of rural households in Bangladesh have multi-purpose homestead ponds or ditches. However, the challenge is to develop low-external input aquaculture practices that can be incorporated into the existing farming systems and sustained without competing for resources with other farm enterprises. These technologies could then be transferred to the farming community.

Since 1985, various agricultural research institutions in Bangladesh have been involved in farming systems research to improve productivity and profitability of small farms (Kar et al. 1992). However, all these efforts were concentrated on developing and improving cropping patterns which would be suitable for the different agroecological regions and on determining fertilizer doses needed for different cropping patterns. Very little attention was paid to integrating and improving livestock and fish productivity, which is an integral part of the farming system. As result, in 1990 the Bangladesh Fisheries Research Institute (BFRI), the Bangladesh Agricultural Research Institute (BARI) and the International Center for Living Aquatic Resources Management (ICLARM) jointly initiated a five-year study on incorporating aquaculture into the farming systems of Bangladesh.

The complexity of soil and hydrological conditions are vital environmental characteristics of Bangladesh. Based on physiography, depth and duration of flooding, soil moisture regimes and temperature variation, the country has been divided into 30 agroecological regions (Brammer et al. 1988). In view of these wide variations, studies were undertaken between 1990-1994 in 5 of the 30 agroecological regions of the country on incorporating aquaculture into the existing farming systems.

Bangladeshi farmers have used on-farm and off-farm resources according to traditional patterns, but with the advent and adoption of aquaculture into farming systems, the resource use pattern might change. The result could be increased farm productivity and resource use efficiency, but other production systems/activities could also be affected. Subsequent to the abovementioned study, a survey was undertaken at one of these five farming systems research sites located in Kalihati thana (Sub-district) of Tangail district (Fig. 1) with the following specific objectives: (i) to document the socioeconomic profile of farmers owning or operating aquatic resources (ponds/ditches) in the flood-

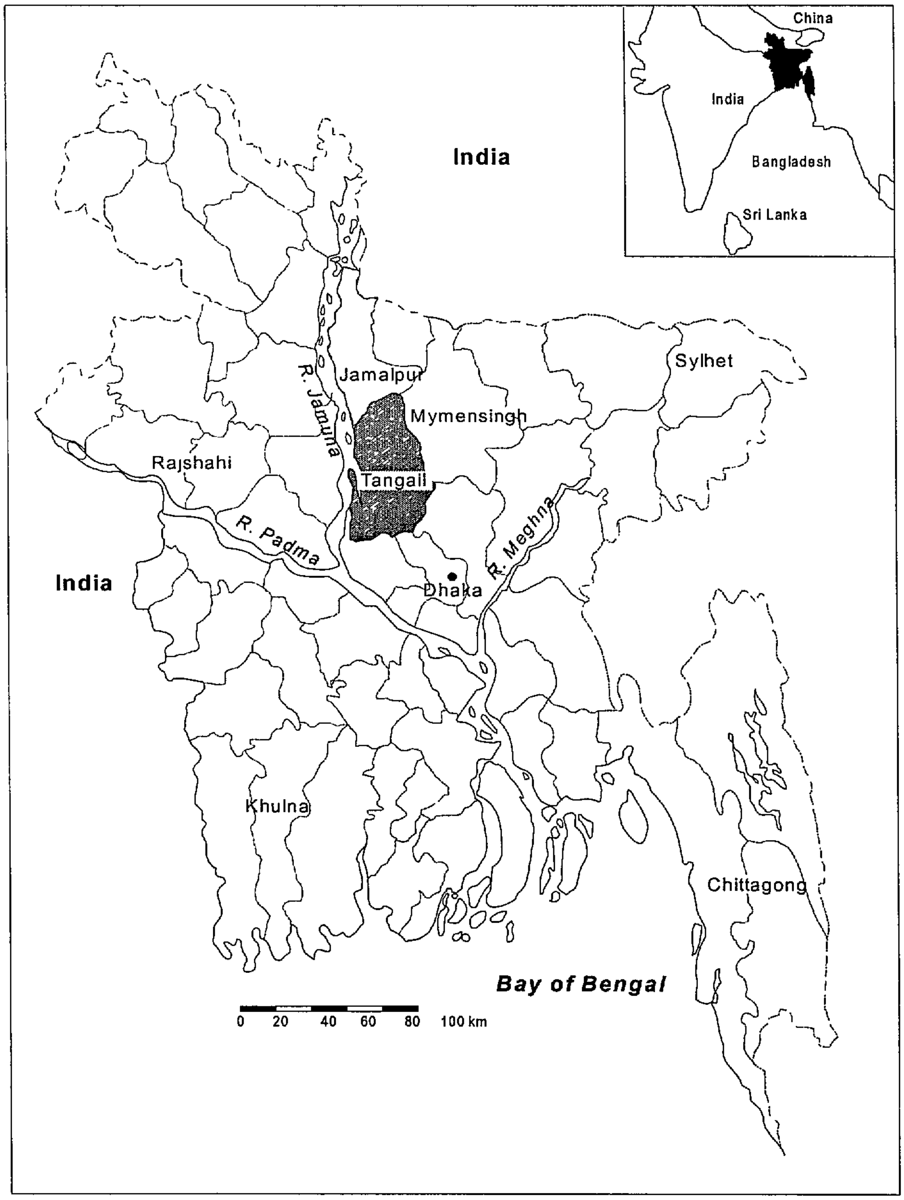

Fig. 1. Map of Bangladesh indicating study area.

plain of the Tangail area; (ii) to assess the waterbody characteristics and aquaculture status on the basis of before and after farming systems research intervention; (iii) to determine the bioresource use pattern of fish farmers before and after research intervention; (iv) to quantify the economic benefits from incorporation of aquaculture into the farming system; and (v) to assess farmers' perception on incorporating aquaculture into their farming system. This report presents the results of the study.

The study area lies between 23°58' and 24°48' north latitude and between 89°45' and 90°15' east longitude and consists of the five villages of Palima, Naga, Tatihara, Tarabari and Charnagarbari of Nandia union parishad of Tangail district. The average annual rainfall in the area is 160 to 180 cm and the average minimum and maximum ambient temperatures range from 12.5°C and 33.6°C, respectively. Topographically the area is composed of 9% high land, 47% medium high land, 34% medium low land and 9% low land. The major crops grown in the area are rice, wheat, mustard, chili peppers, lentils and vegetables. According to the 1986 census, the project site consisted of 854 households, with a total population of 4 624. Since the area is floodprone, houses are built on elevated ground using soil from surrounding areas.

2. RESEARCH METHODOLOGY

2.1. Sample selection

An initial survey of all the ponds in the study area was carried out to determine the owner/operator households and the status of fish farming. Based on this information, respondent households were selected for a detailed survey using stratified random sampling techniques. The households were divided into two categories: "research farmers", those who participated in the farming systems research, and "adopters", those who had ponds/ditches on their farms but were not undertaking fish culture or involved in farming systems research but became adopters after seeing the results of research. A total of 61 farmers (31 research farmers and 30 adopting farmers) were covered in this detailed survey.

2.2. Data collection

A structured questionnaire was used for collection of data on profiles of respondents, physical condition of the waterbodies, tenure and fish culture status, input use pattern for fish production, economics and problems/constraints for aquaculture adoption (Annex). The questionnaire was pretested in the field and necessary changes were made before the survey of all farmers was undertaken.

The data presented (except Tables 3.7 and 5.3) refer to the fish culture period of July 1993 to June 1994. Household income data presented in Table 3.7 and fish production and disposal information in Table 5.3 refer to the baseline data collected in 1990 prior to research intervention.

2.3. Data analysis

Ponds were used as the unit of analysis. This was done in preference over using the hectare as a unit to reflect the actual inputs and outputs that could be easily compared with household resources. Descriptive statistics such as frequency distributions, means, percentages and standard deviations were used to analyze the data. Data were analyzed using SPSS/PC+ program.

3. PROFILE OF RESPONDENTS

The socioeconomic and educational levels of the respondent farmers were studied since they influence the acceptance and adoption of a new technology. All respondents were male and head of households. This does not necessarily indicate that women do not have a role in fish farming. In fact, the women are primarily responsible for feeding the fish and fertilizing ponds since the ponds are generally located near the homestead.

3.1. Household size and age of respondents

The family size of households surveyed was on average 6.72 persons compared to the average family size of 5.3 persons in the overall study area (BBS 1994). The ratio of male members to female members in households was 1:0.85. There were no significant differences among research farmers and adopters in terms of family size or gender (Table 3.1).

Table 3.1. Family size and gender of households in the study area. Figures in parentheses are standard deviations.

Gender	Family size		
	Research farmers	Adopters	All
(n=31)	(n=30)	(n=61)	
Male	3.94	3.33	3.64
	(1.93)	(1.64)	(1.81)
Female	3.06	3.10	3.08
	(2.02)	(1.80)	(1.90)
All	7.00	6.43	6.72
	(3.65)	(3.00)	(3.33)

The majority (39.3%) of farmers surveyed were in the age group of 31-45 years (Table 3.2). Farmers in the age group of 46-60 years constituted 26.2% followed by those in the age group under 30 years (23.0%). Those above 60 years constituted only 11.5%. The trend among research farmers and adopters was more or less the same.

3.2. Literacy

The literacy rate among respondents (head of male family members) was generally high (88.5%) compared to the average rate in the study area (41.7%) (BBS 1994). Over 49% of the farmers had education up to secondary or higher secondary level (Table 3.3). Thirty-six percent had primary education and only 11.5% were illiterate. The literacy rate among research farmers was higher compared to the adopters. While 64.5% of the research farmers had secondary or higher secondary education, only 33.3% of adopters had the same level of education.

3.3. Occupation

Fifty-four percent of the respondents named farming as their principal occupation while for the rest it was the secondary occupation. Over 19% were involved in small trading. Service in offices accounted for 14.8% of the respondents. Some were involved in farm labor (1.6%), rickshaw pulling (1.6%) and other activities (8.2%). Thirty-six percent did not have any secondary occupation, while 16.4% were involved in small trading (Table 3.4).

Table 3.2. Age distribution of respondents.

Age group	Research farmers (n=31)		Adopters (n=30)		All (n=61)	
(years)	No.	%	No.	%	No.	%
<30	8	25.8	6	20.0	14	23.0
31-45	12	38.7	12	40.0	24	39.34
46-60	8	25.8	8	26.66	16	26.23
>60	3	9.67	4	13.33	7	11.48
Total	31	100.00	30	100.00	61	100.00

Table 3.3. Educational status of respondents.

Education level	Research farmers (n=31) No.	%	Adopters (n=30) No.	%	All (n=61) No.	%
Illiterate	2	6.5	5	16.7	7	11.5
Can read	-	-	2	6.7	2	3.3
Primary	9	30.0	13	43.3	22	36.1
Secondary	11	35.5	8	26.7	19	31.2
Higher secondary	9	29.0	2	6.7	11	18.0

Table 3.4. Occupational status of respondents.

Occupation	Research farmers (n=31) No.	%	Adopters (n=30) No.	%	All (n=61) No.	%
Principal						
Farmer	15	48.4	18	60.0	33	54.1
Farm laborer	1	3.2	-	-	1	1.6
Service	7	22.6	2	6.7	9	14.8
Small trader	4	12.9	8	26.7	12	19.4
Rickshaw driving	-	-	1	3.3	1	1.6
Others	4	12.9	1	3.3	5	8.2
Secondary						
No occupation	10	32.3	12	40	22	36.1
Farmer	14	45.2	14	36.7	28	45.9
Farm laborer	1	3.2	-	-	1	1.6
Service	-	-	1	3.3	1	1.6
Small trader	5	16.1	5	16.7	10	16.4
Others	1	3.2	1	3.3	2	3.3

3.4. Landholding and ownership

On average, the respondents owned 1.621 ha of land, of which 1.360 ha was cultivated land, 0.034 ha orchard/forest land, 0.035 ha fallow land, 0.076 ha pond area and 0.116 ha homestead (Table 3.5). There was not much difference in landholding between research farmers and adopters, except that the homestead area of the research farmers was larger than that of adopters. Both the categories of farmers had larger landholdings than the average landholdings in the area. Average net cultivated land area was 1.017 and 1.269 ha among research farmers and adopters, respectively (Table 3.6).

3.5. Household income

The 57 households surveyed before research intervention had an average annual average income of Tk 27 374*. Of this, 60.3% (Tk 16 506) was from on-farm sources and the rest (Tk 10 868) was from off-farm sources (Table 3.7). Of the income from on-farm sources, 70.8% was from cereals, 11.0% from cash crops, 3.2% from vegetables, 2.2% from fruit, 1.0% from forest products (such as bamboo and firewood), 7.1% from livestock and poultry and 4.6% from fish. Off-farm sources of income included service (54.5%), small trading (26.2%), rickshaw pulling (8.9%), handicrafts (6.2%) and wage labor (2.1%).

Table 3.5. Landholding by type of farmer. Figures in parentheses are standard deviations.

Type of land	Average land (ha) Research farmers (n=31)	Adopters (n=29)	All (n=60)
Total	1.613	1.631	1.621
Homestead	0.147	0.083	0.116
	(0.098)	(0.113)	(0.106)
Cultivated	1.336	1.385	1.360
	(1.463)	(1.487)	(1.465)
Orchard/forest	0.034	0.034	0.034
	(0.063)	(0.076)	(0.069)
Fallow	0.018	0.054	0.035
	(0.047)	(0.152)	(0.112)
Pond/ditch	0.078	0.075	0.076
	(0.037)	(0.042)	(0.040)

Table 3.6. Details of area cultivated by farmers. Figures in parentheses are standard deviations.

Type of land	Average land (ha) Research farmers (n=31)	Adopters (n=29)	All (n=60)
Net cultivated	1.017	1.269	1.139
	(1.139)	(1.014)	(1.079)
Shared/leased in	0.116	0.103	0.110
	(0.239)	(0.229)	(0.232)
Shared/leased out	0.502	0.202	0.357
	(1.073)	(0.643)	(0.897)
Mortgaged in	0.084	0.063	0.074
	(0.174)	(0.175)	(0.173)
Mortgaged out	0.018	0.070	0.043
	(0.07)	(0.299)	(0.214)

* US$1= Tk39.

Table 3.7. Annual household income (Tk) of respondents before research intervention. Figures in parentheses are standard deviations.

Income source	n=57
Farm income	16 505.53
	(17 454.47)
Cereals	11 694.74
	(13 032.18)
Cash crops	1 819.30
	(3 225.43)
Vegetables	529.82
	(1 923.44)
Fruit	366.67
	(1 693.19)
Forest products	157.89
	(936.17)
Livestock	1 178.95
	(1 559.96)
Fish	758.16
	(1 381.67)
Nonfarm income	10 868.42
	(15 725.20)
Wage labor	229.82
	(9 960)
Small trading/business	2 850.88
	(6 191.85)
Service	5 922.81
	(14 469.22)
Rickshaw driving	964.91
	(7 284.93)
Bamboo and cane works	671.93
	(1 898.51)
Driving	70.18
	(829.81)
Others	157.89
	(1 026.00)
Total income	27 373.95
	(25 871.18)

4. CHARACTERISTICS OF THE PONDS

4.1 Physical characteristics

The average size of the waterbodies (perennial ponds and seasonal ditches) was 0.076 ha (Table 4.1). The average depth of water during the dry season was 0.5 m and the water retention to a depth of at least 0.9 m (the minimum needed for survival and growth of fish) was for 7.93 months. During the dry season, the pond area decreased by nearly 37%, which indicates that fish culture may not be possible on a year-round basis in many of the waterbodies. More than 55% of the waterbodies were in good condition, while the rest had broken dikes. A baseline survey undertaken in 1990 before research intervention indicated that all the ponds covered by the survey were floodprone. While some of these ponds/ditches flooded every year, others only flooded during years of unusual high rainfall, which was why the majority of farmers did not invest in the maintenance of embankments or decide to take up fish farming.

4.2. Pond ownership and operator type

Of the total number of ponds and ditches in the project area, 51.7% were under single ownership, 42.5% were under joint ownership of 2-5 persons, and 5.7% were under 6-9 owners (Table 4.2). Most of the waterbodies were owner operated: 50.6% by a single owner and 43.7% by joint owners (Table 4.2)

4.3. Types, condition and purpose of excavation

Of all the ponds and ditches in the study area, about 85% were excavated ponds and the rest were roadside ditches. Of those excavated, 50.8% were to generate soil for house building, 29.5% for fish culture and 3.3% only for bathing and washing. The rest (14.8%) were soil pits for road construction (Table 4.3). Over 82% of the ponds were used for bathing and washing and the rest for jute retting.

Table 4.1. Physical characteristics of the waterbodies. Figures in parentheses are standard deviations.

Item	Research farmers (n=31)	Adopters (n=30)	All (n=61)
Water area (ha)			
during wet season	0.078	0.074	0.076
	(0.037)	(0.042)	(0.039)
during dry season	0.048	0.048	0.048
	(0.034)	(0.035)	(0.034)
Depth of water in dry season (m)	0.52	0.59	0.55
	(0.26)	(0.36)	(0.31)
No. of months water retained	7.742	8.133	7.93
(depth of > 0.9 m)	(1.154)	(2.08)	(1.67)
Condition of the waterbody (multiple responses)			
broken dikes	11	16	27
	(35.49)	(53.33)	(44.26)
good condition	20	4	34
	(64.51)	(46.67)	(55.74)

Table 4.2. Ownership of waterbodies and operator type.

	Percentage
Ownership type	
Single	51.7
Joint (2-5 households)	42.5
Joint (6-9 households)	5.7
Operator type	
Single owner operator	50.6
Joint owner operator	43.7
Single lease operator	-
Joint lease operator	1.1
Others	4.6

Table 4.3. Types of waterbodies, purpose of excavation and other uses of ponds/ditches.

	Percentage
Waterbody type	
Excavated	85.2
Roadside ditch	14.8
Purpose of excavation	
Fish culture	29.5
House construction	50.8
Bathing/washing	3.3
Road construction	14.8
Others	1.6
Other uses of waterbody	
Bathing and washing	82.8
Jute retting and others	14.9

5. STATUS OF AQUACULTURE BEFORE RESEARCH INTERVENTION

5.1. Management of waterbodies

The study area is situated in a floodplain with a high risk of flooding. Before research intervention, only 13.1% of the ponds were being used for traditional fish culture. The reasons for not culturing fish in the remaining waterbodies are given in Table 5.1. The two main reasons named by the majority of farmers were the lack of knowledge and nonavailability of fingerlings and inputs.

Traditional fish culture practiced by some farmers included stocking of fingerlings and irregular feeding and fertilization. The survey revealed that the farmers stocked only Indian carps in their ponds. Very few farmers fertilized their ponds: cattle manure was used by two farmers, inorganic fertilizers and chicken manure by one farmer each (Table 5.2). On the other hand, rice bran, oil cake and duck weed were used as supplementary feed by one farmer each.

Table 5.1. Reasons for not culturing fish.

	Number (n=87)	Percentage
Lack of water	13	16.67
Turbidity of water	2	2.56
Natural harvest is abundant	2	2.56
Shareholder's unwillingness to invest	22	28.21
Risk of theft	2	2.56
Non-availability of fingerlings and inputs	83	95.40
Non-availability of cash	1	1.15
Lack of knowledge	69	79.31
Others	18	20.69

Table 5.2. Fertilizer and supplementary feed use in ponds before research intervention. Percentages are in parentheses.

	Research farmers (n=31)	Adopter (n=30)	All (n=61)
Fertilizer			
Cattle manure	2 (6.45)	-	2 (3.28)
Inorganic fertilizers	1 (3.23)	-	1 (1.64)
Chicken manure	1 (3.23)	-	1 (1.64)
Supplementary feed			
Rice bran	1 (3.23)	-	1 (1.64)
Duck weed	1 (3.23)	-	1 (1.64)
Oil cake	1 (3.23)	-	1 (1.64)

5.2. Fish production and utilization pattern

Before research intervention, farmers on an average were producing fish at a rate of 292 kg·ha^{-1} through traditional fish culture practices, of which about 50% were wild fish (naturally occurring fish species which might have entered into ponds along with flood waters) and the rest were cultured fish. The major portion of fish (65.3%) was used for household consumption, 19.3% of fish was sold for cash and the rest was given away or used to pay for professional fish harvesters (Table 5.3). This information is based on the baseline survey of farm households undertaken in 1990 before research was initiated. Fish production and utilization vary across different parts of the country. Ahmed et al. (1993) reported fish production from traditionally stocked ponds of between 455 and 618 kg·ha^{-1} in some areas of Gazipur district.

Table 5.3. Fish production (kg·ha^{-1}) and disposal pattern during the year preceding research intervention. Standard deviations are in parentheses.

Production/disposal	kg·ha^{-1} (n=61)
Production	
Cultured fish	146.06 (399.13)
Wild fish	145.73 (222.77)
Total	291.79 (474.61)
Disposal	
Home consumption	190.65 (276.13)
Sold	55.06 (267.75)
Given away	46.08 (144.60)

6. RESEARCH INTERVENTION AND IMPACT

6.1. Technology profile

The researchers, with the participation of farmers, introduced aquaculture practices that could be suitable for the ecosystem, taking into consideration the agroecosystem, farmers' resources, their preferences and the results of on-station and on-farm research (Ahmed et al. 1995, 1996; Gupta 1992a,b; Gupta and Akhteruzamman 1992; Gupta and Rab 1994; Gupta et al. 1992, 1996; Lightfoot et al. 1992). The waterbodies were divided into two categories: (i) perennial ponds which retain water for more than seven months (at a minimum depth of 0.9 m) in a year and (ii) seasonal ponds and ditches which hold water for less than seven months. For the perennial ponds, management practices developed included the culture of six species of Indian and Chinese carps: catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). For the seasonal ponds, the culture of Nile tilapia (*Oreochromis niloticus*) and silver barb (*Barbodes gonionotus*) were initially taken up for monoculture, but subsequent experimentation indicated that polyculture of *O. niloticus* and/or *B. gonionotus* with other carps could give a higher yield than monoculture of either species (Gupta and Rab 1994). The stocking of fingerlings was followed by supplementary feeding of fish with rice bran, duckweed, terrestrial grasses and fertilization of ponds with cattle manure, compost and inorganic fertilizers: urea and triple super phosphate (TSP).

6.2. Farmers' adoption of aquaculture practices

6.2.1. COMPOSITION AND STOCKING DENSITY OF FINGERLINGS

The research farmers in the study area were initially advised by researchers on stocking densities and species of fingerlings to be stocked based on the results of on-station studies. Adopters stocked fingerlings on their own. The suggested stocking density of perennial ponds was 6 000 fingerlings per ha, while in the case of seasonal ponds it was 16 000 per ha. The general tendency among farmers had been to stock both types of ponds at higher densities (Table 6.1). In perennial ponds, the research farmers on an average stocked 17 208 fingerlings per ha, while the adopters stocked 63 485 per ha. Similarly, in the seasonal ponds, the research farmers on average stocked 19 125 fingerlings per ha compared to 61 530 per ha by the adopters.

These higher stocking densities showed that farmers generally believed that higher fish production could be obtained by stocking larger number of fingerlings. Even the research farmers in a majority of cases stocked higher number and more species of fingerlings than was suggested. Overstocking of ponds was also found to be a common tendency among the fish farmers in other parts of the country (Ahmed et al. 1993; Gupta and Rab 1994). One of the reasons for this high stocking density is that fingerling vendors go from house to house in villages and convince farmers to stock more fingerlings. The fingerlings are often small and are sold by weight rather than by number with the result that the farmers do not know how many fingerlings they are stocking.

When farmers stocked by weight, the number of fingerlings stocked was calculated for this study from the average size of fry/fingerlings stocked as indicated by the farmer. Farmers stocked *C. catla*, *L. rohita*, *C. mrigala*, *H. molitrix*, *C. idella* and *C. carpio* in perennial ponds as was suggested by researchers, but *C. catla*, *L. rohita*, *B. gonionotus*, *O. niloticus*, *H. molitrix* and *C. carpio* were stocked in seasonal ponds (Table 6.1). Some of the farmers, both research farmers and adopters, could not stock *B. gonionotus* and *O. niloticus* as these two species were new introductions in the study area and fingerlings were not easily available to all farmers. The most densely stocked species were *L. rohita*, *H. molitrix*, *C. carpio* and *C. mrigala* because of the greater availability of fingerlings of these species from vendors.

Table 6.1. Species stocked and stocking densities (no. per ha). Ranges are in parentheses.

Species	Research farmers (n=28)		Adopters (n=30)	
	Perennial ponds (n=13)	Seasonal ponds (n=15)	Perennial ponds (n=19)	Seasonal ponds (n=11)
C. catla	2 035	1 585	7 703	11 516
	(1 048-4 446)	(0-4 446)	(0-35 286)	(3 293-41 167)
L. rohita	4 964	3 746	17 822	16 330
	(2 964-8 469)	(0-9 263)	(0-70 571)	(0-41 167)
C. mrigala	693	-	7 547	6 670
	(0-4 560)		(0-41 167)	(0-16 467)
H. molitrix	4 461	2 802	5 977	16 055
	(988-8 469)	(0-9 263)	(0-49 400)	(0-123 500)
C. carpio	3 675	4 076	21 725	8 233
	(741-7 057)	(0-10 978)	(0-172 900)	(0-17 643)
C. idella	712	599	549	2 419
	(0-1 411)	(0-1 544)	(0-8 233)	(0-8 233)
B. gonionotus	668	4 561	65	-
	(0-3 529)	(0-18 525)	(0-1 235)	
O. niloticus	-	1 756	797	307
		(0-16 467)	(0-8 233)	(0-3 293)
Others	-	-	1 300	-
			(0-24 700)	
Total	17 208	19 125	63 485	61 530
	(10 479-31 757)	(11 424-28 714)	(18 772-179 075)	(1 235-20 789)

6.2.2. SOURCES OF FINGERLING SUPPLY

About 95% of the farmers bought their fingerlings from travelling vendors. Only 5% of farmers procured fingerlings from government farms. The study area is located 15 km from the Jamuna river, which is a natural fish seed collection center. Vendors procure fingerlings from river collection centers and sell to the villagers in the study area (Table 6.2). There are no private hatcheries in the area and the only government hatchery is 30 km from the study area.

6.2.3. INPUT USE

Input use during pond preparation was higher among research farmers than among adopters. Lime was used during pond preparation by all research farmers but only one adopter used lime and then only a small quantity. Urea, triple super phosphate (TSP), cattle manure and poultry droppings were used as fertilizers both during pond preparation and the post stocking period. Rice bran, oil cake and duckweed were used as supplementary feeds. Cattle manure was used in pond preparation by 86% of research farmers, while it was used by only 10% of adopters. Urea and TSP were used by 96.4% of the research farmers, but not by any adopters (Table 6.3).

Details of inputs (feeds and fertilizers) used by farmers during fish rearing are presented in Table 6.4. On average, farmers used 371 kg cattle manure, 16 kg poultry droppings, 5 kg urea and 8 kg TSP as fertilizers for the average sized pond measuring 752 m^2. Rice bran, oil cake, wheat bran and duckweed were used as supplementary feeds and their use amounted to 380 kg, 8 kg, 32 kg and 178 kg per pond, respectively.

Overall input use was much lower among adopters especially purchased inputs. Adopters used only 22.9% of the cattle manure used by the research farmers. Research farmers had to purchase 8.6% of the cattle manure used while adopters did not purchase any. Rice bran use as supplementary feed was almost three times higher among research farmers than by adopters. While 40.5% of all rice bran used among research farmers was purchased, only 37% of adopters had to buy. The use of purchased feeds (oil cake and wheat bran) was much lower, only 15 and 67 kg per pond, respectively (194 and 867 kg·ha^{-1}) among research farmers and 1 kg and none per pond, respectively (14 kg·ha^{-1} and none) among adopters (Table 6.4). Poultry droppings, 94% of which were from on-farm sources, were used by research farmers, while none of the

Table 6.2. Sources of fingerlings supply.

Sources	Research farmers (n=30)		Adopters (n=31)		All (n=61)	
	No.	%	No.	%	No.	%
Purchased from vendors	28	90.32	30	100	58	95.08
Purchased from govt. farms	3	9.68	-	-	3	4.92

Table 6.3. Use of inputs (for actual pond size) during pond preparation by the farmers. Standard deviations are in parentheses.

Inputs	Research farmers (n=28) Pond size=772.86 m²		Adopters (n=30) Pond size=733.33 m²		All (n=58) Pond size=752.41 m²	
	Quantity	No. of user(s)	Quantity	No. of user(s)	Quantity	No. of user(s)
Own source						
Labor (day)	2.89	28	2.83	6	2.88	34
	(0.96)	(0.41)		(0.88)		
Cattle manure (kg)	20.46	24	82.33	3	27.33	27
	(33.23)	(28.01)	(37.81)			
Purchased						
Lime (kg)	9.82	28	3.00	1	9.57	29
	(5.98)			(6.01)		
Urea (kg)	1.36	27	-		1.36	27
	(0.58)			(0.58)		
TSP (kg)	2.70	27	-		2.70	27
	(1.19)			(1.19)		

Table 6.4. Fertilizers and supplementary feeds used for fish production (kg per pond). Standard deviations are in parentheses.

	Research farmers (n=28) Pond size =772.86 m²			Adopters (n=30) Pond size=733.33 m²			All (n=58) Pond size=752.41 m²		
	Own	Purchased	Total	Own	Purchased	Total	Own	Purchased	Total
Cattle manure	563	53	616	141	-	141	345	26	371
	(667)	(129)	(653)	(237)		(237)	(534)	(93)	(537)
Rice bran	343	233	575	126	74	200	230	150	380
	(242)	(394)	(481)	(141)	(203)	(290)	(223)	(317)	(434)
Oil cake	-	15	15	-	1	1	-	8	8
		(57)	(57)		(4)	(4)		(40)	(40)
Wheat bran	-	67	67	-	-	-	-	32	32
		(291)	(291)					(203)	(203)
Poultry droppings	31	2	33	-	-	-	15	1	16
	(51)	(7)	(53)				(38)	(5)	(40)
Duck weed	229	-	229	128	1	129	177	1	178
	(283)		(283)	(183)	(4)	(182)	(240)	(3)	(239)
Lime	-	4	4	-	3	3	-	4	4
		(3)	(3)		(5)	(5)		(4)	(4)
Urea	-	9	9	-	1	1	-	5	5
		(9)	(9)		(2)	(2)		(7)	(7)
TSP	-	15	15	-	2	2	-	8	8
		(9)	(9)		(3)	(3)		(9)	(9)

adopters used them. Duckweed collected from nearby rice fields and derelict waterbodies was used for feeding fish by both research farmers and adopters. Use of purchased inputs such as lime, urea and TSP was considerably lower among adopters.

An analysis of input use in perennial and seasonal ponds indicates that use of purchased and on-farm inputs, except for wheat bran and lime, was significantly higher in seasonal ponds than in perennial ponds among both categories of farmers (Table 6.5 and 6.6). Normally, it is to be expected that due to their larger size, input use in perennial ponds would be higher, but this was not the case in the present study. A probable reason could be that farmers do not apply inputs according to the size of their ponds but according to availability. The seasonal ponds are smaller (598 m²) than perennial ponds (877 m²) and hence received higher inputs on per ha basis. Also, there was not much of difference in length of rearing period among perennial and seasonal ponds, as the majority of ponds were harvested in February and March.

6.2.4. HARVESTING TIME AND METHODS

Fish were harvested between January and June but 85% of the ponds were harvested during February and March, when the ponds were usually dry and water depth lower, making it risky for the farmers to keep the fish in shallow water (Table 6.7). Netting was the primary method of harvesting (Table 6.7). Only one adopter reported catching fish by angling, mostly for home consumption. Professional fishers came with seine nets and were paid for their services either by cash or in kind with a portion of the harvested fish.

Table 6.5. Fertilizers and supplementary feeds applied in perennial ponds (kg·ha^{-1}). Standard deviations are in parentheses.

	Research farmers (n=13)			Adopters (n=19)			All (n=32)		
	Own	Purchased	Total	Own	Purchased	Total	Own	Purchased	Total
Cattle manure	5 911	869	6 780	3 211	-	3 211	4 308	353	4 661
	(7 226)	(2 290)	(6 806)	(5 015)		(5 015)	(6 052)	(1 489)	(5 976)
Rice bran	4 900	2 551	7 450	1 660	899	2 559	2 976	1 570	4 546
	(3 715)	(4 046)	(5 312)	(2 621)	(2 088)	(4 084)	(3 456)	(3 090)	(5 154)
Oil cake	-	119	119	-	10	10	-	55	55
		(319)	(319)		(45)	(45)		(209)	(209)
Wheat bran	-	980	980	-	-	-	-	398	398
		(2 998)	(2 998)					(1 929)	(1 929)
Poultry droppings	408	52	460	-	-	-	166	21	187
	(709)	(142)	(808)				(486)	(92)	(553)
Duck weed	3 100	-	3 100	2 730	-	2 730	2 880	-	2 880
	(4 085)		(4 085)	(4 424)		(4 424)	(4 225)		(4 425)
Lime	-	69	69	-	39	39	-	51	51
		(57)	(57)		(60)	(60)		(60)	(60)
Urea	-	107	107	-	8	8	-	49	49
		(64)	(64)		(14)	(14)		(64)	(64)
TSP	-	207	207	-	18	18	-	95	95
		(122)	(122)		(30)	(30)		(123)	(123)

Table 6.6. Fertilizers and supplementary feeds used in seasonal ponds (kg·ha^{-1}). Standard deviations are in parentheses.

	Research farmers (n=15)			Adopters (n=11)			All (n=26)		
	Own	Purchased	Total	Own	Purchased	Total	Own	Purchased	Total
Cattle manure	10 299	734	11 033	1 450	-	1 450	6 555	423	6 978
	(13 735)	(1 407)	(13 355)	(2 374)		(2 374)	(11 304)	(1 116)	(11 200)
Rice bran	5 095	2 766	7 861	3 006	569	3 575	4 211	1 836	6 047
	(4 668)	(2 922)	(4 773)	(2 108)	(1 729)	(2 164)	(3 884)	(2 684)	(4 393)
Oil cake	-	240	240	-	22	22	-	148	148
		(928)	(928)		(74)	(74)		(705)	(705)
Wheat bran	-	110	110	-	-	-	-	63	63
		(425)	(425)					(323)	(323)
Poultry droppings	311	-	311	-	-	-	179	-	179
	(380)		(380)				(325)		(325)
Duck weed	3 796	-	3 796	1 520	32	1 552	2 833	14	2 847
	(4 933)		(4 933)	(1 859)	(106)	(1 833)	(4 040)	(69)	(4 031)
Lime	-	65	65	-	50	50	-	59	59
		(55)	(55)		(65)	(65)		(59)	(59)
Urea	-	124	124	-	32	32	-	85	85
		(93)	(93)		(39)	(39)		(88)	(88)
TSP	-	205	205	-	49	49	-	139	139
		(94)	(94)		(76)	(76)		(116)	(116)

Table 6.7. Harvesting time and methods.

Items	Research farmers (n=31)		Adopters (n=30)		All (n=61)	
	No.	%	No.	%	No.	%
Time of harvesting						
January	1	3.23	-	-	1	1.64
February	11	35.48	5	16.66	16	26.23
March	14	45.16	22	73.33	36	59.02
April	3	9.68	2	6.66	5	8.20
May	1	3.23	1	3.33	2	3.28
June	1	3.23	-	-	1	1.64
Harvesting method						
Netting	31	100	30	100	61	100
Dewatering	-	-	-	-	-	-
Angling	-	-	1	3.33	1	1.64

Table 6.8. Production and disposal pattern of harvested fish (kg·ha^{-1}) before and after research intervention. Standard deviations are in parenthesis.

	Before research intervention	After research intervention								
		Research farmers			Adopters			All		
		Perennial	Seasonal	All	Perennial	Seasonal	All	Perennial	Seasonal	All
	(n=58)	(n=13)	(n=15)	(n=28)	(n=19)	(n=11)	(n=30)	(n=32)	(n=26)	(n=58)
Household consumption	191	876	922	901	707	693	702	776	825	798
	(281)	(677)	(657)	(654)	(466)	(431)	(446)	(558)	(574)	(560)
Given away	46	330	12	159	49	50	50	163	28	103
	(148)	(1 086)	(45)	(743)	(105)	(102)	(102)	(695)	(75)	(519)
Sold	55	1 691	1 362	1 515	677	386	568	1 087	949	1 025
	(274)	(1 207)	(913)	(1 053)	(693)	(365)	(603)	(1 049)	(873)	(968)
Total production	292	2 897	2 295	2 574	1 430	1 129	1 320	2 026	1 802	1 926
	(483)	(1 057)	(681)	(911)	(864)	(528)	(762)	(1184)	(846)	(1 044)

6.3. Impact on fish production and utilization

The average fish production from ponds in the area was 292 kg·ha^{-1} before the research intervention. After intervention, production increased on average to 2 574 kg·ha^{-1} among research farmers and 1 320 kg·ha^{-1} among adopters (Table 6.8) in 6 to 9 months of rearing, showing an increase in production of 880% and 452% among research farmers and adopters, respectively. Of the fish produced, 42% was consumed by the households, 5% was given away to friends and relatives and 53% was sold for cash.

Fish production increased proportionately with increased rearing period. For example, among research farmers, fish production in six months of rearing was 2 008 kg·ha^{-1}, which increased to 3 211 kg·ha^{-1} in 9 months of rearing (Table 6.9). Such trend was also seen in the fish production of adopters.

As mentioned earlier, the study area is located in a floodplain where the ponds are floodprone. Flooding was one of the main reasons discouraging farmers from practicing aquaculture. However, the demonstration of increased fish production and benefits encouraged farmers in the area to integrate aquaculture into farming. To avoid the risk of losing of fish due to flooding, farmers stocked their ponds after the flooding season and harvested before the onset of floods. Thirty-nine percent of ponds surveyed were affected by floods. Farmers developed innovative methods for preventing the escape of fish during the flooding, for example, by putting a screen of jute sticks around the pond embankments. After the flooding season, these jute sticks were removed and used as fuel for cooking. Another discouraging factor was disease. The survey revealed that 13% of the ponds were affected by fish disease (Table 6.10).

6.4. Fish production costs and benefits

Operating costs for fish production on average amounted to Tk 2 971 per pond with an average size of 752 m^2. Costs are given using the pond as a reference unit rather than per hectare, to reflect the actual expenditure per household for incorporating aquaculture into farming systems. Of these costs, Tk 1 757 were cash costs (59.1% of total operating costs) and Tk 1 214 was the estimated cost of on-farm inputs used by farmers. The cash costs on average amounted to 6% of gross income of the households surveyed. Of the cash costs, fingerlings accounted for 60.5%, fertilizers 9.2%, supplementary feeds 17% and harvesting costs 13.3% (Table 6.11). Noncash inputs or on-farm inputs used for fish culture were cattle manure, poultry droppings, rice bran, duckweed and family labor.

There were slight differences in operating costs between research farmers and adopters. Research farmers incurred cash costs of Tk 1 725 per pond, while in the case of adopters, it was Tk 1 791 per pond. While adopters spent Tk 1 528 or 85.3% of cash costs on fingerlings, the research farmers spent only Tk 536 or 31.3% of cash costs. This disparity is due to the extremely high number of fingerlings stocked by the adopters in their ponds (Table 6.1)

The gross benefit from fish culture in perennial ponds per farmer on average amounted to Tk 9 590 per pond (Tk 102 862 per ha) in the case of research farmers and Tk 3 869 (Tk 46 059 per ha) in the case of adopters. The net benefit per pond, taking into consideration only the cash costs, amounted to Tk 7 544 (Tk 80 917 per ha) in the case of research farmers and Tk 1 892 (Tk 22 524 per ha) in the case of adopters (Table 6.11).

Table 6.9. Fish production under different rearing periods. Standard deviations are in parentheses.

Rearing period (months)	No. of cases	Production ($kg{\cdot}ha^{-1}$)
4	-	-
6	2	2 008.35
		(70.69)
7	13	2 339.11
		(724.73)
8	7	2 751.55
		(1 246.78)
9	5	3 211.47
		(883.95)
10	-	-
12	1	2 336.62

Table 6.10. Ponds affected by flooding and disease. Percentages are in parentheses.

Flood/disease	No.of ponds
Total no. of ponds	61
Affected by flood	24
	(39.34)
Affected by disease	8
	(13.11)

Table 6 11 Operating costs and returns from fish culture per pond. Standard deviations are in parentheses.

	Research farmers			Adopters			All		
	Perennial (n=13) *932.31m²	Seasonal (n=15) *634.67m²	All (n=28) *772.86m²	Perennial (n=19) *840.00m²	Seasonal (n=11) *549.10m²	All (n=30) *733.33m²	Perennial (n=32) *877.50m²	Seasonal (n=26) *598.46m²	All (n=58) *752.41m²
A. Total gross benefits:	9 590	5 422	7 228	3 869	2 002	3 120	6 067	3 873	5 053
	(3 339)	(1 855)	(2 554)	(2 498)	(1 027)	(1 929)	(3 737)	(2 097)	(2 943)
Cash benefits	5 526	3 267	4 258	1 854	702	1 369	3 264	2 101	2 728
	(3 950)	(2 264)	(2 967)	(1 980)	(649)	(1 503)	(3 246)	(2 028)	(2 659)
Noncash benefits	4 064	2 155	2 970	2 015	1 300	1 751	2 805	1 772	2 325
	(3 683)	(1 557)	(2 480)	(1 288)	(836)	(1 102)	(2 538)	(1 279)	(1 928)
B Total expenses:	3 941	2 929	3 427	2 884	1 978	2 563	3 295	2 505	2 971
	(1 595)	(1 167)	(1 359)	(1 749)	(1 184)	(1 520)	(1 712)	(1 199)	(1 481)
Cash expenses	2 046	1 422	1 715	1 977	1 426	1 791	2 008	1 431	1 757
	(1 123)	(840)	(964)	(1 194)	(1 359)	(1 348)	(1 157)	(1 114)	(1 182)
Fingerlings	586	476	536	1 640	1 270	1 528	1 241	845	1 063
	(263)	(131)	(191)	(1 010)	(1 398)	(1 304)	(1 003)	(1 077)	(1 098)
Cattle manure	25	14	19	-	-	-	9	8	9
	(65)	(27)	(43)	-	-	-	(40)	(20)	(30)
Duck weed	-	-	-	-	1	1	-	1	1
	-	-	-	-	(4)	(4)	-	(3)	(3)
Rice bran	315	333	338	92	34	68	178	197	195
	(395)	(378)	(404)	(205)	(96)	(161)	(300)	(308)	(323)
Wheat bran	278	14	116	-	-	-	106	8	55
	(849)	(55)	(484)				(514)	(39)	(329)
Oil cake	56	108	92	7	6	7	26	61	47
	(151)	(417)	(378)	(31)	(21)	(26)	(94)	(299)	(257)
Harvesting	453	243	333	204	70	147	300	164	234
	(389)	(256)	(323)	(326)	(87)	(238)	(361)	(205)	(287)
Lime	89	66	77	18	14	17	45	42	45
	(48)	(18)	(31)	(25)	(18)	(22)	(47)	(30)	(39)
Urea	59	45	52	4	9	6	25	29	28
	(32)	(31)	(33)	(6)	(11)	(10)	(32)	(29)	(32)
TSP	185	121	150	12	22	17	78	76	80
	(98)	(55)	(73)	(20)	(34)	(31)	(100)	(64)	(84)
Noncash expenses	1 895	1 507	1 712	907	552	772	1 287	1 074	1 214
	(1 048)	(838)	(946)	(1 036)	(364)	(768)	(1 109)	(764)	(955)
Labor	666	522	597	473	156	352	548	370	467
	(378)	(265)	(315)	(520)	(135)	(382)	(474)	(255)	(367)
Cattle manure	174	201	198	88	25	61	121	121	126
	(202)	(264)	(262)	(143)	(43)	(106)	(168)	(206)	(203)
Rice bran	797	581	685	172	278	232	411	443	445
	(704)	(603)	(657)	(257)	(234)	(277)	(541)	(471)	(531)
Poultry droppings	39	20	28	-	-	-	15	11	13
	(67)	(24)	(43)	-	-	-	(43)	(20)	(32)
Duck weed	219	183	204	174	63	127	192	129	163
	(289)	(238)	(264)	(282)	(78)	(206)	(281)	(186)	(235)
C Net Benefit	5 649	2 493	3 801	985	24	557	2 772	1 368	2 082
(A-B)	(2 323)	(1 763)	(2 177)	(2 491)	(1 794)	(2 254)	(3 219)	(2 109)	(2 709)

*Average size of pond.

6.5. Impact of incorporation of aquaculture on household income

Before research intervention, contribution of fish culture to farm and household income was negligible being only 4.6% and 2.8%, respectively. After research intervention, the contribution of fish culture to farm and household income on average increased to 21.5% and 13.5%, respectively, indicating a fivefold increase as a result of incorporation of aquaculture into the farming system (Table 6.12). Fish production and its contribution to farm and household income was much higher among research farmers compared to adopters, indicating the potential for higher returns if the farmers were properly trained in aquaculture practices.

Table 6.12. Impact of incorporation of aquaculture into the farming system on household income.

	Before research intervention	After research intervention		
		Research farmers	Adopters	All
	(n=57)	(n=28)	(n=30)	(n=58)
Farm Income (excluding fish)	15 747	20 425	16 487	18 388
Income from fish culture	758	7 228	3 120	5 053
Off-farm income	10 869	15 257	12 603	13 884
Total income	27 374	42 910	32 210	37 325
Contribution of fish to farm income (%)	4.6	26.1	15.9	21.6
Contribution of fish to total household income (%)	2.8	16.8	9.7	13.5

Note: Income from fish culture has been calculated on the basis of average pond size. Value of fish before and after research intervention is based on prevailing farm gate prices at the time of survey.

7. IMPACT OF INCORPORATING AQUACULTURE ON RESOURCE UTILIZATION

Since the rationale for incorporation of any new activity into the farming system is to optimize production and maximize benefits through integrated resource management, an effort was made to assess the impact of incorporation of aquaculture into the farming system on resource utilization and the adverse effects, if any, on other enterprises.

7.1. Labor

Two sources of labor were used by farmers for different on-farm activities (including aquaculture): own and hired labor. For all the farmers, 46.8% of the total labor requirement (718 person-days per year) was met from family sources, while the rest was hired. High use of hired labor is probably due to the fact that farming is not the principal occupation for 46% of the farmers surveyed (Table 3.4). In addition, the higher economic status of the farmers enabled more hiring of labor (see section 9). Of the total labor, 72.3% was for cereal farming. Fish culture required only 12 person-days per year for pond preparation and harvesting, of which 32.1% was hired (Table 7.1).

7.2. Use of bioresources

Before research intervention, cattle manure had been used in very low quantities in fish culture. After intervention, the use of cattle manure in fish culture increased significantly. On average, each farmer used 1 645 kg of cattle manure in different farm enterprises and for household fuel. Of the amount used in on farm enterprises, only 434 kg (26.4%) was used for fish culture. The use of cattle manure amounted to 590.7 kg (35.9%), 90.0 kg (5.5%) and 521.4 kg (31.7%) for cereals, cash crops and fuel, respectively (Table 7.2).

Farmers used rice bran for cattle, poultry and fish feed as well as for the maintenance of the earthen walls of their houses. Use varied with the corresponding importance of the enterprise. For all the farmers, a major portion (47.4%) of rice bran was used as supplementary feed in fish culture. Research farmers used more rice bran for fish culture (600 kg per farm) compared to adopters (217 kg per farm) (Table 7.2).

Almost 55% of all poultry droppings used by farmers was for fish culture. Research farmers used considerably more poultry droppings than the adopters (Table 7.2).

Table 7 1 Average labor utilization per farm (person-days per year) in different farm enterprises.

Enterprise	Labor (person-days per year) Own	Hired	Total
Cereals	255.45	263.72	519.17
Cash crops	42.84	77.53	120.37
Vegetables	14.09	36.33	50.42
Cattle	2.36	-	2.36
Poultry	7.93	-	7.93
Fish culture	8.16	3.91	12.07
Others	5.48	-	5.48
Total (%)	336.31	381.49	717.80

7.3. Water and land resource utilization

Before research intervention, only 13.1% of the ponds had been under traditional fish culture. The farmers came to understand the potential of aquaculture for higher returns compared to rice farming as well as the multiple uses of the pond including for irrigation during periods of drought. The survey revealed that not only were all the existing ponds in the study area put into use for aquaculture, farmers also started excavating new ponds in their ricefields near their homesteads. As could be seen from Table 7.3, of the 87 ponds surveyed after intervention, 71 (80.5%) were previously existing ponds and 16 (18.4%) were newly excavated, indicating the impact of the research intervention.

Table 7.2. Utilization of bioresources (kg per farm per year). Standard deviations are in parentheses.

Enterprises	Research farmers (n=28)			Adopters (n=30)			All (n=58)		
	Own	Purchased	Total	Own	Purchased	Total	Own	Purchased	Total
Cattle manure									
Cereals	560.86	-	560 86	541.27	-	541.27	590 72	-	590.72
	(1 672.05)	-	(1 672.05)	(767.35)	-	(767 35)	(1 274.35)	-	(1 274.35)
Cash crops	93.07	-	93.07	87.20	-	87.20	90.03	-	90.03
	(320.66)	-	(320.66)	(342.47)	-	(342.47)	(329.22)	-	(329.22)
Fruit	-	-	-	18.00	-	18.00	9.31	-	9.31
				(98.59)	-	(98.59)	(70.91)	-	(70.91)
Fuel	325.75	-	325.75	703.97	-	703 97	521.38	-	521.38
	(610.94)	-	(610 94)	(1 691.25)	-	(1 691.25)	(1 291.67)	-	(1 291.67)
Fish feed	646.28	62.29	708.57	190.40	-	190.40	404 79	29.28	434.07
	(878.4)	(143.41)	(848.80)	(317.51)	-	(317.51)	(669.28)	(100.84)	(663.00)
Total	1 625.96	62.29	1 688.25	1 540.84	-	1 540.84	1 616.23	29.28	1 645.51
Rice bran									
House maintenance	11.64	-	11.64	73.83	-	73.83	43.81	-	43.81
	(42.49)	-	(42.49)	(212.15)	-	(212.15)	(157.28)	-	(157.28)
Cattle feed	113.21	-	113.21	(241.87)	-	241.87	179.76	-	179.76
	(192.89)	-	(192.89)	(380.37)	-	(380.37)	(308.94)	-	(308.94)
Poultry feed	79.46	14.29	93.75	178.37	2.17	180.53	130.62	8.02	138.64
	(110.07)	(68.17)	(146.95)	(183.44)	(8.38)	(183.99)	(159.20)	(47.69)	(171.36)
Fish feed	391.46	208.54	600.00	159.82	57.73	217.55	268.80	128.65	397.45
	(326.69)	(267.72)	(386.36)	(185.30)	(143.98)	(259.42)	(279.79)	(220.30)	(369.00)
Others	81.25	43.32	124.57	35.67	-	35.67	57.67	20.91	78.58
	(179.93)	(96.88)	-	(99.78)	-	(99.78)	(144.66)	(70.16)	(197.79)
Total	677.02	266.15	943.17	689.56	59.90	749.46	680.66	157.58	838.24
Poultry droppings									
Cash crops	1.50	-	1.50	-	-	-	0.72	-	0.72
	(7.94)	-	(7.94)	-	-	-	(5.51)	-	(5.51)
Fish culture	27.86	1.88	29.74	-	-	-	13.09	0.88	13.97
	(42.90)	(7.68)	(47.65)	-	-	-	(31.83)	(5.23)	(35.10)
Others	5.68	2.14	7.82	13.63	-	13.63	9.79	1.03	10.83
	(27.26)	(11.34)	(29.09)	(20 49)	-	(20.49)	(24.12)	(7.88)	(24.96)
Total	35.04	4.02	39.02	13.63	-	13.63	23.61	1.91	25.52

Table 7.3 Fish culture status of waterbodies before and after research intervention.

Status of waterbody	Before research (n=61)		After research (n=87)	
	No.	%	No.	%
Cultured	8	13.1	70	80.5
Culturable	53	86.9	1	1.1
Newly excavated	-	-	16	18.4

8. FARMERS' PERCEPTION REGARDING THE INCORPORATION OF FISH CULTURE INTO THE FARMING SYSTEM

8.1. On-farm resource use

8.1.1. RICE BRAN

About 71% of the research farmers and 26.7% of adopters reported a reduction in their use of rice bran as household fuel and for house maintenance after adopting aquaculture. Instead it was used as supplementary feed for fish. In addition, 58% of the research farmers also reported purchasing rice bran for feeding fish (Table 8.1).

8.1.2. CATTLE MANURE

Most of the research farmers (38.7%) reported reduced use of cattle manure as fuel in households, while 22.6% reported its purchase from others. Among adopters, only 6.7% reported stopping the household use of cattle manure (Table 8.2).

Table 8.1. Means of managing rice bran for fish culture. Percentages in parentheses.

	Research farmers (n=31)	Adopters (n=30)
Stopped using as fuel	22 (70.97)	8 (26.67)
Gave less feed to animals	2 (6.45)	-
Purchased from market	18 (58.06)	7 (23.33)

Table 8.2. Means of managing cattle manure for fish culture. Percentages are in parentheses.

	Research farmers (n=31)	Adopters (n=30)
Stopped/decreased household use	12 (38.71)	2 (6.67)
Reduced use in other farm enterprises	1 (3.23)	-
Collected from grazing grounds	2 (6.45)	-
Purchased from others	7 (22.58)	-

8.2. Constraints to incorporation of aquaculture

The constraints identified by research and adopter farmers in fish culture are identified in Table 8.3. It is interesting to note that before the research intervention, 79% of the farmers reported lack of knowledge as a constraint (Table 5.1), but in the post-research survey, none of the farmers reported lack of knowledge as a constraint. This indicates that information sharing among farmers and learning from experience of other farmers is an important aspect in dissemination/extension of technologies.

8.3. Benefits from incorporation of fish culture into the farming system

Fish for home consumption, as a source of cash income and for the utilization of unutilized resources, were perceived as the major benefits from incorporating fish culture into the farming system. Over 32% farmers surveyed reported that this has resulted in better social relationships with their neighbors (Table 8.4).

Table 8.3. Constraints faced by farmers in fish culture. Percentages are in parentheses.

	Research farmers (n=31)	Adopters (n=30)	All (n=61)
Inadequate supply of fingerlings	30 (96.8)	28 (93.3)	58 (95 1)
Nonavailability of credit	2 (6.5)	4 (13.3)	6 (9.8)
Nonavailability of feed other than rice bran	6 (19.4)	4 (13.3)	10 (16.4)
Insufficient water in ponds	12 (38.7)	9 (30.0)	21 (34.4)
Flooding	6 (19.4)	6 (20.0)	12 (19.7)
Problems of harvesting	2 (6.5)	3 (10.0)	5 (8.2)
Risk of theft	14 (45.2)	3 (10.0)	17 (27.9)
Risk of disease	2 (6.5)	15 (50.0)	17 (27.9)

Table 8.4. Benefits from incorporating fish culture into the farming system, as perceived by farmers. Standard deviations are in parentheses

	Research farmers (n=31)	Adopters (n=30)	All (n=61)
Fish for household consumption	29	24	53
	(93.5)	(80.0)	(86.9)
Source of cash income	14	22	36
	(45.2)	(73.3)	(59.0)
Help improve economic status	4	7	11
	(12.9)	(23.3)	(18 0)
Rapid return	-	1	1
		(3.3)	(1.6)
Low investment	-	1	1
		(3.3)	(1.6)
Fast growth of fish	-	2	2
	-	(6.7)	(3.3)
Simple technology	1	1	2
	(3.2)	(3.3)	(3.3)
Better social relationship	10	10	20
	(32.3)	(33.3)	(32.8)
Utilization of ditch for other purpose after fish culture	2	3	5
	(6.5)	(10 0)	(8 2)
Increased utilization of unutilized resource	17	16	33
	(54.8)	(53.3)	(54.1)

9. CONCLUSION

Bangladesh is on the verge of attaining selfsufficiency in rice production although rice farming is becoming less attractive due to stagnant yields and higher input costs. At the same time, the gap between increased demand for fish and dwindling supply is widening, resulting in increased fish prices. This has a deleterious effect on the rural population because of its limited purchasing power. According to household surveys, the average per capita consumption of fish in rural Bangladesh has declined compared to urban sector intake levels (World Bank 1991). In view of the above, the farmers are looking for diversification of crops.

The study has clearly indicated the viability and profitability of incorporating aquaculture into the farming systems of the floodprone ecosystem. To avoid risk of loss of fish due to flooding, farmers stocked the ponds after the major flooding season and harvested before the rains. Before the research intervention, almost 87% of the ponds had been lying fallow. After the demonstration of viability and profitability of integrating aquaculture with other enterprises of the farm, not only had all the existing ponds come under aquaculture, but new ponds were being excavated in farms.

The average size of ponds in the study area was 770 m^2, producing 23.4 kg of fish per annum before research intervention. Of this,14.7 kg was consumed by the households. After the research intervention, fish production increased on average to 148 kg per pond among research farmers and adopters. Along with increased production, household consumption also increased to 62 kg of fish produced from the pond, compared to 14.7 kg of fish consumed by the households prior to research intervention, showing substantially increased nutritional intake. Households surveyed had 6.7 family members on average, which means that by adopting aquaculture, the per capita availability of fish for consumption from the farm (excluding cash sales) for each household member had increased to 9.25 kg per annum (excluding the contribution of purchased fish and fish caught from natural waters), which is much higher than the national per capita fish consumption of 7.9 kg per annum. Furthermore, while the farmers on average were previously able to sell 4.2 kg of fish, this amount increased to 78.9 kg after the research intervention, thus providing additional cash income. As stated in 6.5, contribution of fish to household income has shown a fivefold increase after the research intervention.

The study also revealed some interesting facts regarding adoption of technologies. The farmers who had incorporated aquaculture into their farming system had larger households (on average 6.72 persons), larger landholdings (1.62 ha), higher literacy rate (88.5%) and greater annual income (Tk 27 374) than the averages for the households in the study area. The farmers who took to aquaculture are in a higher socioeconomic segment of the population. Ahmed et al. (1993) and Gupta et al. (1998) made similar observations in the case of pond fish farming and integrated rice-fish farming, respectively. Poor households often do not have access to water resources such as ponds or ditches. It takes time for any innovation or technology to be adopted by farmers in a subsistence economy characterized by low literacy and rigid adherence to traditions. The small farmers are often constrained by lack of access to necessary resources such as fingerlings, feeds and fertilizers, knowledge and financial resources. On the other hand, studies undertaken by Gupta et. al (1992), Gupta and Rab (1994) and Gupta and Shah (1995) have clearly indicated that the resource-poor small farmers can benefit from the advances of research if institutional support is provided to access resources and knowledge. For example, in Bangladesh, NGOs have been providing training and ensuring the availability of inputs needed for implementation of the technologies which has led to a faster adoption of low-input technologies by resource-poor farmers (Gupta et al. 1992; Gupta and Rab 1994; Gupta and Shah 1995). It has been observed in the case of green revolution that small farmers caught up with the large farmers in adopting modern varieties of rice when assisted with appropriate government policies such as, credit, extension services, availability of seeds etc. (Hayami and Ruttan 1985; Lipton and Longhurst 1994). This clearly indicates that in addition to technological innovations, an institutional approach is vital if the resource-poor households are to benefit from technological advancements. Unless this is done, it will always be the socioeconomically advantaged segments of the population who will benefit.

There is often a misconception that wastes and byproducts from farms are not fully utilized. However, many small farms in Asia, particularly in Bangladesh, attempt to optimize the use of such resources. The households involved in this study found it necessary to divert some of these resources (cattle manure and rice bran) for aquaculture from other enterprises, albeit without adverse effects on other components of the farm, indicating that aquaculture is an extremely efficient user of farm byproducts.

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ANNEX

Survey Format to Assess Adoption and Impact of Integration of Aquaculture into the Farming Systems of the Floodprone Ecosystems in Bangladesh

I. Respondent's identity

Name of the farmer: ______________________ Research site: ________________

Village: ______________ Thana: ______________ District: ______________

Research site code: ________ |__|__|1-2

Serial number of the respondent: ____________________________ | __|__|__|3-5

Age: ____ |__|__|6-7

Principal occupation: ____ |__|8

Secondary occupation: ____ |__|9

[Occupation code : Farmer-1, Farm labor-2, Nonfarm labor-3, Housewife-4, Service-5, Small trader-6, Fisherman-7, Rickshaw driving-8, Others (specify)-9]

Education:
(Code : Illiterate-1, Can read-2, Primary-3, Secondary-4, Higher secondary-5) |__|10

Sex (Male-1, Female-2) |__|11

Family size: **Male:** __________ |__|12
Female: __________ |__|13

II. Household socioeconomics

1. Landholding of the household (in decimal)*

Land owned		
Homestead	:	|__|__|__|__|14-17
Cultivable (crop)	:	|__|__|__|__|18-21
Orchard/agroforestry	:	|__|__|__|__|22-25
Fallow land	:	|__|__|__|__|26-29
Pond/ditch	:	|__|__|__|__|30-33
Cultivated land		
Own land	:	|__|__|__|__|34-37
Share/leased in	:	|__|__|__|__|38-41
Share/leased out	:	|__|__|__|__|42-45

* a local unit equivalent to 42.4 m^2.

2. Household annual income

a) Annual farm income (Tk)*

Crops	: ______	|__|__|__|46-48
Cash crops	: ______	|__|__|__|49-51
Vegetables	: ______	|__|__|__|52-54
Fruits	: ______	|__|__|__|55-57
Agroforest	: ______	|__|__|__|58-60

b) Other annual nonfarm income

i)	Annual lease/share income (Tk)	: ______	
ii)	Annual interest earning from		|__|__|__|61-63
	savings (Tk)	: ______	|__|__|__|64-66
iii)	Annual income from other sources (Tk)	: ______	|__|__|__|67-69

Type of work	Income	
Wage labor	: ______	|__|__|__|70-72
Petty trading	: ______	|__|__|__|73-75
Business	: ______	|__|__|__|76-78
Service	: ______	|__|__|__|79-81
Rickshaw pulling	: ______	|__|__|__|82-84
Cart driving	: ______	|__|__|__|85-87
Bamboo and cane works	: ______	|__|__|__|88-90
Driving	: ______	|__|__|__|91-93
Boat plying	: ______	|__|__|__|94-96
Others (specify)	: ______	|__|__|__|97-99

III. Utilization of resources in farm production activities

1. Labor use (Person-days per year)

	Own	Purchased	
Crops	______	______	|_|_|_| |_|_|_|1-6
Cash crops (jute, sugarcane, wheat)	______	______	|_|_|_| |_|_|_|7-12
Vegetables	______	______	|_|_|_| |_|_|_|13-18
Pulses/Oil seeds	______	______	|_|_|_| |_|_|_|19-24
Potato/Arum	______	______	|_|_|_| |_|_|_|25-30
Condiments	______	______	|_|_|_| |_|_|_|31-36
Fruit	______	______	|_|_|_| |_|_|_|37-42
Agroforest	______	______	|_|_|_| |_|_|_|43-48
Betel leaf	______	______	|_|_|_| |_|_|_|49-54
Others (specify): ______	______	______	|_|_|_| |_|_|_|55-60
Livestock :			
Cattle	______	______	|_|_|_| |_|_|_|61-66
Poultry	______	______	|_|_|_| |_|_|_|67-72

2. Use of cattle manure (kg)

	Own	Purchased	
Crops	______	______	|_|_|_|_| |_|_|_|_|1-8
Cash crops	______	______	|_|_|_|_| |_|_|_|_|9-16
Vegetables	______	______	|_|_|_|_| |_|_|_|_|17-24
Pulses/Oil seeds	______	______	|_|_|_|_| |_|_|_|_|25-32

* US$ 1 = Tk39.

Potato/Arum ______ ______ |_|_|_|_| |_|_|_|_|33-40
Condiments ______ ______ |_|_|_|_| |_|_|_|_|41-48
Fruit ______ ______ |_|_|_|_| |_|_|_|_|49-56
Agroforest ______ ______ |_|_|_|_| |_|_|_|_|57-64
Betel leaf ______ ______ |_|_|_|_| |_|_|_|_|65-72
Fuel ______ ______ |_|_|_|_| |_|_|_|_|73-80
Others (specify): ______ ______ ______ |_|_|_|_| |_|_|_|_|81-88

3. Use of rice bran (kg)

House maintenance ______ ______ |_|_|_|_| |_|_|_|_|1-8
Cattle feed ______ ______ |_|_|_|_| |_|_|_|_|9-16
Poultry feed ______ ______ |_|_|_|_| |_|_|_|_|17-24
Fish feed ______ ______ |_|_|_|_| |_|_|_|_|25-32
Others (specify) : ______ ______ ______ |_|_|_|_| |_|_|_|_|33-40

4. Use of poultry droppings

Crops ______ ______ |__|__| |__|__|41-44
Cash crops ______ ______ |__|__| |__|__|45-48
Vegetables ______ ______ |__|__| |__|__|49-52
Pulses/Oil seeds ______ ______ |__|__| |__|__|53-56
Potato/Arum ______ ______ |__|__| |__|__|57-60
Condiments ______ ______ |__|__| |__|__|61-64
Fruit ______ ______ |__|__| |__|__|65-68
Agroforest ______ ______ |__|__| |__|__|69-72
Betel leaf ______ ______ |__|__| |__|__|73-76
Cattle ______ ______ |__|__| |__|__|77-80
Poultry ______ ______ |__|__| |__|__|81-84
Fish culture ______ ______ |__|__| |__|__|85-88
Others (specify) : ______ ______ ______ |__|__| |__|__|89-92

IV. Pond information

1. Waterbody area (in decimal) during:

monsoon : __________ |__|__|__|__|1-4
dry season : __________ |__|__|__|__|5-8

2. Depth of waterbody in the dry season (feet): ________________ |__|__|9-10

3. Number of months retain water at least (3 feet): ________________ |__|__|11-12

4. Ownership type: ________________ |__|13

owned by household(s) 1
institutional 2
Khas (government) 3
leased 4

5. If owned by household(s), number of owners: ________________ |__|__|14-15

6. Type of the waterbody: |__|16

excavated	1
natural depression	2
roadside ditch	3

7. Purpose for which the waterbody was dug: ____________________ |__|17

fish culture	1
house building	2
bathing/washing	3
road construction	4
others (specify): ____________	5

8. Condition of the waterbody |__|18

broken dykes	1
fully/partially shaded	2
flood prone	4
good condition	8

9. Other uses of pond (other than fish culture) |__|__|19-20

bathing and washing	1
drinking	2
irrigation	4
jute retting	8
others (specify) : ____________	16

V. Fish culture status before research intervention

1. Use of the waterbody before research intervention |__|__|21-22

fish culture	1
bathing/washing	2
irrigation	4
jute retting	8
stocking water hyacinth for animals	16
others (specify): ____________	32

2. Did you culture fish before 1990 (i.e., before research intervention) (Yes-1, No-0): ______________________ |__|23

3. If answer to question 2 is 'yes', type of species stocked ?: ______________ |__|__|24-25

Indian carps	1
Chinese carps	2
Nile tilapia	4
silver barb	8

4. At what interval did you stock fingerlings? |__|__|26-27

one year	1
two year	2
irregular	3

5. Did you use any fertilizer? |__|28
(Yes-1, No-0): ____________________

6. If question 5 is 'yes', what type of |__|__|__|29-31
fertilizer did you apply?: ____________________

cattle manure	1
inorganic fertilizer	2
chicken manure	4
others (specify): ______________	8

7. If question 5 is 'yes', no. of times fertilizer was used in a year: |__|32

8. Did you use any feed ? (Yes-1, No-0): ____________________ |__|33

9. If answer to question 8 is 'yes', |__|__|__|34-36
what feed did you use?: ____________________

rice bran	1
duck weed	2
oil cake	4
others (specify): ______________	8

10. If answer to question 8 is 'yes' at what |__|37
intervals did you apply feed ?: ____________________
(daily-1, weekly-2, irregular-3)

11. If answer to question 2 is 'no', what factors |__|__|__|38-40
were responsible for not culturing fish?:

lack of knowledge	1
lack of capital	2
nonavailability of fingerlings	4
natural harvest was abundant	8
noncooperation of shareholder	16
flooding of ponds	32
jute retting	64
others (specify): ______________	128

12. Production obtained during last one year

Cultured fish (kg): ____________________ |__|__|__|41-43
Natural fish (kg): ____________________ |__|__|__|__|44-46
Total (kg): ____________________ |__|__|__|__|47-50

13. Disposable pattern:

Household consumption (kg): ______________ |__|__|__|__|51-54
Sold out (kg): ____________________ |__|__|__|__|55-58
Given away to relatives (kg): ______________ |__|__|__|__|59-62

VI. Impact of incorporation of fish culture into farming system

1. Farmer type: |__|63

Research farmer in 1990-91	1
Research farmer in 1991-92	2

Research farmer in 1992-93	3
Research farmer in 1993-94	4
Research farmer during 1990-92	5
Research farmer during 1990-93	6
Research farmer during 1991-93	7
Adopter	8

2. If the farmer is an adopter, when did he start fish culture ______ years. |__|__|__|__| 64-67

3. Pond preparation (1992-93):

Inputs	Quantity	Price/wage per unit		
Own source				
Labor (days)	______	______	|__|__|	|__|__| 1-4
Cattle manure (kg)	______	______	|__|__|	|__|__| 5-8
Chicken manure (kg)	______	______	|__|__|	|__|__| 9-12
Compost (kg)	______	______	|__|__|	|__|__| 13-16
Kitchen waste (kg)	______	______	|__|__|	|__|__| 17-20
Purchased resources				
Lime (kg)	______	______	|__|__|	|__|__| 21-24
Urea (kg)	______	______	|__|__|	|__|__| 25-28
TSP (kg)	______	______	|__|__|	|__|__| 29-32
Pesticide (kg)	______	______	|__|__|	|__|__| 33-36
Cattle manure (kg)	______	______	|__|__|	|__|__| 37-40
Chicken manure (kg)	______	______	|__|__|	|__|__| 41-44
Compost (kg)	______	______	|__|__|	|__|__| 45-48
Carrying cost (Tk)		______		|__|__| 49-50

4. Species stocked:

Species	Number	
Catla	: ____________	|__|__|__| 51-53
Rohu	: ____________	|__|__|__| 54-56
Mrigal	: ____________	|__|__|__| 57-59
Silver carp	: ____________	|__|__|__| 60-62
Common carp	: ____________	|__|__|__| 63-65
Grass carp	: ____________	|__|__|__| 66-68
Bighead carp	: ____________	|__|__|__| 69-70
Silver barb	: ____________	|__|__|__| 71-73
Tilapia	: ____________	|__|__|__| 74-76
Others (specify)	: ____________	|__|__|__| 77-79
Size of fingerlings stocked (in inches)	: ____________	|__|__| 80-81

6. Month of stocking: ______________________________ |__|__| 1-2

7. Cost of fingerlings (Tk.): ______________________________ |__|__| 3-4

8. Cost of fingerling transport (Tk.): ______________________________ |__|__|__| 5-7

9. Principal source of fingerling supply:

purchased from NGOs	1	|__|8
purchased from private vendor	2	
purchased from government farm	4	
purchased from private farm	8	

10. Fertilizers and feed applied:

Fertilizer/ *Feed*	Quantity	Price per unit	
Own source (kg)			
Cattle manure	_______	________	|__|__|__| |__|__|9-13
Rice bran	_______	________	|__|__|__| |__|__|14-18
Oil cake	_______	________	|__|__|__| |__|__|19-23
Wheat bran	_______	________	|__|__|__| |__|__|24-28
Waste/cooked rice	_______	________	|__|__|__| |__|__|29-33
Poultry droppings	_______	________	|__|__|__| |__|__|34-38
Compost	_______	________	|__|__|__| |__|__|39-43
Duck weed	_______	________	|__|__|__| |__|__|44-48
Others (specify)	_______	________	|__|__|__| |__|__|49-53
Purchased (kg)			
Lime	_______	________	|__|__|__| |__|__|54-58
Urea	_______	________	|__|__|__| |__|__|59-63
TSP	_______	________	|__|__|__| |__|__|64-68
Cattle manure	_______	________	|__|__|__| |__|__|69-73
Poultry droppings	_______	________	|__|__|__| |__|__|74-78
Duck weed	_______	________	|__|__|__| |__|__|79-83
Rice bran	_______	________	|__|__|__| |__|__|84-88
Wheat bran	_______	________	|__|__|__| |__|__|89-93
Oil cake	_______	________	|__|__|__| |__|__|94-98
Others (specify)	_______	________	|__|__|__| |__|__|99-103

11. Problems faced in fish culture:

a) Was the waterbody affected by flood? |__|1
(Yes-1, No-0): ________________

b) If yes, was it possible to protect from flood? |__|2
(Yes-1, No-0): ________________

c) If yes, how did you protect from flood? |__|3

by making fence with jute sticks ______________________ 1
by making fence with bamboos ______________________ 2
by strengthening of dikes ____________________________ 4

d) Did you lose any fish due to flooding? |__|4
(Yes-1, No-0): ________________

e) How much was cost of bamboo/
jute fencing? _____________ |__|__|__|5-7

f) Were the fish affected by disease?
(Yes-1, No-0): ________________ |__|8

12. Harvesting and disposal

a) Date (month) of harvesting: __________ |__|__|9-10

b) Harvesting method: _______________ |__|11

netting	1
dewatering	2
angling	4

c) Cost of harvesting (if harvested by fishers): ________________

i) Share of fish (kg): ______________________ |__|__|__|12-14
ii) Cash (Tk): ____________________________ |__|__|__|15-17

d) Disposal pattern of harvested fish (kg)

Household consumed: _____________ |__|__|__|18-20
Given away: _____________________ |__|__|__|21-23
Sold: ___________________________ |__|__|__|24-26
Total production: ________________ |__|__|__|27-29

e) Selling price per kg (Tk): ______________ |__|__|30-31

13. Labor used (person-days):

a) Dike repairing and cleaning: _________________________ |__|__|32-33
b) Duck weed collection: _____________________________ |__|__|34-35
c) Making fence to protect from flood: ___________________ |__|__|36-37
d) Harvesting: ____ |__|__|38-39
e) Marketing: ____ |__|__|40-41

VII. Farmer assessment and attitude towards fish culture

Note: Farmers should not be prompted. Mark farmers' reasons against list.

1. How did you manage additional rice bran
for aquaculture?: __________________________ |__|__|42-43

Stopped indigenous use of rice bran	1
Generated surplus by giving less feed to animals	2
Generated surplus by less feed to poultry	4
Increased production of rice bran by selling processed rice instead of paddy	8
Purchased from market/neighbours	16

2. How did you manage additional cattle manure
for aquaculture?: __________________________ |__|__|44-45

Stopped/decreased household use of cattle manure	1
Increased production by adding more animals	2
Reduced cattle manure use in other farm enterprises	4
Collected from grazing ground	8
Purchased from others	16

3. How did you manage additional poultry droppings for aquaculture?: ______________________ |__|46

Preserved own poultry droppings	1
Started poultry rearing in cages rather than free range grazing	2
Collected from neighbors	4

4. Do you think that labor utilization has increased due to aquaculture practices? Yes _____No______
(Yes-1, No-0) |__|47

5. If answer to question no. 4 is 'yes', how did you manage excess labor required for aquaculture? |__|48

From family labor force	1
Increasing working hours	2
Hired labor	4

6. Did you have to give up any occupation/enterprise in order to devote time and resource to aquaculture? |__|49
Yes: _____ No. _____
(Yes-1, No-0)

7. If yes, what did you give up?
|__|__|50-51

Cultivation of crops	1
Plant nursery	2
Orchard	4
Horticulture in homestead	8
Others (specify): ____________	16

8. What was your annual net income from foregone occupation or enterprise? Tk _______________ |__|__|__|__|52-55

9. Did you have to stop any of the previous uses of pond after adoption of aquaculture ? |__|56
Yes: _____ No: _____
(Yes-1, No-0)

10. If yes, mention those uses: |__|57

Bathing and washing	1
Irrigation	2
Jute retting	4

11. Difficulties faced by farmers |__|__|__|58-60

a)	Inadequate supply of fingerlings	1
b)	Non availability of credit	2
c)	Non availability of feed other than rice bran	4
d)	Insufficient water in the pond	8
e)	Small size of pond	16
f)	Flooding	32

g)	Problems of harvesting	64	
h)	Risk of theft	128	
i)	Risk of disease	256	

12. Benefits derived from fish culture by farmers |__|__|__|__|61-64

a)	Fish for self consumption	1	
b)	Source of cash income	2	
c)	Help improve economic status	4	
d)	Rapid return	8	
e)	Low investment	16	
f)	Fast growth of fish	32	
g)	Simple technology	64	
h)	Better social relationship	128	
i)	Utilization of ditch for other purposes after fish culture	256	
j)	Increased utilization of untouched resources	512	

13. Farmer's attitude towards future involvement in fish culture: ________________ |__|65

Continue	1
Expand	2
Discontinue	3
Undecided	4

14. Remarks: ____

____

____

____

Signature of data collector

Date : ____________________

Signature of the verifier

Date : ________________