Integrating Aquaculture with Rice Farming in Bangladesh: Feasibility and Economic Viability, Its Adoption and Impact

Modadugu V. Gupta • John D. Sollows • M. Abdul Mazid
Aminur Rahman • M. Golam Hussain • Madan M. Dey

ICLARM
International Center for Living Aquatic Resources Management

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FOREWORD

Rice is the major crop grown across the land surface of Asia, occupying about 31% of the arable land area. Agriculture in Asia accounts for 86% of total water withdrawal and rice is a significant user of this water, consuming 7 650 cubic meters of water for every hectare of rice grown. Bangladesh illustrates the dominance of rice cultivation in a landscape where water is usually abundant in the wet (aman) season but where even a partial failure of the rains can cause drought, devastate rice production and seriously undermine food security. Therefore even in a country with an apparent abundance of water, the wise use of that water and other land resources such as the rice fields is crucial to overall food availability, security and income generation.

The knowledge that it is technically possible to cultivate fish as an extra crop in rice floodwaters has been known for thousands of years. However, this practice has not been widely adopted despite its apparent advantages for food production and farm household income. ICLARM and its research partners at the Bangladesh Fisheries Research Institute, with the assistance of the Bangladesh Office of the United States Agency for International Development, investigated the feasibility of adding fish culture to rice farms in the medium highlands of Bangladesh during wet (*aman*) and dry (*boro*) farming seasons. A technology package suited to local conditions and the availability of labor, capital and other inputs was developed and introduced to the farmers. A year later, the impact of this was assessed. The study examined how the technology was adopted and adapted by the farmers, the factors which influenced the adoption, and the potential economic benefits. It also collected information on the impact on household incomes and the perceptions of the farmers on the problems and benefits of integrating aquaculture into their farming systems.

The results of the study show the importance of understanding the local context for successful adoption of a new technology. The performance of rice-fish farming appears very promising, but the better-off farmers were more likely to adopt it and benefit from it. The study challenges development assistance agencies to find ways to ensure that the benefits of this technology are more widespread, especially to the poorer farmers for whom food security is often a special challenge.

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

ABSTRACT

Studies were undertaken on 256 farms in Bangladesh during 1992-1994 to assess the feasibility and economic viability of integrating fish culture with rice farming during *aman* (wet) and *boro* (dry) seasons in medium highlands. Data on management practices, costs and benefits and environmental impact of integration were collected and analyzed.

Management practices followed by the farmers included excavation of ditches as fish shelters during adverse conditions and strengthening of embankments above flood level. The species of fish stocked in rice fields included silver barb (*Barbodes gonionotus*); common carp (*Cyprinus carpio*); catla (*Catla catla*), rohu (*Labeo rohita)* and mrigal (*Cirrhinus mrigala*); Chinese carps such as silver carp (*Hypophthalmichthys molitrix*); Nile tilapia (*Oreochromis niloticus*); and freshwater prawn (*Macrobrachium rosenbergii*). Stocking densities varied widely and ranged from 1 316 to 27 292 fingerlings per ha during the *boro* season and 2 180 to 37 225 per ha during the *aman* season.

Farmers used rice bran and duckweed as fish feed, and cattle manure and occasionally triple superphosphate and urea as fertilizers. Fish production on average amounted to 233 $kg \cdot ha^{-1}$ during the *boro* season and 212 $kg \cdot ha^{-1}$ during the *aman* season. Fish production tended to increase with stocking density, in the absence of other limiting factors. Farmers who stocked at higher densities produced considerably more fish, on average, 577 $kg \cdot ha^{-1}$ during the *boro* season and 485 $kg \cdot ha^{-1}$ during the *aman* season. In addition, 70% of the integrated rice-fish plots had on average, higher rice yields (10.8%) compared to plots with only rice.

Integration resulted in production cost increases of 17.5% in the *boro* season and 15.4% in the *aman* season, compared to plots with only rice. However, integrated farms used less fertilizer, pesticide and labor for weeding, resulting in 10.1% lower rice cultivation costs during the *aman* season and 9.4% in the *boro* season, compared to plots with only rice. Slightly reduced cost of production and higher rice yields from integrated plots resulted in higher net benefits from rice cultivation alone to over 20% in integrated farms. Net benefit from integrated farms (from fish and rice) was on average 64.4% higher during the *boro* season and 98.2% higher during the *aman* season compared to farms with only rice.

Subsequently, a study was undertaken from October 1994 to January 1995, to assess the extent of adoption of the technology, factors contributing to and limiting adoption, factors affecting farmers' management decisions, and the effects of rice-fish farming on local farming systems and the family's general welfare. The study revealed that at least 243 farmers were undertaking rice-fish farming in Mymensingh district during the 1994 rainy season and that the practice was expanding steadily. Of these, an intensive survey of 47 farmers was undertaken.

The mean household size (9.43) and landholding (1.97 ha, including 1.44 ha of cultivated land) of integrated farms are much higher than average for the area. Mean area per farm under rice-fish farming was 0.22 ha in the *boro* season and 0.24 ha in the *aman* season.

The three stimuli most often indicated as encouraging farmers to take up the practice were motivation by extension workers, the experience of being involved in on-farm research and direct observation of examples.

Species most frequently stocked included common carp, silver barb, Indian major carps and Chinese carps. The most frequent factors affecting choice of species were expected good growth, high market price, availability and a desire to experiment. Vendors were the most common source of fingerlings. Stocking densities averaged 11 495 per ha in the *boro* season and 14 882 per ha in the *aman* season. Rice bran, cattle manure and mustard oil cake were the inputs most commonly applied.

Fifty-five percent of the *boro* farmers and 51% of the *aman* farmers reported increases in rice yields following integration of fish. Decreases were reported by 5% of the *boro* farmers and 30% of the *aman* farmers.

Farmers' estimated fish production averaged 1 107 $kg \cdot ha^{-1}$ in the *boro* season and 1 049 $kg \cdot ha^{-1}$ in the *aman* season. These figures were much higher than those for the 1992-1994 feasibility trials because these are the farmers' own estimates. Also, the farmers who adopted the technology stocked and fed their fish more intensively and often had larger ditches associated with the rice fields than did the cooperator farmers in the first trials. The households consumed about 25% of the catch.

Additional income and additional food for the family were the two benefits most often cited by integrated farming practitioners. Another 41% of the practitioners appreciated that the technology allowed them to make more efficient use of meager resources. Sixty-three percent indicated that rice-fish farming had not adversely affected the family's welfare. However, 22% did indicate that loans had to be taken to finance operations.

Eighty-nine percent of the farmers planned to continue with the technology. The remaining 11% were uncertain of their plans.

The survey clearly indicated that the better-off farmers were more likely to take advantage of the technology. This was indicated by the higher literacy rate, larger landholdings, higher cropping intensity and greater intensification of fish culture system (higher stocking densities and inputs) among the new adopters, resulting in more fish production and greater benefits. Lack of financial resources and time have been constraints for the marginal farmers to integrate fish culture with rice farming. Attention needs to be paid by the development agencies to bring benefits of the technology to marginal farmers.

1. INTRODUCTION

1.1 Rationale

Integrated rice-fish farming has had a long and varied history in Asia. The practice existed in China about two thousand years ago (Li 1992). Almost 1 million ha in China and 94 000 ha in Indonesia were reported to be under rice-fish farming (Lightfoot et al. 1992). While similar estimates are not available for Thailand and India, the practice has been expanding rapidly in both countries. Culturing fish and Azolla in rice fields is also an important component of organic farming in China (Wang Zaide et al. 1995).

The extent of the practice appears to be gradually changing. In the wake of crop intensification, the practice appears to be declining in parts of Indonesia and central Thailand (Koesoemadinata and Costa-Pierce 1992; Leelapatra and Sollows 1992), although there has been rapid expansion in other regions of the countries. In northeast Thailand, the decline in availability of wild fish stocks from traditionally fished systems, including rice fields, have resulted in many farmers taking to integrated rice-fish farming.

Integrated rice-fish farming practices are highly variable. Fish are usually cultured within rice areas protected from excess flooding by dikes. The rice plot normally includes a small trench, ditch, sump or refuge pond where fish can be held when water levels are low or prior to harvest. Fish are cultured either concurrently with rice or in rotation. A wide variety of fish species have been cultured, including common carp (*Cyprinus carpio*); Indian major carps such as rohu (*Labeo rohita)*, mrigal (*Cirrhinus mrigala*) and catla (*Catla catla*); Chinese carps such as silver carp (*Hypophthalmichthys molitrix*), and occasionally grass carp (*Ctenopharyngodon idella*); Nile tilapia (*Oreochromis niloticus*); silver barb (*Barbodes gonionotus*) and snakeskin gourami (*Trichogaster pectoralis*). Reported fish production figures also vary widely, ranging from under 100 kg·ha^{-1} to over 2 000 kg·ha^{-1}, depending on the intensity of the system (Lightfoot et al. 1992). In China, average fish production in 1988 from 800 000 ha of rice fields was estimated at 133 kg·ha^{-1} (MacKay 1995). In Indonesia, rice fields are also used as nurseries for raising fingerlings of common carp (Nalim 1994).

With a population of 114 million and growing at 2.2% per year, Bangladesh faces considerable challenges in meeting the food needs of its population (BBS 1995). The traditional staples of the Bangladeshi diet have been rice and fish. Rice production has increased with the growing population, but production of fish from traditional inland water sources, particularly rivers, has not increased to the same extent. Wild fish stocks are decreasing under increased exploitation, as well as environmental threats, and may not be able to meet the growing demand. Fish availability in rural areas is declining and prices are increasing, which will result in fish becoming unaffordable to a majority of Bangladeshis. Per capita protein consumption at 50.5 g·day^{-1} in 1992-1993 (BBS 1995) is on the decline. Of this, animal protein makes up 7.7 g, with fish contributing the major share with 4.4 g or 59.1%. Even this modest level will decline, if fish production is not increased on a national scale.

Under these circumstances, it is not surprising that aquaculture is growing rapidly. Aquaculture production increased by 9.9% during 1989-1990 to 1995-1996, accounting for 31.0% of total fish production. Pond culture systems have considerable potential for addressing the gap between supply and demand, but they may not in themselves be sufficient since many rural households do not have access to ponds.

Rice farming in Bangladesh has three main seasons: the *aman* crop, which coincides with the rainy season, is normally seeded in June-July, transplanted during July-September and most varieties are harvested from November to January. In irrigated areas, this is followed by a dry season irrigated *boro* crop, which is seeded in December-January, transplanted during January-February and harvested during May-June. Where moisture is sufficient, a third crop, *aus* is sometimes planted in between *boro* and *aman* during March-May and harvested in July-August (Fig. 1.1). *Aman* rice cropland and low-lying *boro* areas are usually flooded throughout the growing season. The rice growing area in Bangladesh during *aman, boro* and *aus* seasons in 1993/94 was estimated at 5.75, 2.58 and 1.65 million ha, respectively (BBS 1995). More than one-third of the area of the country is under rice cultivation.

Fish have traditionally been a natural component of rice field ecosystems in Bangladesh and have provided farmers with a convenient source of protein and income. Government agencies and NGOs are also promoting integrated pest management in an effort to lower dependence on pesticides. These efforts are making integration of rice cultivation and fish culture more compatible, since pesticides are not only hazardous to insects, but also to fish.

Given the importance of rice and fish in the national economy and diet, the decline in wild fish stocks, and the growing need for fish protein, the feasibility of integrating fish culture with rice cultivation has been attracting increasing attention and could result in fish becoming available to a substantially greater number of rural households.

Various agencies in Bangladesh have undertaken a number of on-station and on-farm experimental studies over the years on integrating aquaculture with agriculture (Das 1982; Islam and Ahmed 1982; Haroon and Alam 1992; Haroon et al. 1992; Ali et al. 1993; CARE 1993; Kamp and Gregory 1993; Kohinoor et al. 1993; Gupta et al. 1996; Gupta 1998). These studies have used a variety of species such as Indian carps, common carp, silver barb, Nile tilapia and catfish. While these studies have indicated the technical viability of integrating aquaculture with

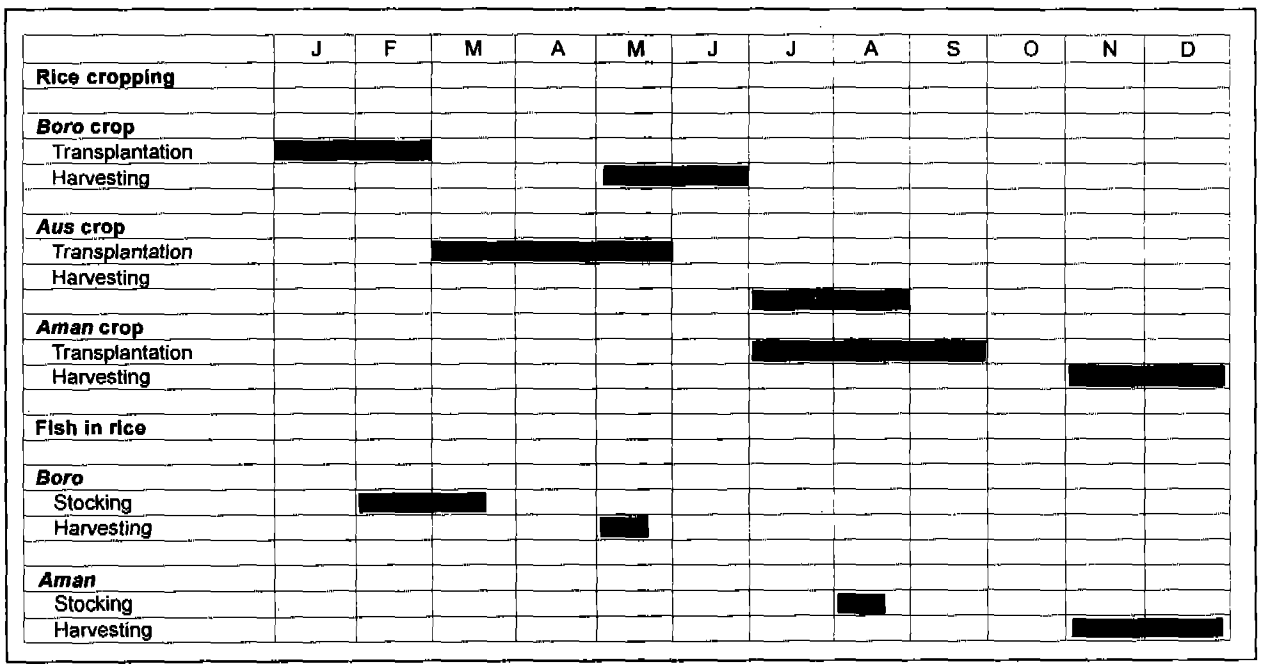

Fig. 1.1. Rice cropping pattern and integration of fish culture.

agriculture, very little is known of the economics of integration, the farmers' attitudes and their constraints to adoption.

The participants of the Third Asian Regional Rice-Fish Farming Research and Development Workshop in Indonesia in 1994 concluded that on-station trials and researcher-managed on-farm trials did not reflect the real situation. They also stressed the need for assessment of the viability of the technology through farmer-managed on-farm trials before policymakers could be asked to support dissemination of the technology. It was suggested that research should be carried out to document and quantify the effect of fish culture on rice ecosystems, particularly on rice yields and pest management. Constraints to adoption and the economic impact on farms should also be studied (de la Cruz 1994).

As a result, the Bangladesh Fisheries Research Institute (BFRI) and the International Center for Living Aquatic Resources Management (ICLARM) in collaboration with the Mymensingh Office of the Department of Agriculture Extension (DAE) undertook intensive studies during 1992-1994 in Mymensingh and Jamalpur districts (Fig. 1.2) to assess the economic viability of integrated rice-fish farming. The results of these farmer-managed on-farm trials are presented in Chapter 2 of this report. Subsequently, from October 1994 to January 1995, 47 farmers experienced in rice-fish farming were surveyed in Mymensingh district to assess the extent of adoption of the technology, factors contributing to and limiting adoption, factors affecting the farmers' management decisions and the effects of rice-fish farming on local farming systems and the general family welfare. The results of this survey are presented in Chapter 3 of this report.

1.2. Traditional rice-fish farming systems in Bangladesh

In the traditional rice-fish farming systems in Bangladesh, farmers excavate a small sump or ditch in their fields, modify the dikes and add brush to improve collection and capture of wild fishes (Dewan 1992). Fry of different carp species are sometimes stocked. Rice is harvested during November-December, but fish harvesting continues as late as March. According to MPO (1985), fish production from seasonal floodplains averaged around 37 kg·ha^{-1}, but this is considered a very rough estimate.

In coastal areas in the southern part of the country, fish/shrimp is cultured either concurrently or in rotation with rice, depending on salinity and other conditions. In this traditional system, rice fields are enclosed by small embankments with inlet and outlet channels controlled by sluice gates. The enclosed area, locally known as *gher,* could vary from 3 to 50 ha each. Tidal water carrying shrimp and fish juveniles are trapped in these *ghers* after the rice harvest, usually in January. Yields on an average were estimated at 210 kg of shrimp and 80 kg of fish·ha^{-1} (MPO 1985).

1.3. Integrated rice-fish farming studies in Bangladesh

Hossain et al. (1987) reported fish production of 43.2 to 146.3 kg·ha^{-1} when *L. rohita, C. catla, C. reba, C. carpio* and *B. gonionotus* were cultured in various combinations. In on-station studies, fish production averaged 400 kg·ha^{-1} when *O. niloticus* fingerlings were stocked at 60 kg·ha^{1} and water depth was maintained at 25-30 cm. Rice yields, however, were on average 1% lower than comparable unstocked fields (Haroon et al. 1992). Studies undertaken in deepwater rice ecosystems using 4-m-high net enclosures showed fish production as high as 650 kg·ha^{1} in four months with supplementary feeding. Although fish production was much

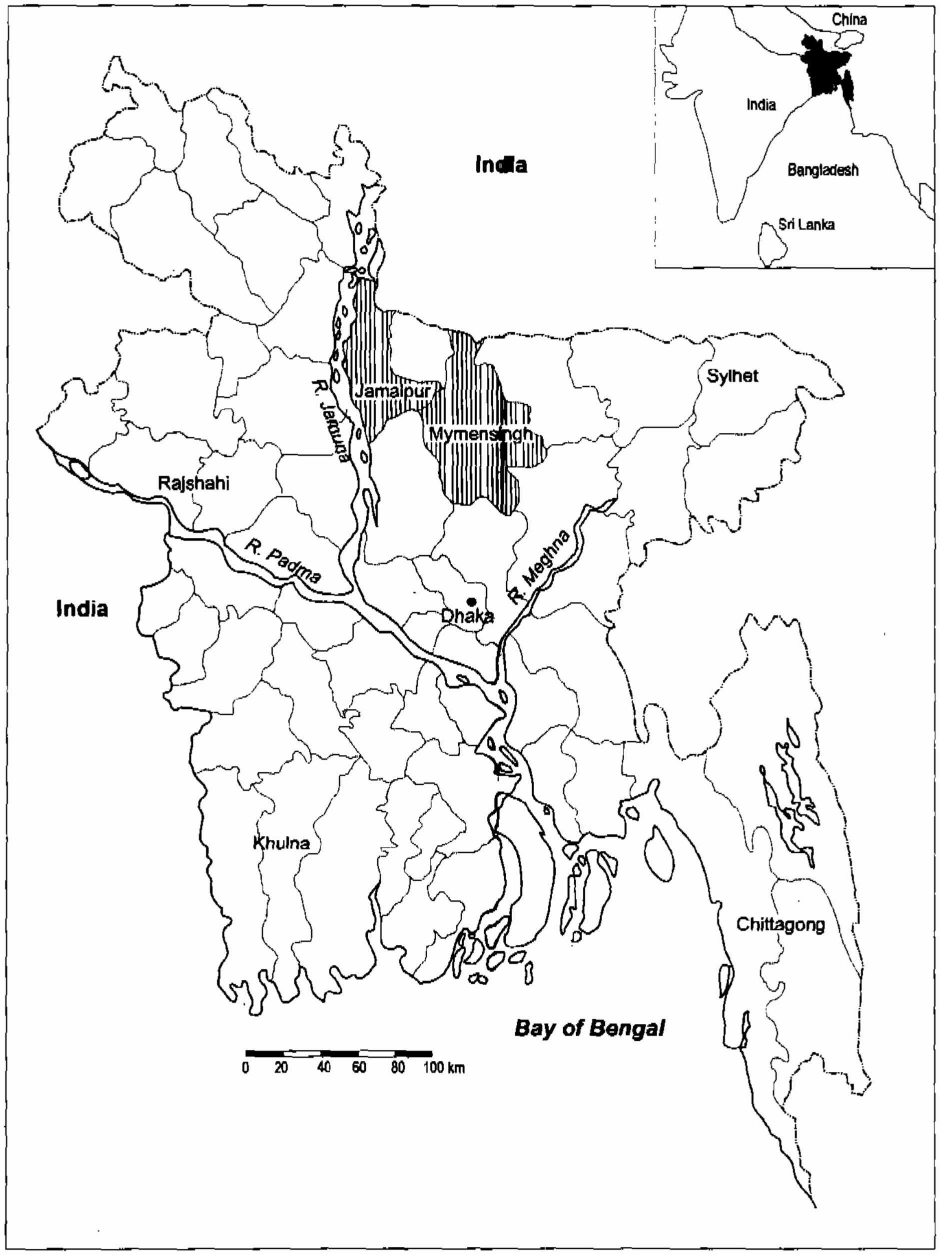

Fig. 1.2. Map of Bangladesh indicating study areas.

higher than more conventional rice-fish farming, the investment costs of the net enclosures to contain the fish were prohibitive making the operation uneconomical and unsustainable (Ali et al. 1993; Gupta 1998).

Based on on-station studies undertaken during 1987-1991, Haroon and Alam (1992) recommended stocking of 10 000 to 11 250 per ha of 8-9 g size seed of *Macrobrachium rosenbergii* in rice fields together with local varieties of rice. Their studies did not indicate any effect of feed and fertilizer on production. Stocking *L. rohita, C. catla, C. mrigal* and catfish (*Heteropneustes fossilis)* resulted in none of the carp species attaining marketable size over the growing season of six months; the catfish reached marketable size, but recovery was very low. Kohinoor et al. (1993) reported initial on-farm trials with *B. gonionotus* stocked at 3 000 per ha. Over a growing period of 70-90 days, gross production of fish reached 58-104 $kg{\cdot}ha^{-1}$.

NGOs are showing increasing interest in integrated rice-fish farming. Haroon et al. (1992) cited efforts in 1989 by the Noakhali Rural Development Program where 50 fields planted with local rice varieties were stocked with various species, including *L. rohita, C. catla, C. mrigala, C. carpio, C. idella* and *H. molitrix.* Stocking densities ranged from 3 000 to 6 000 per ha. Due to water logging, high-yielding varieties of rice were not suitable in these fields. After six months, production ranged between 223 and 700 $kg \cdot ha^{-1}$. The Bangladesh Rural Advancement Committee (BRAC) tested the technology in some areas in 1991, but the results were discouraging (Haq, pers. comm.).

In recent years, CARE has been the most active NGO involved in rice-fish farming, as part of its integrated pest management program. Kamp and Gregory (1993) reported appreciable returns from both the rainfed and irrigated systems, although the irrigated *boro* fields averaged higher returns because flooding was less of a problem. Most of the farms were used as nurseries to rear hatchlings and fry to fingerling size (CARE 1993). A few were used to grow marketable size fish from fingerlings while others were used for breeding and hatching common carp.

2. FEASIBILITY AND ECONOMIC VIABILITY OF INTEGRATING AQUACULTURE WITH RICE FARMING

2.1. Research methodology

The studies were carried out by farmers and research and extension workers on a total of 256 farms during five rice farming seasons: three rainy seasons (*aman*) from 1992 to 1994 and the two dry seasons (*boro*) of 1993 and 1994. The number of participating farmers varied from season to season. Eleven of the 12 thanas (subdistricts) in Mymensingh district as well as farmers from Sadar thana of Jamalpur district were involved (Fig. 1.2). The results presented in this report are based on data collected from 107 farms during the *aman* season and 149 farms during the *boro* season (Table 2.1).

The research team monitored management practices and water regimes to assess possible factors affecting fish production and economics because there was a great variation among the rice farms. Rice yields were also monitored throughout the course of these studies.

At each season, participating farmers and plots were selected by the DAE and BFRI personnel for monitoring. Criteria for selection of plots included level of interest on the part of the farmer, water-holding capacity of the plot and capacity of the farmer to make necessary preparations. In the *boro* season, preference was given to blocks of adjacent plots in an irrigated area in order to conserve water.

2.1.1. Soil structure

Farms included in the study were spread over a wider area during the *boro* season, resulting in considerably more varied soil types than during the *aman* season. During the *boro* season, 25% of the plots were in clay soils, 31% in loamy clay, 29% in loam, 11% in sandy loam and 4%

Table 2.1. Number of farms monitored in the study by season and thana. Mean plot area (ha) is in parenthesis.

Thana	No. of farms (mean plot area in ha)				
	Boro season		*Aman* season		
	1993	1994	1992	1993	1994
Mymensingh sadar	11 (0.21)	21 (0.32)	10 (0.17)	17 (0.24)	17 (0.27)
Muktagacha	10 (0.20)	11 (0.23)	24 (0.18)	-	-
Fulbaria	4 (0.30)	8 (0.23)	-	-	-
Trishal	7 (0.10)	-	-	-	2 (2.26)
Bhaluka	6 (0.31)	6 (0.62)	-	-	-
Gafargaon	1 (1.20)	11 (0.28)	-	-	-
Nandail	7 (0.29)	9 (0.54)	-	7 (0.37)	-
Ishorganj	1 (0.60)	-	9 (0.17)	-	-
Gouripur	5 (0.37)	6 (0.35)	9 (0.24)	4 (0.47)	8 (0.61)
Fulpur	4 (0.35)	7 (0.33)	-	-	-
Halwaghat	2 (0.40)	6 (0.20)	-	-	-
Jamalpur sadar	6 (0.28)	-	-	-	-
Total	64 (0.28)	85 (0.34)	52 (0.18)	28 (0.30)	27 (0.50)

An integrated rice-fish farm with the fish refuge at the center of the rice farm.

in sandy clay, silt or sandy soils. In the 1993 *aman* season, 67.5% of the plots were in loam, 30% of the plots in sandy loam and 2.5% in sandy soil. All 1994 *aman* plots were in loam soils.

2.1.2. Training

Following selection, farmers and DAE block supervisors were given training in rice-fish farming practices. Trainings were typically held on-site, and included a step-by-step description of the technology, as well as practical demonstrations. During the *boro* season, when pesticide use tended to be more prevalent, integrated pest management techniques were demonstrated. A total of 484 agriculture extension staff and 1 304 farmers were trained.

2.1.3. Plot preparation

Plot preparation involved strengthening and raising of dikes above flood level and the excavation of a small ditch or sump as fish refuge when water levels are low. The fish refuge typically occupied 1 to 5% of the rice field area, while some farms had larger natural depressions/ditches. The fish refuges were 0.5-0.8 m deep (Table 2.2). Farmers installed bamboo or net screens in the embankments to drain excess water during heavy rains and to prevent the fish from escaping.

2.1.4. Rice varieties

During the *boro* season, 12 high-yielding varieties of rice were planted by farmers in monitored farms. BR-14 was the most common variety planted in 42.3% of the plots, followed by Pajam in 22.1% of the plots (Table 2.3).

Table 2.2. Details of rice plot and ditch/sump area. Standard deviations are in parentheses.

Year	Season	No. of plots stocked	Plot area (ha)		Ditch area (m^2)		% of ditch in plot area	
			Range	Mean	Range	Mean	Range	Mean
1993	*Boro*	62	0.40 - 1.20	0.28 (0.22)	8 - 600	78 (107)	0.4 - 14.5	3.06 (3.39)
1994	*Boro*	85	0.80 - 1.20	0.34 (0.22)	40 - 320	81 (62)	1.0 - 13.6	2.80 (1.86)
1992	*Aman*	50	0.40 - 0.44	0.18 (0.09)	8 - 280	93 (60)	0.4 - 35.0	6.10 (5.64)
1993	*Aman*	28	0.12 - 0.80	0.30 (0.17)	20 - 320	80 (58)	1.0 - 7.0	2.96 (1.43)
1994	*Aman*	26	0.70 - 3.60	0.50 (0.76)	20 - 680	147 (173)	0.1 - 26.7	4.61 (5.34)

A total of 17 varieties of rice were planted in the *aman* season which included both local (35.3% of plots) and high-yielding (64.7% of plots) varieties (Table 2.4). Local varieties were preferred by some farmers for their tolerance to flooding. BR-11 was the variety most commonly planted (42.9% of the plots) followed by Pajam (29.5% of the plots).

2.1.5. Rice-fish farming practices

The integrated farmers followed normal rice farming practices. *Boro* plots were transplanted in January-February, about one month after seeding. A basal fertilizer dose of triple superphosphate (TSP), muriate of potash and gypsum was typically applied, followed by two to three doses of urea at two to three-week intervals. Many farmers also used cattle manure (Table 2.5). The plots were weeded once or twice during the *boro* season, usually about three weeks and six weeks after transplantation. Pesticide use was highly variable, but more frequent in the *boro* season. Rice was normally harvested in May.

Table 2.3. Rice varieties planted in two *boro* seasons, 1993-1994. The total exceeds 100% because several plots had two rice varieties.

Rice variety	No. of plots	Plots with this variety (%)
BR-14	63	42.3
Pajam	33	22.1
BR-3	21	14.1
BR-11	5	3.4
BR-2	16	10.7
Fizer	11	7.4
Lota	2	1.4
IR-8	4	2.7
Purbashi	6	4
BR-16	1	0.7
BR-23	1	0.7
Iratom	1	0.7
Total	149	

Table 2.4. Rice varieties planted in three *aman* seasons, 1992-1994. The total exceeds 100% because several plots had two rice varieties.

Rice variety	No. of plots	Plots with this variety (%)
Unknown	2	1
BR-11	45	42.9
Pajam	31	29.5
Kumri[a]	6	5.8
BR-10	5	4.8
Kashin-bini	2	1.9
Aloi[a]	3	2.9
Boji-uzzaman	2	1.9
Biroi[a]	2	1.9
IR-8	1	1.0
BR-23	1	1.0
Binaisail[a]	1	1.0
Kishobganj[a]	1	1.0
Kalizira[a]	1	1.0
Boroabza[a]	1	1.0
Aliboza[a]	1	1.0
Basiraj	4	3.8
Lakri Bilas	1	1.0
Total	105	

[a]Local varieties of rice.

Table 2.5. Fertilizer application rates for *boro* and *aman* rice crops. Standard deviations and ranges are in parentheses.

Fertilizer	*Boro* 1994		*Aman* 1993	
	Mean rate (kg·ha^{-1})	Farmers who used (%)	Rate (kg·ha^{-1})	Farmers who used (%)
Urea	207.0 (69) (60-417)	100.0 (0-200)	62.8 (57.3)	70.0
TSP	75.8 (43.3) (0-200)	85.9 (0-75)	6.5 (20.1)	10.0
MP	49.0 (57.2)	80.0 (0-352)	3.35 (12.1)	7.5 (0-50)
Gypsum	30.1 (36.1)	51.8 (0-150)	5.0 (18.1)	7.5 (0-75)
Cattle manure	137.0 (151)	62.4 (0-893)	6.3 (39.5)	2.5 (0-250)

In general, *aman* rice cultivation is less intensive than *boro*. *Aman* plots are usually transplanted in July-August, about one month after seeding. Fertilization rates were much lower in the *aman* season (Table 2.5). Weeding was less frequent for *aman* than for *boro* rice: only 21 farmers out of 40 (52.5%) reported weeding in the 1993 *aman* season, whereas all farmers weeded their plots during *boro* season. Harvesting is done mostly in November-December.

2.1.6. Fish culture

2.1.6.1. Stocking

Farmers stocked fish fingerlings in rice plots 15-20 days after rice transplantation and when water in the rice field had accumulated to a depth of at least 8-10 cm. If the ditches/sumps were full of water and there were no predator fish, fingerlings were sometimes stocked prior to rice transplanting. Suggested density of fingerlings stocking was 3 000 per ha. In practice, deviations from these densities were common with some farmers stocking at higher densities leading to overstocking. Species stocked consisted primarily of *C. carpio* in the *boro* season and *B. gonionotus* in the *aman* season, reflecting the seasonal availability of these fingerlings. Few farmers stocked *O. niloticus* in any season since the species had less consumer preference and fetched a lower price in the market. All three species can reach an acceptable marketable size within a relatively short period. Harvested weights of over 80 g for *O. niloticus* after about four to six months' rearing in low-input seasonal pond aquaculture was reported by Gupta (1992) and Gupta et al. (1991, 1992). Gupta (1992) and Gupta and Rab (1994) indicated that *B. gonionotus*

Silver barb (*Barbodes gonionotus*), one of the cultured species in integrated rice-fish farming.

could grow well under low-input pond culture with fish production of 0.7-1.5 t·ha^{-1} in three to eight months' rearing. According to Jahan and Gupta (1994), *C. carpio* could grow to larger sizes than indicated above during similar period. These studies clearly indicate the suitability of these species for short duration culture and they were by far the three most common species cultured in rice fields in northeast Thailand (Leelapatra and Sollows 1990).

2.1.6.2. Input use

Following stocking, farmers applied a variety of inputs. The majority of farmers used rice bran as supplementary feed and cattle manure as fertilizer. Duckweed (*Lemna* sp.) was also often used as additional feed. A few farmers used other feeds, including mustard oil cake and wheat bran (Table 2.6). Dikes and drains were repaired throughout the season as needed. The fish were normally harvested three to four months after stocking.

2.1.6.3. Water depth and rearing period

Water depth in rice fields varied from farm to farm and during different times of culture period. Water depth during the *boro* season was almost nil to 30 cm, while during the *aman* season it was 5-47 cm (Table 2.7). In several cases, the rice plot was not entirely flooded and as a result the rice growing area accessible to the fish varied from 10% to 100% during the *boro* season and 66.7% to 100% during the *aman* season. The rearing period of fish varied from plot to plot depending on water availability and was in the range of 34-113 days during the *boro* season and 42-138 days during the *aman* season (Table 2.7).

2.1.7. Monitoring

Farms were visited at one to two week-intervals and information collected on inputs used for rice and fish, pest control, water depth in rice fields, irrigation and production of fish and rice. At the close of the season, harvests and sales were recorded (data collection format used is in Annex 1). Some monoculture rice farms were also monitored to compare the costs and production of rice (Annex 2). Caution has been exercised in comparing results among seasons as the monitoring methods were refined with experience. Logistics also affected monitoring differentially from season to season.

Table 2.6. Supplementary feeds and fertilizers applied by users during *boro* and *aman* seasons. Standard deviations and ranges are in parentheses. Data for ricebran, cattle manure and duckweed are from two *boro* seasons and three *aman* seasons. Data for mustard oil cake and wheat bran are from the 1994 season only.

Input	*Boro*		*Aman*	
	Mean rate (kg·ha^{-1})	Farmers who used (%)	Mean rate (kg·ha^{-1})	Farmers who used (%)
Rice bran	205.1 (248.2) (4.2-1687.5)	88.0	318.8 (261.9) (35.0-1137.5)	93.3
Duckweed	175.3 (155.7) (8.6-500.0)	13.0	261.8 (253.3) (7.5-1062.5)	42.0
Mustard oil cake	8.8 (0)	1.2	46.9 (41.9) (8.3-104.2)	14.8
Wheat bran	48.2 (37.9) (5.0-95.5)	4.7	97.0 (87.2) (20.8-222.2)	18.5
Cattle manure	428.3 (465.7) (10.0-3928.6)	86.0	295.2 (327.7) (25.0-1291.7)	60.0

Table 2.7. Data on water regimes and fish culture periods by season. Standard deviations and ranges are in parentheses. For all *aman* seasons, plot depths are based on 1993 and 1994 data; per cent inundation based on 1994 data.

Season	Year	No. of cases	Water depth (cm)	% inundation of plot	Fish culture period (days)
Boro	1993	62	8.91 (5.50)	81.1 (23.3)	81.1 (16.2)
			(0.76-29.97)	(10-100)	(34-113)
	1994	85	12.85 (3.85)	96.8 (6.0)	70.9 (7.0)
			(5.08-20.57)	(70-100)	(55-88)
	All	147	11.19 (5.00)	90.1 (17.6)	75.3 (13.0)
			(0.76-29.97)	(10-100)	(34-113)
Aman	1992	49	NA[a]	NA[a]	84.4 (14.5)
					(44-121)
	1993	28	15.03 (2.72)	NA[a]	84.5 (10.4)
			(9.65-21.08)		(57-94)
	1994	26	19.95 (11.00)	86.1 (8.8)	87.1 (25.4)
			(5.08-47.50)	(66.7-100)	(42-138)
	All	103	17.45 (8.25)	86.6 (8.8)	85.0 (18.5)
			(5.08-47.50)	(66.7-100)	(42-138)

[a]NA - Data not available.

2.1.8. *Data analysis*

Data were analyzed with FOXPRO, SPSS PC+ and SAS/ETS packages. Both descriptive and econometric tools were used to present the results of the study in this report. The primary econometric tool was multiple linear regression to test the relationship between variables (average weight at harvest, survival and yield) and the various parameters monitored. Correlations between various individual variables were also investigated.

Yield or production per unit area is a function of stocking density, growth (size of fish at harvest) and recovery. Growth and survival rates are also dependent on factors such as input use and production environment. Regression models were estimated for growth (average weight at harvest) and survival rate based on data collected through on-farm monitoring. As both equations (average weight and survival rate) have similar sets of independent variables and are parts of a simultaneous system, regression coefficients were estimated by the seemingly unrelated regression (SUR) method (Zellner 1962)

2.2. Results

Data were collected from 149 and 107 farms during *boro* and *aman* seasons, respectively, but only information from 145 *aman* and 98 *boro* farms was used in the analysis since the other farms had missing information for several important variables.

2.2.1. *Boro season*

2.2.1.1. Species stocked and density

C. carpio was the predominant species stocked in the *boro* season, mainly due to availability of the seed of the species at that time of year. A few plots were stocked with *B. gonionotus* and *O. niloticus*, either in monoculture or in combination with other species. In 1994, 12 farmers stocked additional fish of various species, which are the "multispecies" plots referred to in this report. Additional species stocked by farmers included *H. molitrix*, *L. rohita*, *C. catla*, *C. mrigala* and *C. idella*.

Table 2.8. Species, stocking density and size of fish at stocking during *boro* season. Standard deviations are in parentheses.

Species	No. of cases	Stocking density per ha	Size at stocking (cm)			Average
			C. carpio	*B. gonionotus*	*O. niloticus*	
C. carpio	96	3 400 (1 107)		5.40 (0.96)		5.40 (0.96)
B. gonionotus	13	3 017 (319)	7.36 (1.64)			7.36 (1.64)
O. niloticus	8	3 156 (442)			10.10	10.10
C. carpio + *B. gonionotus*	13	3 070 (324)	5.62 (1.58)	8.75 (1.59)		7.18 (0.94)
C. carpio + *O. niloticus*	1	4 667	4.80		10.10	7.45
B. gonionotus + *O. niloticus*	2	3 643 (909)		8.00	6.70	7.35
Multispecies	12	9 323 (7 503)	4.80	9.00	6.70	5.77 (1.88)
All	145	3 825 (2 814)	5.37 (1.01)	8.12 (1.63)	9.53 (1.32)	6.07 (1.64)

Average stocking density ranged from 3 017 per ha in farms stocked with *B. gonionotus* to 9 323 per ha in farms stocked with multispecies, with an overall average of 3 825 per ha. Average size of fingerlings at stocking was 5.4 cm for *C. carpio*, 7.4 cm for *B. gonionotus* and 10.1 cm for *O. niloticus* (Table 2.8).

2.2.1.2. Feed and fertilizer use

Rice and/or wheat bran was used as supplementary fish feed by 88% of farmers during the *boro* season. A few farmers used other feeds such as oil cake (meal) or duckweed (*Lemna* sp.). About 86% farmers used cattle manure as fertilizer. Only one farmer used chemical fertilizers, urea and TSP during the *boro* season, while four farmers (2.75%) used lime (Table 2.9).

2.2.1.3. Water depth and rearing period

Water depth in rice fields varied from field to field and during different times of the culture period. The water depth in rice fields during the *boro* season ranged from almost nil to 30 cm, with an overall average of 11.2 cm. The average water depth was less than 15 cm in all plots except where *C. carpio* and *O. niloticus* in combination were cultured.

Rearing period of fish depended on water availability, varying from 34 to 113 days, with an average of 75 days during the *boro* season. Plots with lower water depth had shorter culture period due to limited water; however, above a certain depth, the effect of water depth on culture period was not obvious (Table 2.10)

2.2.1.4. Fish production

Production is a function of stocking density, growth (in this case, approximated by the size of fish at harvest) and recovery. Table 2.11 shows average weight of fish at harvest, recovery percentage and total fish production during the *boro* season. On average, production from fish

Table 2.9. Mean input use level (kg·ha^{-1}) for fish culture during *boro* seasons of 1993 and 1994. Standard deviation are in parentheses.

Input	No. of users	Farmers who used (%)	Input use level (kg·ha^{-1})	
			Users	Users and nonusers
Urea	1	0.7	9.26	0.06 (0.77)
TSP	1	0.7	6.18	0.04 (0.51)
Cattle manure	125	86.2	427.46 (464.64)	368.50 (455.83)
Duckweed	18	12.4	175.10 (157.98)	21.73 (79.38)
Oil cake	9	6.2	16.61 (5.71)	1.03 (4.24)
Rice/wheat bran	128	88.3	202.39 (245.60)	178.66 (239.72)
Lime	4	2.8	8.29 (4.94)	0.23 (1.54)

Table 2.10. Water depth and fish culture period by species during *boro* season.

Species	No. of cases	Water depth (cm)		Culture period (days)	
		Average	Standard deviation	Average	Standard deviation
C. carpio	96	11.38	5.26	76.7	12.5
B. gonionotus	13	7.77	3.86	77.2	21.6
O. niloticus	8	10.64	3.20	73.8	8.2
C. carpio + B. gonionotus	13	11.73	3.20	72.4	7.8
C. carpio + O. niloticus	1	18.80	-	65.0	-
B. gonionotus + O. niloticus	2	7.62	1.80	65.5	0.7
Multispecies	12	13.49	4.78	67.3	8.9
All	145	11.22	4.98	75.2	12.9

stocked amounted to 233 kg·ha^{-1} (details of additional production from wild fish are in section 2.7). The average weight of fish at harvest was 121 g and the survival rate was 55.6%. Among various species combinations followed by farmers, multispecies stocking resulted in the highest average weight of fish at harvest (241 g). Except for one plot stocked with a combination of *C. carpio* and *O. niloticus*, the average recovery rate did not vary substantially among various species combinations and was in the range of 49.1% to 69.5%. Plots stocked with multispecies resulted in higher average production of 605 kg·ha^{-1}, as these plots produced larger fish at harvest, higher stocking density and modest survival rate (49.1%).

The recovery rate and size of fish at harvest varied greatly, as conditions among rice fields were highly variable.

2.2.1.5. Factors affecting fish production during *boro* season

Various factors affecting fish production, such as stocking density, input use levels, culture period, water depth in the plot, ditch size, presence or absence of flooding, species combination followed and soil structure, were investigated. Multivariate analysis of input use level and production environment with harvested size of fish and rate of recovery was undertaken. Results of seemingly unrelated regression estimation of harvested size and rate of recovery are in Table 2.12.

Stocking density. Regression analysis indicated a significant and negative relationship between stocking density and recovery rate, but no significant effect on harvested size of fish. A 1% increase in stocking density is expected to decrease survival rate by 0.14% with insignificant decrease in harvested size. Fish production showed positive correlation with stocking density. Stocking density ranged from 1 316 to 27 293 per ha, with a mean of 3 825 per ha. Cultured fish production ranged from 0 to 1 447 kg·ha^{-1}, with an average of 233 kg·ha^{-1}. Stocking densities less than 3 000 per ha led to a mean production of 164 kg·ha^{-1}, while plots stocked at over 6 000 per ha had a mean production of 616 kg·ha^{-1} (Table 2.13).

Table 2.11. Stocking density, weight at harvest, recovery rate and production of fish during *boro* seasons of 1993 and 1994. Standard deviations are in parentheses.

Species	No. of cases	Stocking density per ha	Average weight at harvest (g)	Recovery (%)	Fish production (kg·ha^{-1})
C. carpio	96	3 400 (1 107)	115 (56)	53.8 (24.5)	204 (133)
B. gonionotus	13	3 017 (319)	95 (72)	65.0 (22.3)	188 (154)
O. niloticus	8	3 156 (442)	108 (25)	69.5 (12.1)	239 (75)
C. carpio + B. gonionotus	13	3 070 (324)	107 (42)	59.3 (15.4)	187 (64)
C. carpio + O. niloticus	1	4 667	86	39.6	158
B. gonionotus + O. niloticus	2	3 643 (909)	25 (4)	50.5 (35.4)	47 (37)
Multispecies	12	9 323 (7 503)	241 (255)	49.1 (24.4)	605 (385)
All	145	3 825 (2 814)	121 (96)	55.6 (23.4)	233 (197)

Table 2.12. Seemingly unrelated regression estimates for harvested weight and recovery rate.

Independent variable	Ln harvested weight ($kg{\cdot}fish^{-1}$)		Recovery rate (%)	
	Estimated coefficient	I t I ratio	Estimated coefficient	I t I ratio
Intercept	-6.231 ***	4.08	1.425 ***	3.20
Ln Plot water depth (cm)	0.322 ***	3.71	0.135 ***	4.05
Ln Rice/wheat bran ($kg{\cdot}ha^{-1}$)	-0.005	0.29	0.028 ***	3.92
Ln Stocking density ($no.{\cdot}ha^{-1}$)	-0.103	0.75	-0.136 **	2.43
Ln Culture Period (days)	0.979 ***	4.39		
Ditch-plot ratio (%)	0.004 **	2.56	0.001 **	2.55
Flood dummy (1 if flooded)			-0.190 ***	5.16
Species dummy I (1 for *B. gonionotus*)	-0.156	1.13	0.070	1.23
Species dummy 2 (1 for *O. niloticus*)	-0.068	0.38	0.053	0.75
Species dummy 3 (1 for multispecies)	0.552 **	2.96	-0.052	-0.66
Species dummy 4 (1 for 2 species)	-0.207 *	1.62	0.007	0.13
Year dummy (1 for 1994)	0.086	0.82	-0.091 **	2.28
Adjusted R^2	0.74		0.95	
System weighted R^2		0.45		

*$p<0.1$; **$p<0.05$; ***$p<0.01$.

These results clearly indicate that fish production under the range of culture conditions in these trials increased with increase in stocking intensity. The recommended stocking rate of 3 000 per ha was below the optimal rate. Closer inspection of the data suggests that this relationship diminished at higher densities, but a clear point of diminishing returns is not present (Fig. 2.1).

Feed. Only rice and wheat bran were used as the feed input in the regression analysis, since these were the supplementary feeds used by the majority of farmers. Regression analysis indicated that rice and/or wheat bran had significant and positive relationship with recovery, but their relationship to average size of fish at harvest was not significant. Any effect at or below the mean levels applied appear negligible, but more intensive feeding may have some effect on size of fish at harvest.

Estimated coefficients reveal that a 1% increase in rice and/or wheat bran application would increase recovery rate by 0.03%, although the reason is rather unclear. Most farmers tended to feed

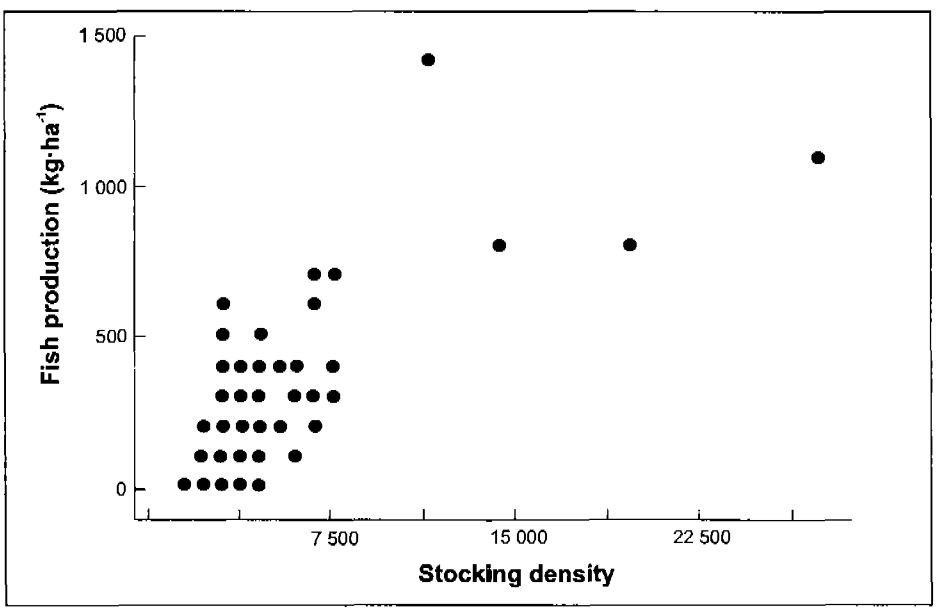

Fig. 2.1. Fish production at different stocking densities during *boro* season.

Table 2.13. Fish production at different stocking densities during *boro* season. Standard deviations are in parentheses.

Density (per ha)	No. of cases	Mean fish production ($kg \cdot ha^{-1}$)
0-3 000 (mean=2 952)	103	164 (92)
3 000-6 000 (mean=4 118)	30	276 (150)
Over 6 000 (mean=10 032)	14	616 (351)

Table 2.14. Coefficients of correlation (r) between high and low levels of rice bran and cattle manure use and fish production. Data from nonflooded plots only. "Level" is relative to the mean of each input (**:p<.001; *:p<.01). 'n' is number of cases.

Input		Production parameter (m=parameter mean)		
Level	Mean ($kg \cdot ha^{-1}$)	Production ($kg \cdot ha^{-1}$)	Recovery (%)	Size of fish at harvest (g)
Rice bran				
Low	75	n = 73 m = 215 r = 0.244	n = 60 m = 55.8 r = 0.311*	n = 59 m = 106 r = 0.124
High	402	n = 36 m = 344 r = 0.229	n = 28 m = 76.1 r = 0.128	n = 28 m = 102 r = 0.301
Cattle manure				
Low	115	n = 64 m = 227 r = 0.224	n = 54 m = 56.3 r = 0.183	n = 53 m = 111 r = 0.215
High	590	n = 45 m = 302 r = 0.227	n = 34 m = 71.6 r = 0.333	n = 34 m = 96 r = 0.399*

in or near the fish refuge usually located in the lowest part of the field where fish congregated. They were therefore less likely to get stranded elsewhere in the field and die when water level dropped.

Although cattle manure was not incorporated in the regression analysis, the effects of both cattle manure and rice bran were analyzed using simple correlation coefficients (Table 2.14). Neither feed nor fertilizer (as represented by rice bran and cattle manure) had significant correlation with size of fish at harvest at the low level of input use. However, size of fish at harvest and cattle manure application had a positive significant relationship at the higher levels of cattle manure use.

Level of duckweed application was also recorded, but no significant relationship with production parameters was indicated. Many of the farmers who did not provide duckweed indicated that this was because of an abundance of natural feed in the rice fields. These plots were dropped from the analyses when this fact was noted. Duckweed was applied in only 18 plots, at a mean rate of 175 kg. This was a small sample and hence no conclusion could be reached on the effect of duckweed on fish production.

The evidence for an effect of feeding and fertilization on growth remains inconclusive, but feeding appears to enhance recovery of fish from integrated farms.

Water regime. Mean water depth in the rice plot, averaging 11.2 cm, had a significant and positive relationship with size of fish at harvest and recovery. At a low depth, development of natural fish food organisms was less, movement of fish restricted and crowding inhibited growth. Shallow water depth also appeared more likely to limit recovery.

As the inundated area of the rice plot was strongly related to depth of water, these two variables were not included together in the regression analysis. However, estimates of simple correlation coefficients between mean percent inundation of the plot and of fish production parameters (production, recovery and size of fish at harvest) indicate that inundation is more likely to limit recovery when less than 90% of the field is normally covered by water (Table 2.15).

It appears that farmers who could continuously keep more water in over 90% of plot area were more likely to achieve higher fish production than the farmers with less stable or shallower water regimes in their plots.

Culture period. Culture period was included only in the size of fish at harvest equation, not in the recovery equation. Results indicate that culture period, which averaged 75.3 days overall, was significantly and positively related with size of fish at harvest. Hence, it is expected that, within the range of culture period practised by the participating farmers (34 to 113 days), size of fish at harvest and overall production are expected to increase with increase in culture period.

Rice plot and fish refuge size. Both fish refuge-rice plot ratio and fish refuge area were used separately in the regression equations. Fish refuge-rice plot ratio averaging 2.9% gave statistically consistent results, showing positive and significant relationship with both average size of fish at harvest and recovery. This suggests that, within the range of fish refuge-rice plot ratios (ranging from almost nil to 18%) practiced by farmers, fish production could be increased by increasing the size of ditch per unit area.

As plot size is significantly correlated with input use levels, plot size was not included in the regression models. However, simple correlation analysis indicates that plot size, which averaged 0.31 ha overall, had no clear relationship with production parameters.

Flooding. Flooding was reported in 17.7% of the plots during the 1993 season and in 31.8% of the plots in 1994. In the *boro* season of 1994, recovery from flooded plots was 53% of that of nonflooded plots and production reached only 42.3% of the mean level from nonflooded plots (Table 2.16). Fewer cases of flooding were reported in 1993 and no clear effect was indicated. The dummy variable representing flooded and nonflooded situation was included in the recovery equation. Results indicate that recovery from flooded plots was 19% lower than that of nonflooded plots.

Effect of species. Aside from the effects of input use levels, stocking density and production environments, the effect of various species combinations on production parameters was estimated. The results indicate that multispecies combinations had higher growth performance as compared to single or two species culture. This may be due to better performance of some of the species in this polyculture system and efficient utilization of natural and supplementary feeds. In addition, plots stocked with multispecies had larger ditches, and ditch-plot area ratio averaged 0.032 (±0.013), compared to 0.029 (±0.026) for others.

Effect of soil type on production. Soil type appeared to have an effect on production in 1994, with lower yields in sandy soils (including silt, sandy and sandy clay) compared to nonsandy soils

Table 2.15. Coefficients of correlation (r) between high and low levels[a] of percent inundation of plot and fish production parameters. Data were from nonflooded plots.

Inundation of plot (%)		Production parameter (m-parameter mean)		
Level	Mean	Production ($kg{\cdot}ha^{-1}$)(%)	Recovery	Size of fish at harvest (g)
Low	64.4	n = 30 m = 171 r = 0.439*	n = 23 m = 56.2 r = 0.556*	n = 22 m = 92 r = 0.150
High	98.0	n = 78 m = 292 r = 0.092	n = 64 m = 64.6 r = 0.169	n = 64 m = 110 r = 0.201

[a] "Level" is relative to the mean of each input (*:p<.01; **:<.001). 'n' is number of cases.

Table 2.16. Effect of flooding on fish production during *boro* season. Standard deviations are in parentheses. Recovery and harvested size are based on figures for *C. carpio* only.

Year	Flood situation	No. of cases	Fish production ($kg \cdot ha^{-1}$)		Weight of fish at harvest (g)		Recovery (%)
			Range	Mean	Range	Mean	
1993	Flood	11	21-568	230 (186)	67-200	113 (41)	54 (25)
	No flood	51	0-604	225 (154)	15-304	115 (60)	61 (27)
1994	Flood	27	52-270	121 (46)	80-152	119 (20.2)	34 (11)
	No flood	58	63-1 446	286 (253)	55-150	95 (18)	64 (18)
Both years	Flood	38	21-568	152 (116)	67-200	118 (26)	39 (18)
	No flood	109	0-1 446	258 (213)	15-304	105 (45)	62 (23)

(loam, clay and loamy clay). However, no such pattern was evident during 1993 (Table 2.17). Bigger fingerlings stocked by farmers in plots with sandy soils during 1993 might have mitigated any negative effect of soil on production.

2.2.2. Aman *season*

2.2.2.1. Species stocked and density

B. gonionotus was the major species stocked in the *aman* season because of easy availability of fingerlings. *C. carpio* was stocked in some plots, either in combination with *B. gonionotus* or alone (Table 2.18). Multispecies stocking is becoming increasingly popular. Additional species stocked in the *aman* season included *H. molitrix*, *L. rohita*, *C. mrigala*, *C. catla* and *C. idella*.

Average stocking density ranged from 3 130 per ha in farms stocked with *B. gonionotus* to 6 778 per ha in farms with multispecies stocking, with an overall average of 4 082 per ha. Average size of fingerlings at stocking was 8.8 cm for *C. carpio*, 7.6 cm for *B. gonionotus* and 7.3 cm for all species (Table 2.18).

2.2.2.2. Feed and fertilizer used

Rice and/or wheat bran as supplementary feed was used by 92% of farmers during the *aman* season. The mean level of rice bran applied by users only for the three seasons was 302.1 $kg \cdot ha^{-1}$. About 57% farmers used cattle manure as fertilizer, with an average of 280.1 $kg \cdot ha^{-1}$ for users only and 164.6 $kg \cdot ha^{-1}$ for all farmers. Only 39% farmers used duckweed during the *aman* season; duckweed use averaged 252.2 $kg \cdot ha^{-1}$ when users only were taken into consideration and 103.5 $kg \cdot ha^{-1}$ when averaged among all farmers (Table 2.19).

Table 2.17. Fish production parameters by soil type during *boro* season. Recovery and harvested size are based on figures for *C. carpio* only. Standard deviations are in parentheses.

Year	Soil type	No. of cases	Fish production ($kg \cdot ha^{-1}$)	Weight of fish at harvest (g)	Recovery (%)
1993	Sandy	14	291 (138)	107 (43)	74 (21)
	Nonsandy	48	207 (160)	117 (61)	55 (27)
1994	Sandy	9	130 (47)	85 (16)	44 (11)
	Nonsandy	76	246 (233)	106 (21)	53 (22)
Both years					
	Sandy	23	228 (136)	100 (38)	64 (23)
	Nonsandy	124	231 (208)	111 (41)	54 (24)

Table 2.18. Species, stocking densities and size of fingerlings at stocking during *aman* season. Standard deviations are in parentheses.

Species	No. of cases	Stocking density (per ha)	Size at stocking (cm)		
			C. carpio	*B. gonionotus*	Average
C. carpio	4	4 090 (2 314)	8.83 (2.28)	-	8.83 (2.28)
B. gonionotus	53	3 130 (603)	-	7.62 (1.70)	7.62 (1.70)
C. carpio + B. gonionotus	20	3 771 (1 611)	7.88 (2.32)	8.86 (2.01)	8.28 (1.87)
Multispecies	21	6 778 (2 834)	-	-	5.13 (0.81)
All	98	4 082 (2 198)	8.04 (2.29)	7.32 (2.05)	7.27 (1.97)

2.2.2.3. Water depth and rearing period

The water depth in rice fields during *aman* season varied from 0 to 47.5 cm, with an average of 8.94 cm. During some sampling periods, there was no water in the rice field where the depth reading was taken and the fish were forced to move to low-lying areas or to ditches. This would have an effect on the growth and survival of fish. Plots where multiple species were stocked had higher water depth, 5.1-47.5 cm, with an average of 18.97 cm. In about 25% of the plots, where *C. carpio* and *C. carpio* along with *B. gonionotus* were stocked, average water depth was less than 2.5 cm (Table 2.20).

The rearing period in the *aman* season was longer than the *boro* season, varying from 42 to 138 days, with an average of 85 days. Unlike in the *boro* season, the rearing period is not directly related to water depth as the *aman* crop is grown in the wet season with sufficient rainfall.

2.2.2.4. Fish production

On average, fish production during the *aman* season amounted to 184 kg·ha^{-1}. The average weight of fish at harvest was 90 g and the survival rate 59%. Production from 53 plots stocked with *B. gonionotus* had an average of 125 kg·ha^{-1}, while production from 20 plots stocked with both *B. gonionotus* and *C. carpio* was lower at 116 kg·ha^{-1} (Table 2.21). These figures represent the production from stocked fish and do not include the wild fish catches which are detailed in section 2.7. Only four plots were stocked exclusively with *C. carpio* which is too small a sample to draw conclusions from, but the production potential of *C. carpio* looks encouraging. As in the *boro* season, an increasing number of farmers stocked supplementary fish (the multispecies plots), which enhanced production considerably in many cases. Plots without additional fish were stocked at a mean density of 3 346 per ha, and achieved a mean production of 122 kg·ha^{-1}. The mean stocking density of the multispecies plots was 103% higher (6 778 per ha) and production was 224% higher (396 kg·ha^{-1}) than in the other plots.

Among various species combinations followed by farmers, multispecies stocking gave highest average weight of fish at harvest (214 g); thus in spite of lower recovery (34%), these plots had higher yields (Table 2.21).

Table 2.19. Input use level for fish culture component in rice-fish farming during *aman* seasons of 1992-1994.

Input	No. of users (%)	Input use level (kg·ha^{-1})			
		Users only		Users and nonusers	
		Mean	S.D.	Mean	S.D.
Cattle manure	57	280.09	319.31	164.59	280.51
Duckweed	39	252.18	230.89	103.53	192.63
Rice/wheat bran	92	302.11	249.74	283.61	252.61

Table 2.20. Water depth and fish culture period by species combination during *aman* season.

Species	Depth of water in rice field (cm)		Culture period (days)	
	Average	S.D.	Average	S.D.
C. carpio	2.20	0.05	91.8	19.4
B. gonionotus	8.18	9.12	84.6	12.8
C. carpio + B. gonionotus	2.18	5.31	84.6	15.0
Multispecies	18.97	11.84	87.0	26.2
All	8.94	10.67	85.4	17.0

Table 2.21. Average values for weight at harvest, recovery rate and production of fish during *aman* seasons of 1992-1994. Standard deviations are in parentheses.

Species	No. of cases	Stocking density per ha	Weight at harvest (g)	Recovery (%)	Fish production ($kg \cdot ha^{-1}$)
C. carpio	4	4 090 (2 314)	54 (19)	76.8 (13.4)	156 (77)
B. gonionotus	53	3 130 (603)	58 (29)	66.4 (15.6)	125 (90)
C. carpio + B. gonionotus	20	3 771 (1 611)	53 (38)	61.7 (22.0)	116 (85)
Multispecies	21	6 778 (2 834)	214 (146)	34.1 (20.7)	396 (256)
All	98	4 082 (2 148)	90 (97)	59.0 (22.3)	184 (179)

2.2.2.5. Factors affecting fish production during the *aman* season

Various factors which could have influenced fish production during the *aman* season were investigated using multivariate regression analysis. Results of seemingly unrelated regression estimation of size (weight) of fish at harvest and rate of recovery are in Table 2.22.

Stocking density. Results indicate that there was no significant relation between stocking density and either harvested size or recovery of fish during the *aman* season. As in the *boro* season, fish production showed positive correlation with stocking density in the *aman* season too (Fig. 2.2). Plots stocked at less than 3 000 fingerlings per ha had a mean stocking density of 2 948 per ha and achieved a mean production of 118 $kg \cdot ha^{-1}$. Those stocked at rates over 6 000 per ha had a mean stocking density of 11 363 per ha and a mean production of 571 $kg \cdot ha^{-1}$ (Table 2.23). Only in 1993 was a relationship between density and production not strongly indicated; stocking densities in that year tended to be quite constant, with only two plots deviating much from 3 000 per ha density (Table 2.24).

Feed. As in the *boro* season, only rice and/or wheat bran was used as feed in the regression analysis. Results indicate that rice and/or wheat bran had significant and positive relationship with size (weight) of fish at harvest, but the relationship with recovery was not significant (Table 2.22). The estimated coefficient reveals that a 1% increase in rice/wheat bran application would increase average weight at harvest by 0.06%.

Water regime. Mean water depth in the rice plots, which averaged 8.94 cm, had a significant and positive relationship with size of fish at harvest; but the relationship was not significant with recovery (Table 2.22). Results indicate that a 1% increase in water depth would increase fish production by 0.24%

Data on percent of rice plots inundated were only available for 1994 when inundation did not have a significant effect on any production parameter. Percent inundation averaged 86.43 ± 9.66. Had inundation levels been lower, a significant effect may have been evident.

Culture period. Mean culture period ranged from 45 to 138 days, with an average of 85 days. While culture period has positive effect on size (weight) of fish at harvest, the relationship was significant only at 15% level of significance (Table 2.22). Culture period appeared to affect

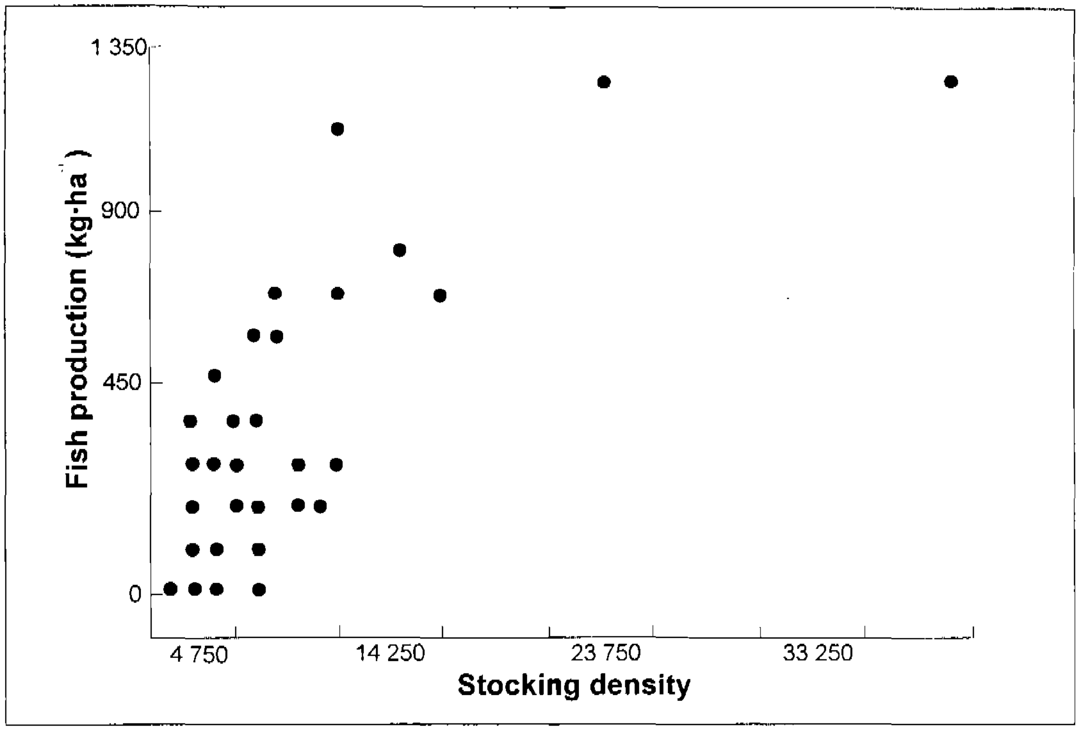

Fig. 2.2. Relationship between stocking density and production during *aman* season.

harvested size more strongly in the *boro* season, probably due to a shorter growing period compared to the *aman* season.

Rice plot and fish refuge size. Fish refuge-rice plot ratio showed a positive and significant relationship with average size of fish at harvest, but not with recovery. Results indicate that, within the present range of fish refuge-rice plot ratio currently in use, farmers could get larger size fish by increasing the size of fish refuge per unit area.

Flooding. Flooding was reported in 53.6% of the plots during the 1993 season and in only 8% of the plots during 1994. A binary dummy variable was included in the recovery equation to represent flooded and nonflooded situations. Results did not show any significant effect of flooding on recovery. Descriptive analysis did not also show clear indication of the effect of flooding on fish production

Table 2.22. Seemingly unrelated regression estimates for size (weight) of fish at harvest and recovery rate during *aman* seasons, 1992-1994.

Independent variable	Ln weight at harvest (kg/fish)		Recovery rate (%)	
	Estimated coefficient	ǀtǀ	Estimated coefficient	ǀtǀ
Intercept	-3.162**	1.93	0.815	1.39
Ln plot water depth (cm)	0.239***	8.25	0.012	0.87
Ln rice/wheat bran (kg×ha^{-1})	0.060**	2.32	0.011	0.98
Ln stocking density (no×ha^{-1})	-0.169	1.01	-0.253	0.35
Ln culture period (days)	0.325	1.44		
Ditch-plot ratio (%)	0.012**	2.16	-0.001	0.21
Flood dummy (1 if flooded)				
Species dummy I (1 for *Barbodes*, else zero)	-0.174	1.53	0.016	0.33
Species dummy 2 (1 for multispecies, else zero)	0.703***	3.73	-0.303***	3.69

*p<0.1; **p<0.05; ***p<0.01.

Table 2.23. Fish production at different stocking densities during *aman* season. Standard deviations are in parentheses.

Stocking density (per ha)	No. of cases	Fish production (kg·ha^{-1})
0-3 000 (mean=2 948)	57	118 (71)
3 000-6 000 (mean=4 135)	26	165 (121)
Over 6 000 (mean=11 363)	15	571 (396)

Table 2.24. Stocking densities by year and their correlations with fish production parameters during *aman* season.

Year	Correlation coefficient with		
	Production	Recovery	Size of fish at harvest
1992	0.5037 **	-0.0297	0.0174
1993	0.2494	0.0193	-0.2047
1994	0.8107 **	-0.0963	-0.0547
All	0.8176 **	-0.1247	0.0863

*p<.01; **p<.001

(Table 2.25). The higher incidence of flooding in 1993 reflects the higher rainfall in that year. The apparent absence of a clear effect on production deserves note. The fact that mean stocking density was considerably higher in nonflooded plots (6 485 vs 3 753 per ha) appears to account for the difference in fish production between the two conditions.

Effect of species. As in the *boro* season, multispecies rearing had higher growth performance (70%) than the other species combinations during the *aman* season although it had a 30% lower recovery rate. However, after correcting for the effect of input use levels, stocking density and production environments, the multispecies plots had higher yields compared to plots with other species.

Soil type. While fish production from plots in sandy soils was considerably lower compared to plots in loam soils, there was no clear effect of soil type on production (Table 2.26). The data presented in Table 2.26 are from the 1993 *aman* season. Soils in all plots during the 1994 trials were reported to be loam.

Table 2.25. Effect of flooding on fish production during *aman* season. Standard deviations are in parentheses.

Year	Flood situation	No. of cases	Fish production (kg·ha^{-1})	Size of fish at harvest (g)	Recovery (%)
1993	Flood	15	176.0 (63)	72 (11)	65 (13)
	No flood	13	189.5 (94)	82 (21)	71 (21)
1994	Flood	2	318.0 (72)	90 (15)	52 (31)
	No flood	23	490.0 (381)	64 (30)	63 (25)
Both years	Flood	17	192.7 (77)	74 (13)	63 (15)
	No flood	36	381.5 (342)	71 (28)	66 (24)

Table 2.26. Fish production parameters by soil type during 1993 *aman* season. Standard deviations are in parentheses.

Soil	No. of cases	Fish production (kg·ha^{-1})	Size of fish at harvest (g)	Recovery (%)
Sandy	9	144 (44)	73 (15)	65 (17)
Loam	19	201 (84)	78 (18)	69 (17)

Stocking densities for sandy soils averaged slightly lower than for loam (2 995 vs 3 391 per ha). The slightly lower stocking density, size of fish at harvest and recovery probably account for the lower production noted in plots with sandy soils.

Size of fingerlings. There is no strong evidence for an effect of size of fingerlings at stocking either on size of fish at harvest or recovery. Size of fingerlings tended to be consistent in any given year, and any effects are probably obscured by other variations between years.

2.3. Economic performance of fish culture in rice fields

The capital costs involved in integrating fish culture with rice farming are the labor costs for excavation of a ditch or sump as fish refuge and strengthening of dikes. This work is done by either family and/or hired labor.

The operational costs include cost of fingerlings, supplementary feeds and fertilizers for fish and irrigation charges. Of these, fingerlings and irrigation costs are totally cash costs, while supplementary feeds and fertilizers account partly for cash costs, as farmers generally used rice bran and cattle manure from their on-farm resources. Harvesting of fish is mostly done by family members and hence not included in the economic analysis.

The cost of integrating fish culture with rice farming (cash costs only) on average amounted to Tk 2 612[a] and Tk 2 389 per ha during *boro* and *aman* seasons, respectively, while net benefit amounted to Tk 5 243 and Tk 5 071 per ha during *boro* and *aman* seasons (Figs. 2.3 and 2.4). Details of costs and benefits are described in the following section.

2.3.1. Boro *season*

Details of costs incurred by farmers for production of fish in integrated rice-fish farming during the *boro* season are outlined in Table 2.27. Fingerlings were the major cash costs, accounting for 58.7% of total costs, followed by plot preparation (25.8%). Feed and fertilizers constituted 10.2% of total costs.

Cash costs for rice bran and cattle manure amounted to 13.7% and 1.2%, respectively, of total costs for these inputs. In the case of plot preparation, cash costs accounted for 85.8% of total costs. However, once a ditch was excavated, no further labor was needed at least for three years and hence these costs could be amortized against six crops (2 crops a year).

Irrigation costs of pumping additional water for the fish were only available for 1994 (Table 2.27). The costs were an average of the total sample of 82 farmers. Additional cost was involved only in plots supplied with water from diesel-powered tubewells. Farmers who got water from electricity-driven pumps did not pay additional charge for pumping extra water. Irrigation costs for the farmers with diesel-powered wells averaged Tk 470·ha^{-1}.

Cost of fingerlings was slightly higher in 1994 because of an increasing tendency among farmers to stock higher number of fingerlings. The high cost of plot preparation in 1993 reflects the fact that 91% of the farmers were new to rice-fish farming and 79% of the ditches/sumps were new. In 1994, new farmers made up only 69% of those culturing, and only 48% of the ditches were new. In plots with established ditches and dikes, some maintenance was normally needed each year, and experienced farmers sometimes excavated new ditches or enlarged the existing ones. The proportion of operating costs for plot preparation is probably somewhat overestimated here.

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[a]1US$ = Tk39.

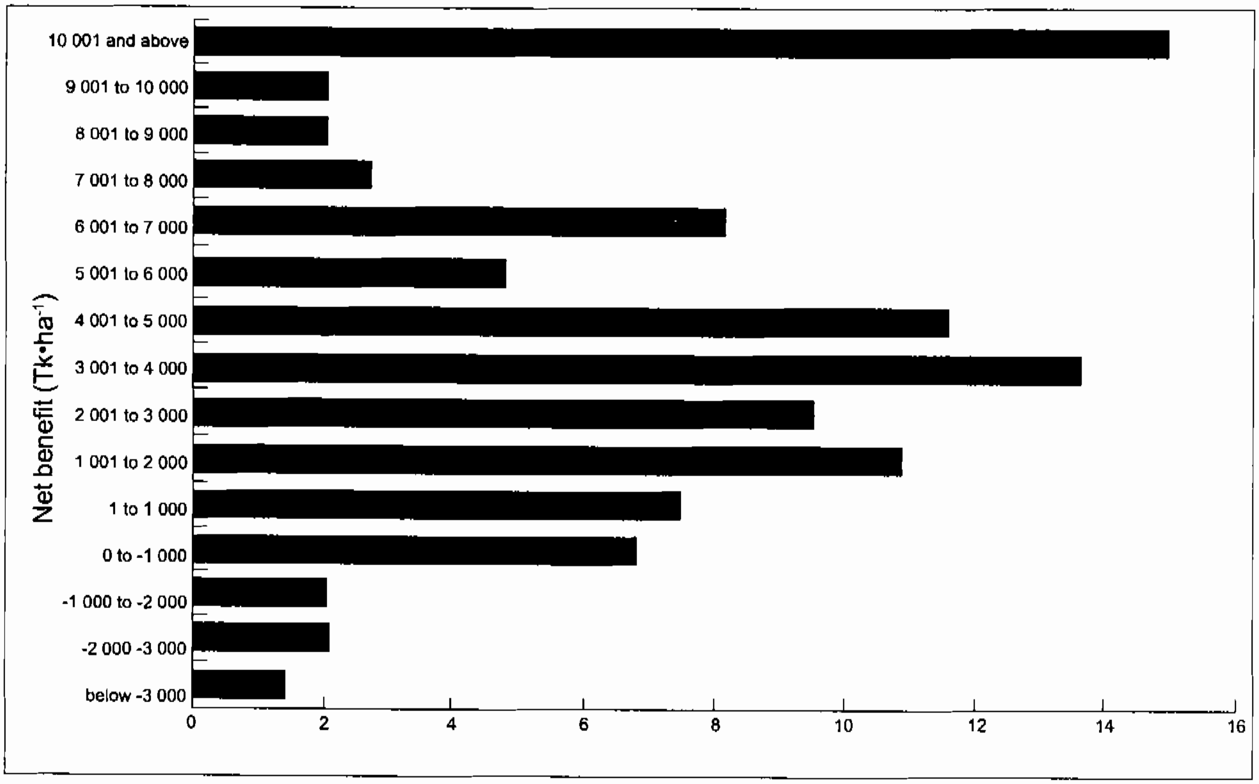

Fig. 2.3. Net benefit from fish culture during *boro* season, 1992-1994.

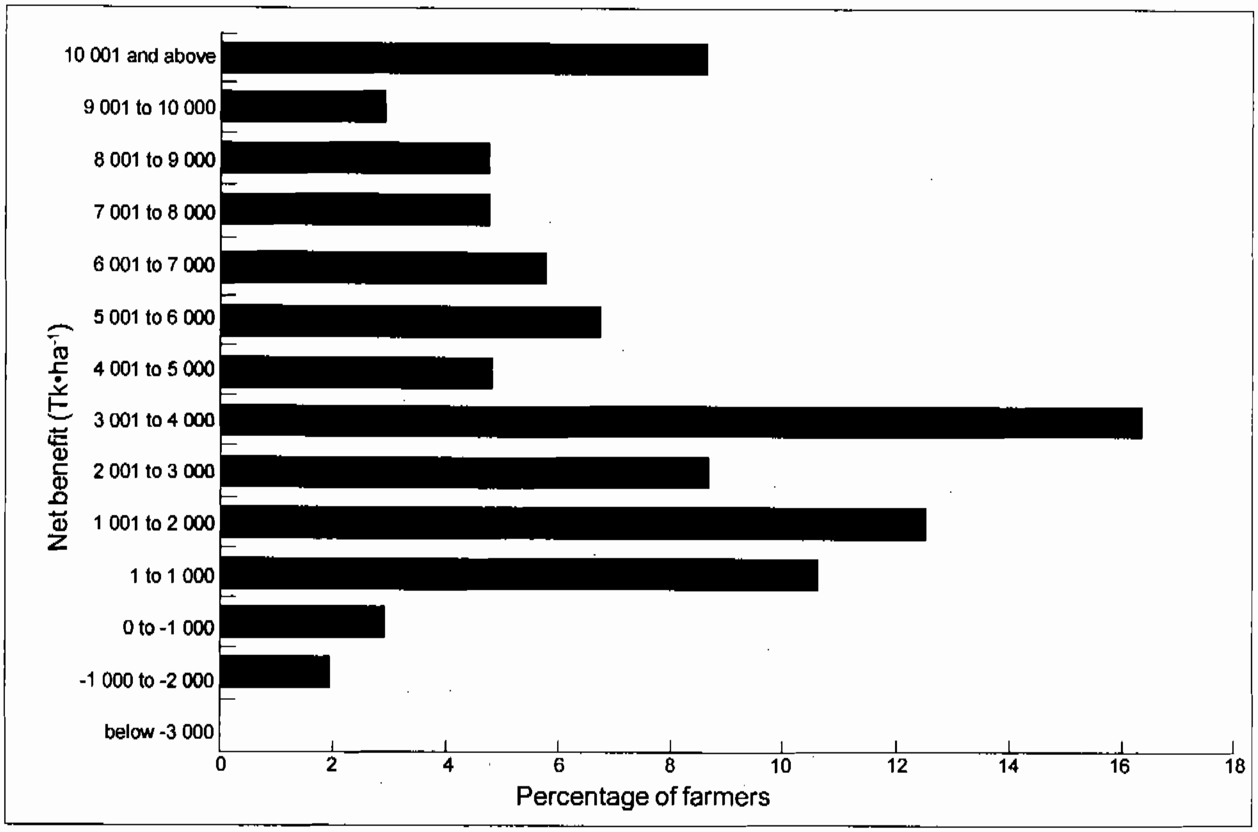

Fig. 2.4. Net benefit from fish culture during *aman* season, 1992-1994.

Table 2.27. Cash and noncash costs of fish production (Tk·ha^{-1}) in integrated rice-fish farming during *boro* season. Standard deviations are in parentheses.

Year	No. of cases	Cost (Tk) Feed and fertilizer Range	Average	Fingerlings Range	Average	Plot preparation Range	Average	Irrigation Range	Average	Total Range	Average
1993	62	0-1 828	316 (395)	658-3 750	1 601 (722)	0-5 385	1 069 (1 226)	NA[a]		759- 8 886	2 986 (1 837)
1994	82	29-1 173	281 (229)	900-9 492	1 719 (1 981)	0-6 250	543 (912)	0-1 200	267 (299)	956-16 281	2 810 (2 320)
Both	144	0-1 828	296 (311)	658-9 492	1 693 (1 575)	0-6 250	745 (976)	0-1 200	152 (255)	759-16 281	2 886 (2 121)

[a] NA - Data not available.

Table 2.28. Noncash costs (Tk·plot^{-1}) for fish culture in integrated rice-fish farming during *boro* season.

Season	Plot preparation (Tk) Total	Noncash	Rice bran (Tk) Total	Noncash	Cattle manure (Tk) Total	Noncash	Duckweed (Tk) Total	Noncash	Total noncash (Tk)
1993	1 069	N.A	224	166	61.5	61.5	16	16	243.5
1994	558	79	149	147	115	113	3.53	3.53	342
Both	774	N.A	181	155	92	90.8	8.79	8.79	325

[a] NA - Data not available.

Table 2.29. Cash costs and benefits of fish component in integrated rice-fish farming during *boro* season. Standard deviations are in parentheses.

Year	No. of cases	Costs (Tk·ha^{-1})	Gross benefit (Tk·ha^{-1})	Net benefit (Tk·ha^{-1})
1993	62	2 742 (1 611)	8 135 (5 834)	5 393 (5 614)
1994	82	2 513 (2 219)	7 604 (6 281)	5 129 (4 770)
All	144	2 612 (2 084)	7 834 (6 077)	5 243 (5 304)

Table 2.30. Cash and noncash costs and benefits (Tk·ha^{-1}) of fish component in integrated rice-fish farming during *boro* season. Standard deviations are in parentheses.

Year	No. of cases	Costs (Tk·ha^{-1})	Gross benefit (Tk·ha^{-1})	Net benefit (Tk·ha^{-1})
1993	62	2 986 (1 837)	8 135 (5 834)	5 149 (5 610)
1994	82	2 810 (2 320)	7 604 (6 281)	4 794 (4 696)
All	144	2 886 (2 121)	7 834 (6 077)	4 948 (5 094)

Details of noncash costs of production are given in Table 2.28. The cost of integrating fish culture with rice farming on an average amounted to Tk 2 612·ha^{-1} when only cash costs are taken into consideration (Table 2.29), and Tk 2 886·ha^{-1} when both cash and noncash costs are considered (Table 2.30). Against this, gross benefit on an average amounted to Tk 7 834·ha^{-1}, leaving a net benefit of Tk 4 948 and 5 243·ha^{-1} with and without noncash costs. Fig. 2.3 gives details of number of farms with different net benefit ranges.

Details of cost of production and benefits for different species during the *boro* season are presented in Tables 2.31 (cash only) and 2.32 (cash and noncash costs). The data presented indicate that the economic performance of *C. carpio* was better than *B. gonionotus*. The major reasons for this difference are the availability and price of fingerlings, i.e., *C. carpio* fingerlings are more available to farmers during the *boro* season than in the *aman* season and their price is lower compared to *B. gonionotus* (Table 2.33). The converse is the case with regard to *B. gonionotus* (Table 2.33). The prices given are for fingerlings of 4-6 cm in length. Moreover, in 1994, the size of *C. carpio* fingerlings stocked was uniformly small, and *B. gonionotus* fingerlings were large which increased the price differential between the two species.

Low production reported from some of the plots stocked with *B. gonionotus* in 1993 had a strong effect on average returns from this small sample. Farmers culturing *B. gonionotus* tended to give more rice bran as supplemental feed than those culturing *C. carpio*, as they can observe *B. gonionotus* feeding on rice bran immediately on giving the feed in the ditch/sump. This also added to costs for plots stocked with *B. gonionotus*.

In the 1993 *boro* season, 13 farmers (21%) lost money on fish culture in rice farms, while in the 1994 season, only two farmers (2.4%) lost money. When noncash costs are not taken into consideration, only 12 of the total of 144 farmers (8.3%) lost money during the *boro* season. Mean loss per farmer was Tk 278 (Tk 1 533·ha^{-1}), with a maximum of Tk 572 (Tk 4 082·ha^{-1}).

While soil type had an inconsistent effect on economic parameters during the 1993 and 1994 seasons, some of the contrasts deserve to be noted (Table 2.34). Many of the 1993 plots

Table 2.31. Cash costs and benefits of culturing different species in integrated rice-fish farming during 1993-1994 *boro* season.

Species	No. of cases	Total costs (Tk·ha^{-1})	Gross benefit (Tk·ha^{-1})	Net benefit (Tk·ha^{-1})
C. carpio	96	2 196	7 055	4 853
B. gonionotus	11	2 968	5 971	3 081
O. niloticus	8	2 316	7 787	5 481
C. carpio + *B. gonionotus*	13	2 625	7 004	4 379
C. carpio + *O. niloticus*	1	1 700	5 300	3 600
B. gonionotus + *O. niloticus*	2	2 517	2 308	-209
Multispecies	13	5 388	17 044	11 625
All	144	2 612	7 834	5 243

Table 2.32. Cash and noncash costs and benefits of culturing different species in integrated rice-fish farming during 1993-1994 *boro* season. Standard deviations are in parentheses.

Species	No. of cases	Total costs (Tk·ha^{-1})	Gross benefit (Tk·ha^{-1})	Net benefit (Tk·ha^{-1})
C. carpio	96	2 442 (1 595)	7 055 (4 917)	4 613 (4 527)
B. gonionotus	11	3 170 (1 269)	5 971 (4 282)	2 800 (4 286)
O. niloticus	8	2 792 (1 593)	7 797 (2 637)	5 005 (1 821)
C. carpio + *B. gonionotus*	13	2 987 (848)	7 004 (2 502)	4 018 (2 274)
C. carpio + *O. niloticus*	1	2 116	5 300	3 183
B. gonionotus + *O. niloticus*	2	3 365 (2 414)	2 308 (2 027)	-1 057 (387)
Multispecies	13	5 863 (4 249)	17 044 (10 794)	11 181 (8 373)
All	144	2 886 (2 121)	7 833 (6 077)	4 948 (5 094)

Table 2.33. Estimated fingerling prices by species and year during *boro* and *aman* seasons.

Species	Estimated unit price (Tk)						
	Boro season			*Aman* season			
	1993	1994	Average	1992	1993	1994	Average
C. carpio	0.44	0.30	0.37	0.88	0.80	NA[a]	0.87
B. gonionotus	0.48	1.00	0.68	0.41	0.30	0.30	0.36
O. niloticus	0.30	0.40	0.38				

NA - Data not available.

Table 2.34. Costs and benefits of integrated rice-fish farming under different soil conditions during *boro* season.

Year	Soil	No. of cases	Mean production ($kg \cdot ha^{-1}$)	Mean cost ($Tk \cdot ha^{-1}$)	Mean net benefit ($Tk \cdot ha^{-1}$)
1993	Sandy	14	291	4 169	5 708
	Nonsandy	48	207	2 641	4 985
1994	Sandy	9	130	2 287	2 262
	Nonsandy	73	246	2 874	5 106

Table 2.35. Effect of flooding on fish production economics during *boro* season.

Year	Flood situation	No. of cases	Mean production ($kg \cdot ha^{-1}$)	Mean cost ($Tk \cdot ha^{-1}$)	Mean net benefit ($Tk \cdot ha^{-1}$)
1993	Flood	11	230	3 901	3 788
	No flood	51	225	2 789	5 442
1994	Flood	27	121	1 957	2 297
	No flood	55	286	3 229	6 020

with sandy soil were stocked with larger fingerlings, and farmers applied substantial quantities of mustard oil cake as feed, which added considerably to the cost. Most of these farmers were able to keep their plots well supplied with water, resulting in higher fish production. Therefore, while returns differed little from those of other plots, returns on investment were low because of the higher cost of fingerlings and feed.

Flooding affected fish production, particularly in 1994. Hence, economic parameters in flooded and nonflooded fields are compared (Table 2.35). As with the production figures, the 1993 data gave no indication of any relation between flooding and economic returns. Mean costs were higher in flooded plots, for which there is no definite explanation. In 1994, farmers who experienced flooding tended to reduce feed. However, losses lowered production, leading to reduced net benefits and returns on investment. In the analyses that follow, only nonflooded plots were considered for the 1994 data.

A strong relation between economic returns and fish refuge and plot area was indicated in the 1994 season (Table 2.36). The sample included multispecies plots. Many of these plots had larger ditches/sumps and were stocked at higher densities. When these farms are not considered, the significance of the relationship in question disappears.

Multiple regression tests indicated higher net benefit from plots with relatively larger fish refuges, which hold a greater volume of water and in which intensive stocking and feeding were practiced (Table 2.36). Return on money invested appears to be maximal in nonsandy plots and where investments were relatively low. Prudent attention to water conservation appears more cost-effective than heavy investments in feed, fingerlings and irrigation costs.

The noticeable contrast between the two years is the importance of water on benefits in the 1993 season and that of investments in 1994. Water depth and culture period covered a greater range in 1993, while a number of farmers cultured very intensively in 1994. Water depth was monitored more thoroughly in 1993 and irrigation costs were not considered in the analyses for that year.

2.3.2. Aman *season*

Details of costs incurred by farmers for production of fish in integration with rice farming during the *aman* season during different years are presented in Table 2.37. Fingerlings constituted the major costs, accounting for 67.2% of total costs, while supplementary feeds and fertilizers accounted for 21.5% of total costs.

In contrast to the *boro* season, cost of feeds and fingerlings as a proportion of the total costs was higher during the *aman* season. With two exceptions, there was no irrigation in the *aman* season and hence no costs for irrigation. Fingerling costs in 1994 were relatively higher, reflecting the high densities stocked that year. In 1992, extension workers and farmers had limited experience in the technology, and feed levels were excessive. Heavy rainfall in 1993 induced many farmers to feed and fertilize lightly.

The relatively high cost for plot preparation reported in 1994 reflects more thorough monitoring in that year. This figure includes costs of initial excavation, when carried out for this season. This investment will normally continue to provide returns over several years. Closer scrutiny of the data indicates that new farmers had higher excavation costs, but expenses for farmers with one and two years' experience were also high because many farmers excavate a rudimentary ditch during the first year, which they often deepen or expand once they begin to receive returns from the technology.

The average cost of fish production (excluding family labor for fingerlings procurement and harvesting of fish) during the three-year study period amounted to Tk 2 661·ha^{-1} when cash and noncash costs were taken into consideration (Table 2.38) and Tk 2 389·ha^{-1} when only cash

Table 2.36. Coefficients of significant correlations between economic parameters and independent variables during *boro* season.

Variable	1993 Net benefit	1993 Return on investment	1994 Net benefit	1994 Return on investment
Density	0.1635	-0.0781	0.7302**	-0.0340
Culture period	0.5000**	0.4307**	0.0735	0.1806
Water depth	0.5036**	0.4863**	0.4416**	0.1953
% inundation	0.3614*	0.3214	n/a	n/a
Feed costs	0.1557	-0.1812	0.3682*	-0.2108
Fingerling costs	0.1028	-0.2317	0.6472**	-0.1630
Total costs	-0.0448	-0.3664*	0.5191**	-0.3789*
Ditch area	0.2452	0.0765	0.5656**	0.4420**
Plot area	0.0732	0.0957	0.3152	0.4400**

*p>.01; **p<.001.

Table 2.37. Costs for integrating fish culture with rice farming during *aman* season. Standard deviations are in parentheses.

Year	No. of cases	Costs (Tk·ha^{-1}) Feed and fertilizer	Fingerlings	Plot preparation	Irrigation	Total
1992	50	711 (497)	1 919 (1 273)	NA[a]	5 (35)	2 635 (1 438)
1993	28	135 (69)	1 022 (272)	53 (101)	-	1 210 (349.5)
1994	26	773 (829)	2 444 (1 682)	1 113 (1 676)	31 (157)	4 361 (382.5)
All	104	574 (603)	1 789 (1 307)	NA[a]	10	2 661 (2 270)

[a]NA - Data not available.

Table 2.38. Cash and noncash costs and benefits from fish component in integrated rice-fish farming during *aman* season. Standard deviations are in parentheses.

Year	No. of cases	Costs ($Tk \cdot ha^{-1}$)	Gross benefit ($Tk \cdot ha^{-1}$)	Net benefit ($Tk \cdot ha^{-1}$)
1992	50	2 636 (1 438)	4 404 (2 760)	1 745 (2 280)
1993	28	1 210 (350)	7 124 (2 954)	5 917 (2 761)
1994	23	4 436 (3 561)	14 512 (11 560)	10 076 (9 954)
All	101	2 661 (2 270)	7 460 (7 328)	4 799 (6 147)

Table 2.39. Cash costs and benefits from fish component in integrated rice-fish farming during *aman* season. Standard deviations are in parentheses.

Year	No. of cases	Cash cost	Gross benefit ($Tk \cdot ha^{-1}$)	Net benefit ($Tk \cdot ha^{-1}$)
1992	50	2 381 (1 396)	4 404 (2 760)	2 023 (2 392)
1993	28	1 065 (320)	7 124 (2 954)	6 059 (2 781)
1994	23	4 019 (3 192)	14 512 (11 560)	10 493 (10 002)
All	101	2 389 (1 412)	7 460 (5 619)	5 071 (3 894)

Table 2.40. Economic performance of different species during *aman* seasons of 1992-1994. Standard deviations are in parenteses.

Species	No. of cases	Total costs ($Tk \cdot ha^{-1}$)	Gross benefit ($Tk \cdot ha^{-1}$)	Net benefit ($Tk \cdot ha^{-1}$)
B. gonionotus	54	1 582 (683)	5 035 (2 580)	3 453 (2 755)
C. carpio	4	4 322 (2 701)	6 737 (4 406)	2 415 (1 949)
B. gonionotus + *C. carpio*	21	3 167 (1 412)	5 784 (4 013)	2 617 (4 098)
Multispecies	22	4 524 (3 606)	15 142 (11 872)	10 619 (9 911)
All	101	2 661 (2 270)	7 460 (7 328)	4 798 (6 147)

costs were considered (Table 2.39). Gross benefit on an average amounted to Tk 7 $460 \cdot ha^{-1}$, leaving a net benefit of Tk 4 $799 \cdot ha^{-1}$ (Table 2.38) when all costs were considered and Tk 5 $071 \cdot ha^{-1}$ when only cash costs were considered (Table 2.39). Fig. 2.4 shows a number of cases with different net benefit ranges. Details of costs and benefits with different species combinations are in Table 2.40 (noncash costs included) and Table 2.41 (only cash costs).

Noncash costs were applied in some cases for plot preparation, rice bran, cattle manure and duckweed. A breakdown by year is given in Table 2.42. Noncash costs made up 10.5, 10.4 and 9.0% of the total costs in 1992, 1993, and 1994, respectively.

In general, it appears to be more profitable to stock with *B. gonionotus* than with *C. carpio* in the *aman* season, because *C. carpio* fingerlings are in short supply at this time of the year and cost more. The price of 5-7 cm size *C. carpio* fingerlings (during the *aman* season) was quoted at Tk 0.80 each. Fingerlings 7-10 cm in size can fetch up to Tk 1.50 each. By contrast, rates quoted for *B. gonionotus* fingerlings of same sizes were Tk 0.30 and Tk 0.50, respectively (Table 2.33).

Net benefits tended to be higher for the multispecies plots, where farmers stocked at higher densities. This practice may well be advisable in well-watered plots, particularly when the farmer can provide supplementary feed and fertilizers. Farmers culturing under more uncertain conditions can risk greater losses from intensive systems. The multispecies systems represent a higher profit, but also carry higher risks.

Table 2.41. Economic performance of different species during *aman* seasons of 1992-1994 (cash costs only).

Species	No. of cases	Cash costs ($Tk{\cdot}ha^{-1}$)	Gross benefit ($Tk{\cdot}ha^{-1}$)	Net benefit ($Tk{\cdot}ha^{-1}$)
B. gonionotus	54	1 407	5 035	3 627
C. carpio	4	4 110	6 737	2 628
B. gonionotus + *C. carpio*	21	2 823	5 784	2 961
Multispecies	22	4 074	15 142	11 068
All	101	2 389	7 460	5 071

Table 2.42. Noncash costs by component during *aman* season ($Tk{\cdot}ha^{-1}$).

Season	Component								Total noncash costs
	Plot preparation		Rice bran		Cattle manure		Duckweed		
	Total	Noncash	Total	Noncash	Total	Noncash	Total	Noncash	
1992	NA[a]	NA[a]	464	168	17	17	63	63	278[b]
1993	53	6.70	88	88	31	31	0.45	0.45	126
1994	1 113	44	364	174	115	109	121	71	398
All	563	25	221	129	71	68	58	34	257

[a]NA - Data not available.
[b]A few farmers added other feeds which required no cash in 1992. Hence, total noncash cost is greater than the sum of noncash costs for rice bran, duckweed and cattle manure.

Table 2.43. Coefficients of significant correlations between net benefit and independent variables during *aman* season.

Variable	1992	1993	1994
Density	-0.0401	0.1410	0.6316**
Duckweed	0.4592**	0.4448*	0.2497
Feed costs	0.1672	0.2629	0.5073*
Fingerling costs	-0.0108	0.4510*	0.5639*
Total costs	0.0560	0.5064*	0.4254
Ditch area	0.0048	0.4431*	-0.0477
Plot area	-0.0408	0.4419*	0.0218

*$p>.01$; **$p<.001$.

In the 1992 *aman* season, 10 farmers (20% of the total) incurred losses from fish culture in rice fields, whereas in 1994, only two farmers (8.3%) incurred losses. No farmers lost money on the venture in 1993. Mean loss for this group of farmers was Tk 196 (Tk $999{\cdot}ha^{-1}$), with a maximum of Tk 544 (Tk 2 $788{\cdot}ha^{-1}$). Flooding and soil type had no noticeable effect on economic parameters, aside from the effects on production noted earlier.

Correlations between net benefit and independent variables were tested (Table 2.43). The strong correlations between density and feed costs with net benefit in 1994 reflect the wider variation and higher mean levels of all three variables in that year. Feed costs in 1992 were high, relative to stocking density. Given the weak relation between costs and net benefit in that year, it is possible that many farmers had incurred unnecessary higher expenses on feed. Many of the plots stocked at higher densities in 1992 included *C. carpio*, whose fingerlings tended to be more expensive than *B. gonionotus*. This would tend to reduce net benefit and help explain the weak negative relation between density and net benefit in 1992. Only in 1993 did both the size of fish refuge and rice plot areas had strong positive correlations with net benefit.

2.4. Integrated rice-fish farming vs rice monoculture

Although returns from fish in integrated rice-fish farming look promising from the farmers' point of view, rice is still the most important product. Since the adverse effects of integration of fish on rice production or economics would call into question the viability of the technology, the performance and economics of rice in rice-fish farming relative to plots where only rice is grown were assessed.

2.4.1. Rice production

Studies undertaken elsewhere have indicated that rice yields from plots stocked with fish appear, by and large, modestly higher than those from comparable unstocked plots (Jintong 1995), but there is considerable variation. Kamp and Gregory (1993) indicated 15% and 7% increases in rice yields from integrated farming during *boro* and *aman* seasons, respectively, compared to yields from monoculture rice during the preceding year. In some cases, yields from stocked plots were reported to be lower compared to unstocked plots (Lightfoot et al. 1992). The findings of the present study are similar.

Rice production from unstocked plots and plots stocked with fish are shown in Table 2.44. The comparisons are based on the subsamples of stocked plots with which unstocked, control plots could be paired. Hence, each case represents a pair of plots, each with the same rice variety, from the same location and in many cases same farmer.

There is wide variation in rice yield among plots, but a total of 70% of the integrated plots sampled during the four seasons had higher yields from stocked fields. During the *boro* seasons of 1993 and 1994, 70% and 87.5% of the integrated farmers had higher rice yields, by an average of 19.5% and 6.4%, respectively, compared to monoculture rice farms. The same trend was observed in the *aman* season, with 67% and 40% of integrated farms showing higher rice yields of 12.7% and 9.9%, respectively. Fig. 2.5 presents details of the number of farmers with increases and decreases in rice yields during the *boro* season of 1994.

During the 1993 *aman* season, farmers were asked to compare their rice harvest with that of the previous year when there was no integration. Of the 28 integrated rice-fish farmers, 19 (68%) farmers reported increased yields, while only three of the 11 farmers (27%) with rice monoculture reported increases. Of the 28 integrated plots, six (21%) had decreased yields, while four out of 11 rice monoculture plots (36%) reported decreases.

Table 2.44. Rice yields from integrated rice-fish plots and monocropped rice plots. Ranges are in parentheses.

Season	Year	No. of cases	Rice yield ($kg \cdot ha^{-1}$)		Cases with higher yields from integrated plots (%)	Mean difference in yield from control (%)	
			Control plot	Integrated plot			
Boro	1993	10	3 957 (3 046-4 940)	4 651 (3 264-6 175)	70	+19.5	(-13.3 to +57.6)
	1994	24	4 804 (3 550-6 000)	5 117 (3 500-6 571)	87.5	+6.4	(-30.0 to +19.0)
	All	34	4 555 (3 046-6 000)	4 980 (3 264-6 571)	82.4	+10.25	(-13.3 to 57.6)
Aman	1992	15	3 749 (2 375-6 250)	4 108 (3 000-4 889)	67	+12.7	(-21.3 to +55)
	1993	10	3 121 (1 976-3 952)	3 364 (2 058-4 940)	40	+9.9	(-30.6 to -66.7)
	All	25	3 498 (1 976-6 250)	3 811 (2 058-4 940)	56.2	11.6	(-21.3 to 66.7)

When asked for the probable reason for increased or decreased rice yields, all 19 farmers with increased yields reported that fish kept pests under control. Seventeen of the 19 (89%) felt that there was a fertilizing effect from fish or fish excreta. The same proportion indicated that more intensive care of their plots was a factor. Stirring of the soil by fish was mentioned by 14 of the farmers (74% of the total), and two (11%) mentioned that weeds were kept under control by the fish. Of the six farmers who reported decreased rice yield from stocked plots, only one farmer indicated the fish as a factor because they ate the rice.

2.4.2. *Irrigation*

To assess additional irrigation requirements for integrating fish culture with rice irrigation, costs for fish culture were considered separately from those for rice during the 1994 *boro* season. In cases where a farmer indicated that water was added for both fish and rice, half of the cost was assigned to each commodity. Farmers normally paid a fixed rate per unit area per season for irrigating with tubewell water. If the tubewell pump was electrically operated, this rate also included the electricity charge. If the pump was diesel-powered, the farmer incurred the cost of fuel each time the pump was operated.

Of the 85 farmers who cultured fish in rice fields during the *boro* season of 1994, 38 incurred no additional irrigation charge since they were drawing water from electricity-powered water pump. The additional fuel cost due to fish culture for the remaining 47 farmers ranged from Tk 140 to Tk 1 200·ha¹, with an average of Tk 470·ha¹. This amounted on average to 35% of the total irrigation fuel cost, with a range of 13% to 63% of the total. Fuel costs for the fish culture component constituted on average an additional 59% over those for rice and ranged from an additional 15% to 167%. This figure can be considered a rough approximation of the additional water requirements for fish in irrigated rice fields.

Soil type, timing and quantity of early rains, and the management of water also played a role in determining water requirements.

2.4.3. *Economics*

Based on data from the 1993 *aman* and 1994 *boro* seasons, total costs in integrated farming (for rice and fish), compared to control plots with only rice, were 15.4% higher in the *boro* season and 17.5% in the *aman* season (Table 2.45). Rice cultivation costs in plots stocked with fish averaged 9.4% and 10.1% lower than in comparable unstocked plots during *boro* and *aman* seasons, respectively. While small sample sizes and slight differences make definite conclusions risky, Table 2.46 gives some explanation of the lower rice cultivation costs applicable in stocked plots.

Table 2.45. Production costs of plots stocked with fish and comparable unstocked plots. Standard deviations are in parentheses.

Season	Year	No. of cases	Cost of production ($Tk{\cdot}ha^{-1}$)				
			Control plot: rice	Stocked plot: rice	% difference from control	Stocked plot: rice and fish	% difference from control
Boro	1994	22	13 135 (2 538)	11 983 (2 909)	-9.4 (12.6)	14 925 (3 834)	+15.4 (23.1)
Aman	1993	10	5 088 (934)	4 543 (809)	-10.1 (9.6)	5 981 (953)	+17.5 (15.5)

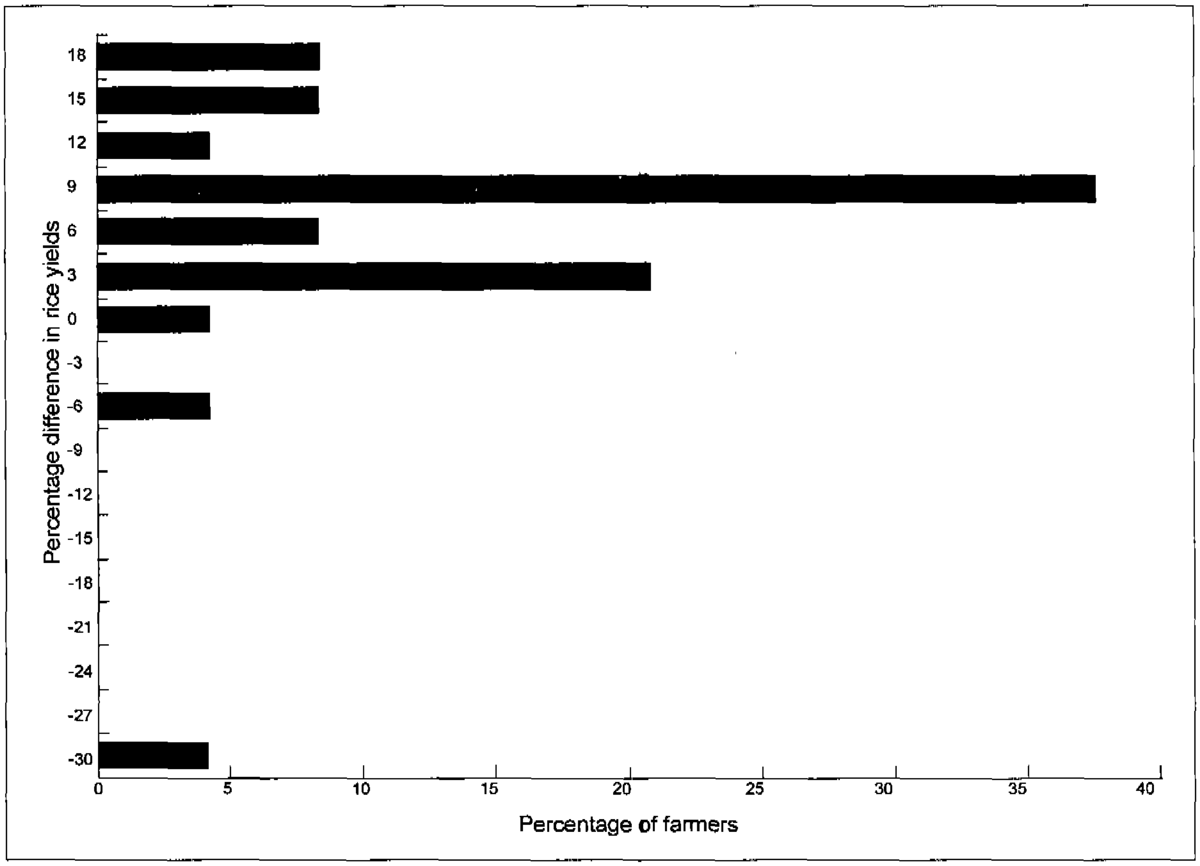

Fig. 2.5. Increases and decreases in rice production due to fish culture, *boro* season, 1994.

Costs listed do not include those specifically used for fish only. As a result, the total costs of cattle manure, inorganic fertilizers, and irrigation for the integrated plots will be higher than the values listed here. About half of the *boro* farmers applied cattle manure (64% of the integrated plots and 48% of the monoculture rice plots), but only one farmer applied it in the *aman* season. While all farmers undertook weeding in the *boro* season, only six of the 10 monoculture plots and five of the 10 integrated plots were weeded during the *aman* season. Pesticides were applied in 46% of the monoculture *boro* plots, but only in 7% of the integrated plots. In the *aman* season, only two monoculture plots received pesticides.

Differences in costs between integrated and monoculture plots rarely approached statistical significance, but the sample sizes were small, especially in the *aman* season, making it difficult to draw any conclusion. Cost of inorganic fertilizers in integrated plots averaged 13% and 46% lower than monoculture plots in the *boro* and *aman* seasons, respectively. Average weeding cost for integrated plots was 29% lower in the *boro* season, and 23% in the *aman* season. Cost of pesticides for integrated plots in the *boro* season was 86% lower than for unstocked plots, and use of pesticides in the *aman* season was very rare in both cases.

Slightly lower costs for rice cultivation in integrated farms put the overall costs for integrating fish culture with rice in the range of only 15-20% higher than for comparable, unstocked fields. However, there was considerable variation here, particularly for plots where culture was more intensive or where there have been high preparation costs.

The slightly lower mean costs of rice cultivation and slightly higher mean rice yields from integrated farms combined to give mean net benefits from rice cultivation alone to over 22.6% during *boro* season and 11.9% during *aman* season, compared to monoculture rice. These differences are not statistically significant. Most farmers made a greater profit from their integrated plots, based on rice cultivation alone (Table 2.47).

When the net benefit from fish culture is combined with benefits from rice farming, the advantage of integration becomes clear: in no case was the net benefit from integrated rice-fish farming lower than that from rice monoculture. Cases of loss from rice-fish farming were non-existent in the 1993 *aman* season, and only two of the 85 *boro* farmers in 1994 reported net losses from rice-fish farming. When data from all five seasons are considered, 10% of the farmers lost money from culture of fish in rice fields. In 27.2% of the cases from the above two seasons, relatively low net benefits from rice cultivation in stocked fields occurred. The probability of the two phenomena combining to generate a lower net benefit from an integrated operation can be estimated at 2.7%. Hence, risk of financial loss is reduced through integration of the two activities.

Based on the average cost for integrating fish culture with rice farming and the average retail price for fish in the study area for the species used in the study, the break-even point for integration to be viable would be a production of 81.1 and 61.5 kg·ha[1] of fish during *boro* and *aman* seasons, respectively (Table 2.48).

2.5. Pests and pesticide use

As mentioned earlier, fewer farmers used pesticides in integrated farms. Pesticide use for the five seasons discussed is shown in Table 2.49.

Although data for monoculture plots during *aman* season is available only for 1993, there does appear to be less pesticide use than in the *boro* season. There are consistently fewer farmers applying pesticides in plots stocked with fish.

The data from the 1994 *boro* season provide additional details on the use of pesticides in integrated and monoculture farms. The pesticides used in integrated farms were basudrin, furadon, diazinon and dimicron. Mean rate of application was 6.1 kg·ha^{-1}, at a mean cost of Tk 528·ha^{-1}. Four of the nine farmers applied pesticide one day before transplantation, and the rest applied it 14 to 22 days later. In all cases, the pesticide was applied before fish were stocked.

Table 2.46. Comparison of costs for rice cultivation in stocked and unstocked plots during *boro* and *aman* seasons. Standard deviations are in parentheses. (n - number of cases)

Input/activity	*Boro* 1994				*Aman* 1993			
	Unstocked plots		Stocked plots		Unstocked plots		Stocked plots	
	n	cost	n	cost	n	cost	n	cost
Seed	28	750 (163)	27	665 (179)	10	458 (104)	10	370 (185)
Plowing	28	1 382 (490)	27	1 400 (551)	10	1 700 (612)	10	1 592 (611)
Cattle manure	28	140 (115)	27	80 (102)	10	0	10	25 (79)
Inorganic fertilizer	28	2 605 (549)	27	2 272 (730)	10	919 (450)	10	496 (339)
Transplanting	28	1 267 (458)	27	1 253 (433)	10	802 (192)	10	716 (185)
Weeding	28	1 269 (641)	27	897 (718)	10	207 (282)	10	159 (217)
Harvesting	26	2 062 (457)	27	2 080 (659)	10	1 213 (216)	10	1 346 (186)
Pesticide	28	277 (331)	27	38 (140)	10	47 (149)	10	0
Irrigation	14	2 949 (993)	27	3 105 (807)	10	0	10	0

Table 2.47. Net benefits from rice plots stocked with fish and comparable unstocked plots. Standard deviations are in parentheses.

Season	Year	No. of cases	Net benefit (Tk·ha^{-1})				
			Control plot: rice	Stocked plot: rice	% difference from control	Stocked plot: rice and fish	% difference from control
Boro	1994	22	14 200 (4 599)	17 405 (5 576)	+22.57 (24.4)	22 902 (7 508)	+61.28 (38)
Aman	1993	10	11 962 (3 605)	13 379 (3 594)	+11.85 (54.7)	21 540 (4 889)	+80.07 (86)

Table 2.48. Break-even point of fish production.

Average cost of production (Tk·ha^{-1})	2 891	2 661
Average price of fish (Tk·ha^{-1})	35.6	43.3
Break-even production (kg·ha^{-1})	81.1	61.5

The pesticides used in monoculture rice farms were the same as in integrated farms: basudrin, furadon, dimicron and diazinon. Mean rate of application was 6.7 kg·ha^{-1} (or liters) at a mean cost of Tk 596·ha^{-1}. All but one farmer applied chemicals 1 to 34 days after transplantation. This indicates that the integrated fish culture farmers who used pesticides applied them at rates similar to those in nonintegrated rice fields although the time of application was different.

Since the study has shown that pesticide use is low in integrated farms because of low pest infestation as reported by farmers, four integrated plots and four monocropped rice

A happy farmer showing his produce.

Table 2.49. Frequency of pesticide use in stocked and unstocked plots, by season.

Season	Unstocked		Stocked	
	No. of plots	Cases with pesticide use (%)	No. of plots	Cases with pesticide use (%)
Boro, 1993	23	21.7	64	9.4
Boro, 1994	28	46.4	85	10.6
All *boro*	51	35.3	149	10.1
Aman, 1992	23	NA[a]	52	9.6
Aman, 1993	12	16.7	28	0
Aman, 1994	0	NA[a]	27	0
All *aman*	12	16.7	28	0

[a]NA - Data not available.

plots were monitored during the *boro* season of 1995 to assess insect population. For this purpose, 20 hills (2 m distance between hills) from each plot were sampled at random for insects over a period of 10 weeks. The observed insects were collected and identified. In all, five samplings were done after transplantation but before harvesting of rice. The first sampling was done six to eight weeks after rice transplantation and the subsequent samplings at two-week intervals. Integrated and control plots were selected in pairs in the same area, with the same rice variety and management, and belonging to the same farmer. The insects were grouped into pests which are harmful to rice crop and useful insects or defenders which prey on pests. The pests identified from the plots were: larval and adult stages of stem borer (*Scirpophaga incertulas, Chilo suppressalis, Rupela albinella*), rice bug (*Leptocorisa oratorius*), green leafhopper (*Nephotettex* sp.), white leafhopper (*Cofana spectra*), short-horned grasshopper (*Oxya* spp.), golden cricket (*Euscyrtus concinnus*), gall midge (*Orseolia oryzae*), rice earhead bug (*Leptocorisa acuta*), rice skipper (*Pelopidas mathias*) and black bug (*Scotinophara* spp.) (Table 2.50). The defenders or the insects which prey on pests identified from the sampled farms were: water bug (*Microvelia douglasi, Mesovelia vittigera*), wasps (*Panstenon collaris, Amromorpha excepta, Gonatocerus* spp.), karabit beetle (*Ophinea nigrogasciata*), spiders (*Lycosa pseudo-annulata, Phidippus* spp., *Argiope catenulata*), lady beetle (Coccinellidae) and damsel fly (*Agriocnemis* spp.).

Details of number of different pests and useful insects collected from 20 hills from four plots of integrated and four plots of monocropped rice farms are enumerated in Table 2.50. The major pest populations observed were grasshopper, stem borer and rice bug. The major useful insects were lady beetle, spider and damsel fly. As can be seen from Fig 2.6, the pest population was 40.5% to 167% higher in monocropped rice farms compared to integrated farms during all samplings at different times of crop growth.

During the first three samplings (i.e., up to 10-12 weeks after transplantation) the population of useful insects was higher in integrated farms by 5.5% to 48.6% (Fig. 2.7). During the last two samplings it was observed that the population of useful insects was higher in monocropped rice farms compared to integrated farms.

The farmers indicated that pest infestation during *boro* season of 1995, when this study was undertaken, was comparatively less than in previous years. The survey results confirm lower infestation of pests in integrated farms. Halwart (1995) reported significant reduction in incidence of stem borer damage (white heads) in integrated rice-fish farming. While fish may not be able to completely control pests, they are able to keep pest populations below an economic threshold. Common carp has shown to be a better biocontrol agent compared to tilapia (Halwart 1995).

Table 2.50. Number of insects collected from 20 hills in each of four plots during *boro* season.

Pests/Useful insects	1st sampling		2nd sampling		3rd sampling		4th sampling		5th sampling		Total	
	Integrated plot	Control plot	Integrated plot	Control plot	Integrated plot	Control plot	Integrated plot	Control plot	Integrated plot	Control plot	Integrated plot	Control plot
Pests												
Adult stem borer	2	22	7	17	6	10	3	4	4	8	22	61
Stem borer larva	4	13	1	11	2	10	4	6	2	7	13	47
Rice bug	-	7	1	11	6	11	6	14	7	9	20	52
Green leafhopper	7	4	-	1	-	1	-	-	1	1	7	7
Gall midge	-	-	-	1	-	-	-	-	-	2	-	3
Rice earhead bug	-	-	2	2	1	1	-	-	-	-	3	3
Rice skipper	-	-	-	1	-	-	3	7	-	2	3	10
White leafhopper	2	1	3	-	1	-	1	3	-	3	7	7
Case worm	-	-	-	2	-	-	-	-	-	1	-	3
Grasshopper	5	10	11	21	17	19	25	19	15	23	73	92
Golden cricket	1	-	-	-	-	-	-	-	-	-	1	-
Black bug	-	-	-	-	-	-	-	6	2	3	1	9
Total	21	57	25	67	33	52	42	59	31	59	151	292
Useful insects												
Water bug	-	-	1	-	-	-	-	-	-	-	1	-
Wasp	1	1	-	-	-	-	-	-	-	-	1	1
Karabit beetle/Ground beetle	4	10	4	2	4	2	4	2	10	9	26	25
Spiders	16	15	24	10	12	8	9	11	9	11	70	55
Lady beetle	22	15	13	19	17	18	12	15	17	35	81	102
Damsel fly	11	6	10	5	10	8	10	12	10	6	51	37
Housefly	4	8	3	1	2	4	2	2	1	4	12	19
Total	58	55	55	37	45	40	37	42	47	65	242	239

Hendarsih et al. (1994) reported reduction in damage to rice by rice leaffolder and white-backed planthopper by 50% and 33%, respectively, in Indonesia.

2.6. Weed infestation

Many farmers in the study area indicated that weed infestation in integrated rice-fish farms is much less than in monocropped rice farms because fish feed directly on weeds. In addition, when the soil is disturbed by the browsing of fish, the weeds get uprooted and die off. This results in lower labor costs for clearing weeds in integrated farms (Table 2.46). To verify these perceptions and to quantify the weed infestation in integrated and monocropped rice farms, the volume of weeds was studied in seven integrated and seven monocropped rice farms at two-week intervals during the *boro* season of 1995. A total of four samplings were done during the rice growing season, the first after 30-45 days of transplantation and before the first weeding by the farmers, and the subsequent samplings at 15-day intervals. All the weeds in a square meter area at three randomly selected places in each farm were collected using a 1-m^2 bamboo frame. The weeds were identified as far as possible and their number and weight were noted (Table 2.51). Of the 14 farms studied, eight farms (four integrated and four monocropped rice farms) were weeded twice by the farmers and the rest only once. The first weeding was done 30-45 days after transplantation and the second weeding 15-20 days later. No pesticides or herbicides were applied in these farms.

The weeds identified from the rice fields were: *Marselia crenata*, *Cyperus iria*, *Commelina diffusa*, *Monochoria vaginalis*, *Echinochola crusgalli*, *Scirpus* sp.; *Fimbristylis miliacea*, *Cynodon dactylon*, *Lindernia* sp., *Leersia hexandra*, *Ipomea aquatica* and *Sphenoclea zeylanica*

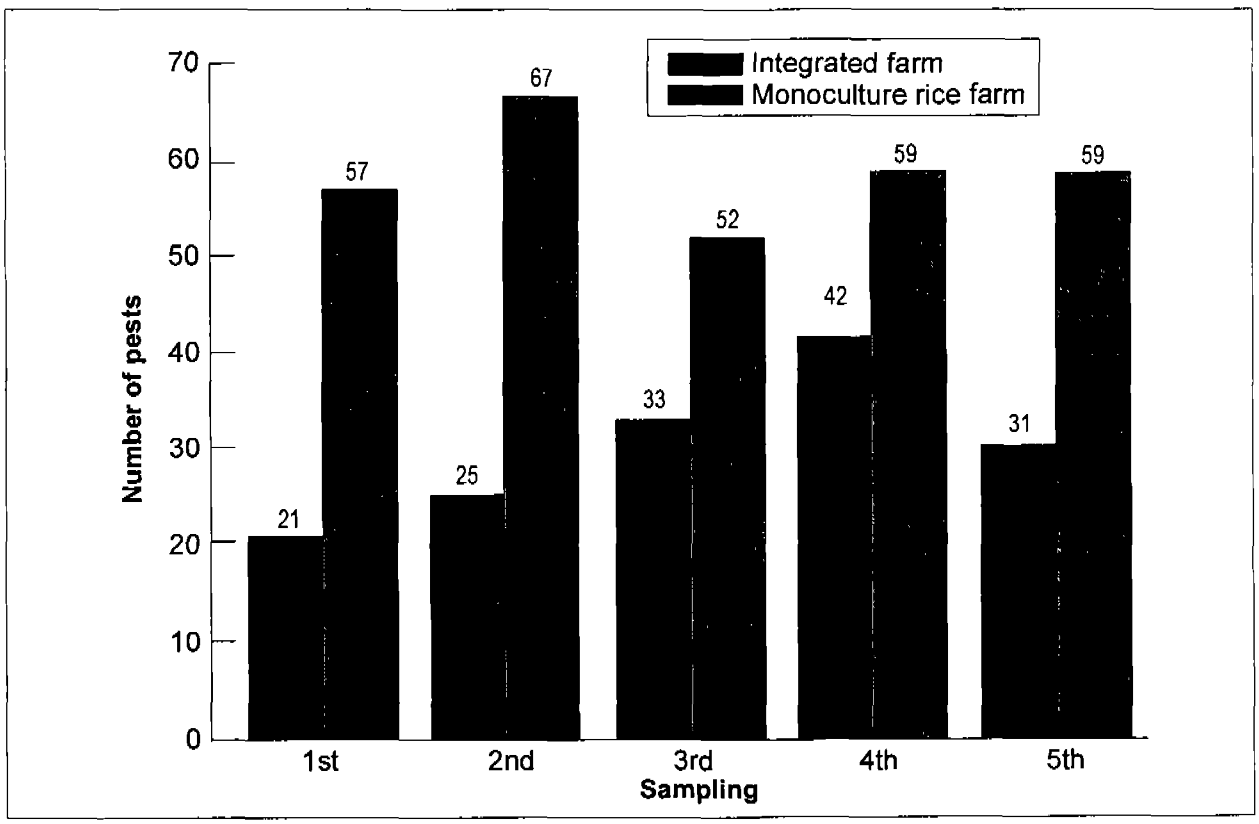

Fig. 2.6. Pests collected from 20 hills in each of four plots during *boro* season.

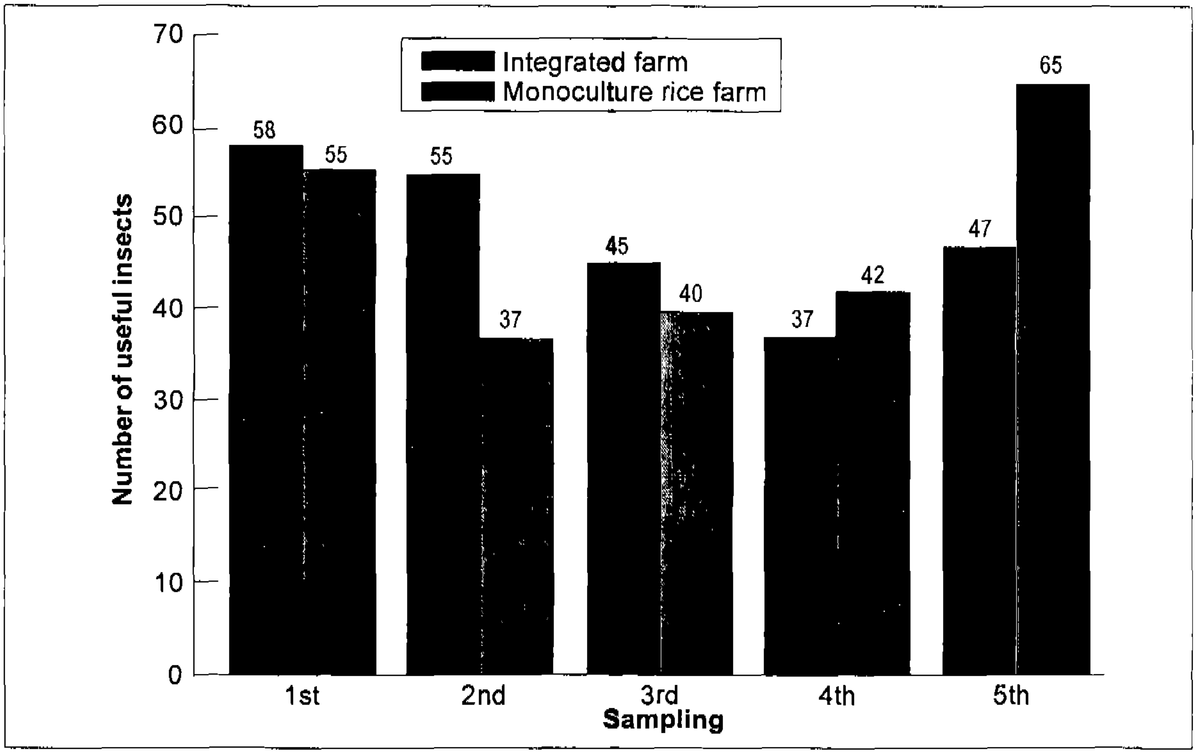

Fig.2.7. Useful insects collected from 20 hills in each of four plots during *boro* season.

(Table 2.51). Of these, *C. iria, Scirpus* sp., *F. miliacea, M. vaginalis, M. crenata* and *Lindernia* sp. were the major weeds both in number and weight. The quantity of weeds was highest during the first sampling before farmers undertook weeding. There was a gradual decline during subsequent samplings (Figs. 2.8 and 2.9). In integrated farms, an increasing trend in weight of weeds collected was observed during the third and fourth samplings. One possible reason for this could be that there was very little rainfall during the year of study and drought conditions prevailed. Farmers could not maintain water levels in the integrated farms during the later part of that season, forcing the fish to be restricted to ditches. However, there was enough water or moisture for the weeds to grow well, unlike in monocropped rice farms.

As evident from Fig. 2.8, the number of weeds recorded from monocropped rice farms was 75.2%-218.4% higher during different times of rice farming, compared to integrated farms. By weight also, the quantity of weeds was higher by 68.4%-204.1% in monocropped rice farms during different times of rice farming (Fig 2.9).

These observations confirm the earlier findings that labor costs for weeding are lower in integrated farms compared to monocropped rice farms (Table 2.46).

2.7. Wild fish

The fish production figures given in the earlier sections of the report are from stocked and cultured fish. The farmers at harvesting time also caught wild fish that entered the fields during flooding. These wild fish catches were monitored through the course of the 1993 and 1994 seasons.

Wild fish catches were clearly greater in the *aman* season due to flooding and entry of catchment water. Of the 149 plots covered in the survey of 1993 and 1994 *boro* season, 131 (88%) reported no wild fish catches. By contrast, of the 52 *aman* plots covered, only

Table 2.51. Number and weight (g) of weeds collected from three 1-m^2 areas from seven plots during *boro* season.

Weed	1st sampling				2nd sampling				3rd sampling				4th sampling				Total integrated		Total control	
	Integrated plots		Control plots		Integrated plots		Control plot		Integrated plots		Control plots		Integrated plots		Control plots		No.	Wt (g)	No.	Wt (g)
	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)	No.	Wt (g)				
Shushnishak *(Marselia crenata)*	67	133	205	265	25	82	119	135	11	32	31	43	47	98	123	210	150	345	478	653
Barochucha *(Cyperus iria)*	957	1 366	1 843	3 445	393	630	1 116	2 102	346	603	698	1 555	132	333	368	937	1 828	2 932	4 025	8 039
Kanainala *(Commelina diffusa)*	-	-	7	35	-	-	-	-	1	20	-	-	-	-	9	95	1	20	16	130
Panikochu *(Monochoria vaginalis)*	40	177	33	143	32	130	26	82	45	220	93	267	41	674	35	470	158	1201	187	962
Shama *(Echinochloa crusgalli)*	36	501	72	795	22	135	48	470	12	128	29	491	10	475	24	651	80	1 239	173	2 407
Chechra *(Scirpus* sp.*)*	134	221	121	285	57	92	99	179	85	158	69	130	55	126	29	60	331	597	318	654
Baro javani *(Fimbristylis miliacea)*	26	17	92	54	26	24	140	132	113	96	142	177	53	61	109	159	218	198	483	522
Durba *(Cynodon dactylon)*	-	-	17	45	-	-	7	17	-	-	34	38	-	-	-	-	-	-	58	100
Helencha *(Lindernia* sp.*)*	9	31	76	440	4	20	33	149	19	145	80	398	8	130	37	190	40	326	226	1177
Arail *(Leersia hexandra)*	15	20	16	45	15	17	36	80	16	42	35	98	28	76	41	102	74	155	128	325
Kolmi *(Ipomea aquatica)*	-	-	-	-	1	2	-	-	1	5	-	-	1	1	-	-	3	8	-	-
Gearton *(Sphenoclea zeylanica)*	180	77	53	39	25	28	67	58	35	26	47	72	21	28	121	220	261	159	288	389
Argoli	-	-	-	-	-	-	-	-	-	-	-	-	2	20	10	135	2	20	10	135
Unidentified	26	35	26	39	31	39	318	215	76	95	99	208	18	77	154	285	151	246	597	747
Total	1 490	2 578	2 561	5 630	631	1 199	2 009	3 619	760	1 570	1 357	3 477	416	2 099	1 060	3 514	3 297	7 446	6 987	16 240

Table 2.52. Wild fish catch from stocked and unstocked plots during *aman* and *boro* seasons. Standard deviations are in parentheses.

Season	No. of cases		Wild fish production ($kg \cdot ha^{-1}$)	Proportion of total production occupied by wild fish
	Stocked plots	Control plots		
Aman, 1993	28	-	33.5 (31.2)	15.3 (9.5)
Aman, 1994	24	-	45.3 (44.1)	11.9 (10.0)
All	52	-	38.9 (37.8)	13.7 (9.8)
Aman, 1993	-	12	63.6 (63.4)	NA[a]
Boro, 1993	64	-	0.32 (2.5)	0.07 (0.6)
Boro, 1994	85	-	3.61 (8.06)	1.37 (3.5)
All	137	12	2.19 (6.5)	0.82 (2.7)

[a]NA - Data not available.

one (1.9%) reported no wild fish catches. Mean wild fish production was 38.9 kg·ha^{-1} in the *aman* season, and only 2.19 kg·ha^{-1} in the *boro* season (Table 2.52). Wild fish on average were 13.7% of the total fish catch in the *aman* season, but represented only 0.82% of the *boro* catch. Plots that received catchment water from neighboring fields reported higher wild fish catches.

The relatively high wild fish catch reported from the control plots in the 1993 *aman* season (63.6 kg·ha^{-1}) is noteworthy. This sample of 12 plots included one 600-m^2 plot with a reported catch of 15 kg or 250 kg·ha^{-1}. If this plot is not taken into consideration, the mean catch was 46.7 kg·ha^{-1} for the remaining 11 plots, which is still higher than the mean for the stocked plots.

2.8. Conclusion

The potential to increase land area under rice is limited. Intensive rice monoculture and rice field ecosystem management are considered contradictory. With intensification of rice cropping, farmers tend to ignore the ecology of rice fields. There are concerns that yield under intensive rice cultivation has reached a plateau or may even be declining (Pingali 1991). In many countries, rice production is becoming less profitable to farmers due to low prices, stagnant yields and high input costs. Therefore, there is an increasing tendency towards diversification from rice monoculture (Pingali 1992). The present study has clearly indicated that integration of fish culture with rice farming is a viable, environment-friendly, low-cost, low-risk economic activity with multiple benefits including increased incomes and greater availability of fish to rural farming households, especially those who do not own or have access to a pond; an entry point for integrated pest management (IPM) leading to a better environment; decreased labor requirements in view of lower weed infestation; and optimum utilization of land and water resources. Fujisaka and Vejpas (1990) reported 65% higher average net returns from rice-fish farming in Thailand. The integration gains much more importance in marginal/water logged areas where

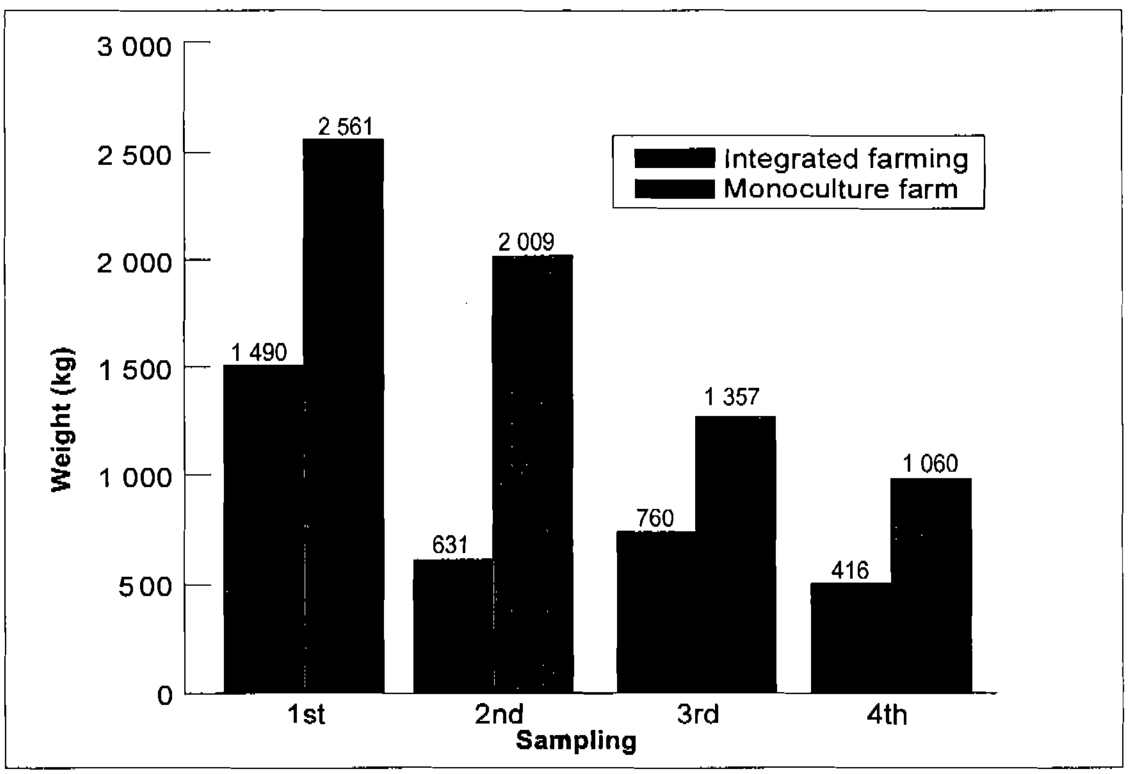

Fig. 2.8. Weeds collected from the three 1-m^2 areas from seven plots during *boro* season.

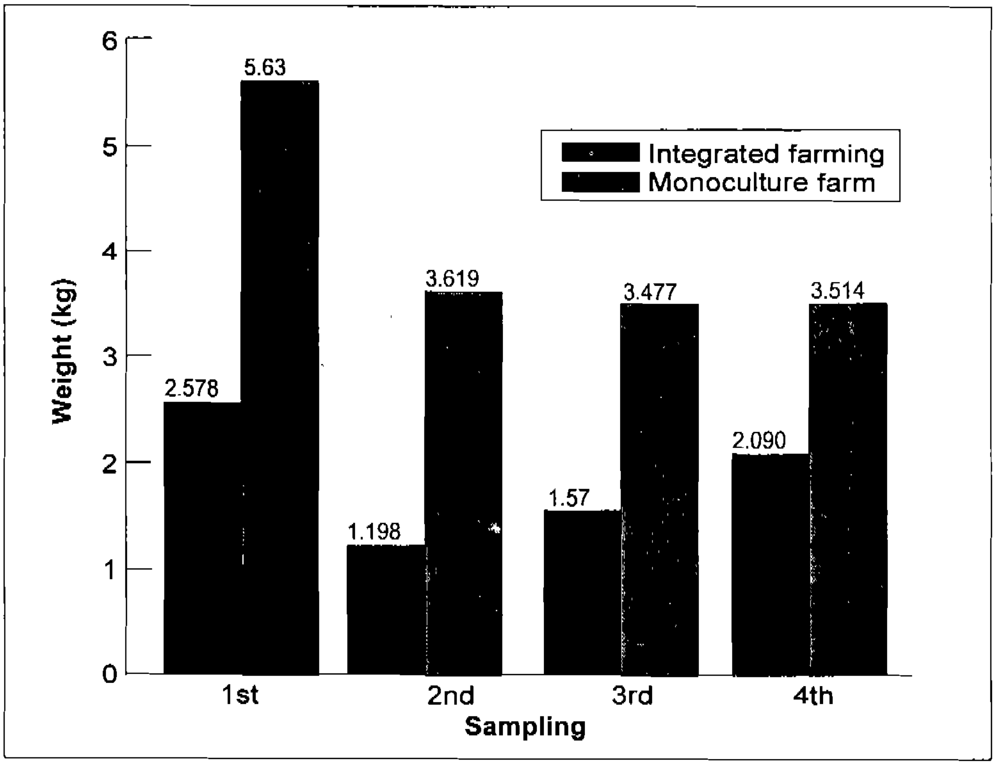

Fig. 2.9. Total weight (kg) of weeds collected from the three 1-m^2 areas from seven plots during *boro* season.

high yields of rice are not feasible. The fact that many farmers are taking to integrated rice fish farming, in spite of the small size of fish at harvest (due to short rearing period and low water depth), indicates their interest and the sustainability of the operation.

Pesticides have become an indispensable input in green revolution package of technologies for rice. Governments have encouraged the use of pesticides through subsidies as an instrument of food policy (Waibel 1992). Loses in rice production due to insect pests were estimated at 8%-14% (Waibel 1986). Studies undertaken have indicated that farmers' pesticide applications paid off in less than 50% of the cases in Thailand (Zeddies and Waibel 1982) and incurred a loss of US$3.7·$ha^{-1}$ in Thailand (Waibel and Engelhardt 1988). Litsinger (1984) estimated that rice production in the Philippines can be maintained with roughly half the level of pesticides being used. The potential income from fish represents the opportunity cost of pesticide use, raising the economic threshold for rice pests (Waibel 1992). The present study has revealed that farmers practicing integrated rice-fish farming use fewer or no pesticides, with few adverse effects on rice production. Integrated rice-fish farming could be an entry point for IPM. In view of this, agencies working for propagating IPM methods should work closely with the agencies and extension workers involved in disseminating integrated rice-fish farming practices.

Of the total area, as of 1995, 5.75 million ha was under transplanted *aman,* 2.58 million ha under *boro* and 1.65 million ha under *aus* rice crops (BBS 1995). Of these areas, 39.3%, 90.5%, and 24.3% area, respectively, were under high-yielding varieties of rice (BBS 1995). Not all of these rice growing areas may be suitable for integration with fish due to land elevation, flooding and soil characteristics. However, even if 10% of the total area under *aman* rice and 5% of the area under *boro* rice could be brought under integrated rice-fish farming, a moderate fish production of 150 kg·ha^{-1} per crop would result in a total fish production of about 93 000 tons per year, which is about 50% of the total aquaculture production and 10% of total fish production in Bangladesh during 1992-1993.

However, to harness this potential, the government should address the constraints for adoption by: (i) making fingerlings of required species easily available to the farmers when needed and (ii) transferring knowledge to farmers by extension workers through demonstrations, training of farmers and distribution of pamphlets. To achieve this, it is necessary for the researchers and the fisheries and agriculture extension workers to work closely for technology transfer.

3. ADOPTION AND IMPACT OF INTEGRATED RICE-FISH FARMING

3.1. Methodology

The survey to assess the adoption and impact of integrated rice-fish farming was undertaken from October 1994 to January 1995. A total of 47 farmers were surveyed in Muktagacha, Bhaluka and Trishal thanas in Mymensingh district, where farmer-implemented integrated rice-fish farming studies had been undertaken from 1992 to 1994 (Fig. 1.2). A structured questionnaire was prepared, pretested in the field and final changes were made before the survey was carried out (Annex 3). The survey covered status of rice-fish farming in Mymensingh district, profile of rice-fish farmers, production environment, management practices, productions obtained and farmers' perceptions on integrating aquaculture with agriculture.

Of the total 47 farmers surveyed, 41 were from Muktagacha thana where no extension activities for rice-fish farming had been undertaken for a year prior to this survey. This is expected to give a real picture of the extent of adoption by farmers without extension support and identify constraints to adoption, if any. In all, 41 farmers from 16 villages in Muktagacha thana, four farmers from one village in Bhaluka thana, and two farmers from one village in Trishal thana were interviewed (Table 3.1).

Respondent farmers were selected specifically to include only those farmers who had previously undertaken rice-fish farming and/or were practicing rice-fish farming at the time of interview. There is probability of some bias in favor of those who worked in their own villages, since those with outside jobs tended to be available less often. The sole criteria used in selecting interviewees was that they had some previous or current experience in rice-fish farming. Farmers were warned at the outset that the interview would take one to two hours. This allowed farmers who did not have the time the opportunity to be excused, and allowed those interviewed to focus on answering the questions.

The quantitative data collected in the course of the interview were based on farmers' recollections for the previous or current season and are therefore subject to some error. The absolute values of most inputs and fish productions reported here are rough approximations. However, they do allow data from farmers in different circumstances to be compared.

Table 3.1. Villages and farmers surveyed.

Thana	No. of villages surveyed	No. of farmers surveyed
Muktagacha	16	41
Bhaluka	1	4
Trishal	1	2
Total	18	47

Data collected were entered into FOXPRO database format, and analyzed with SPSSPC+, primarily through cross-tabulations.

Farmers surveyed were classified according to type of farmer and season of farming:

1. either cooperator farmers, having implemented the on-farm research trials undertaken in previous years (results are presented in the previous section of this report), or new adopters, and;
2. *boro* season only, *aman* season only, both seasons, or neither season, based on the season in which they had undertaken integrated rice-fish farming in 1994.

3.2. Results of survey

3.2.1. Status of rice-fish farming in Mymensingh district

To estimate the extent of integrated rice-fish farming in Mymensingh district, the offices of the Department of Agriculture Extension (DAE) in each thana were asked to submit a list of farmers who had undertaken rice-fish farming in the 1994 *boro* season, were culturing fish during the 1994 *aman* season, and those who had stopped rice-fish farming (Table 3.2).

The number of practitioners listed is conservative. In most cases, it appeared that the farmers listed were those who worked under the advice of the Block Supervisors of DAE. The number listed did not include those operating independently. In the course of the interviews, farmers were asked if they knew any others who were practicing rice-fish farming, or any who had discontinued. DAE provided the names of 47 farmers for the survey, whom they knew were undertaking integrated rice-fish farming. The survey revealed an additional 42 names, that is 89% above the expected number provided by DAE. Applied to Muktagacha thana where farmers were known to have practiced rice-fish farming in 1994, a total of 250 farmers may have been involved in rice-fish farming in the 1994 *aman* season. Another 10 farmers were said to have discontinued the practice.

In one village in Bhaluka thana, two additional farmers were found to be involved in rice-fish farming. One more farmer had discontinued the practice. Reports from other locations suggest that the number of farmers practicing rice-fish farming is much higher than indicated in this report.

Table 3.2. Farmers involved in rice-fish farming in Mymensingh district during 1994, as per information from DAE.

Thana	No. of farmers involved in rice-fish farming		
	Boro	*Aman*	Discontinued
Fulbaria	10	10	5
Muktagacha	12	136	?
Mymensingh Sadar	32	15	30
Nandail	10	14	13
Ishorganj	3	18	13
Gouripur	19	18	9
Fulpur	9	4	1
Halwaghat	3	3	1
Dhobaura	1	2	0
Trishal	3	7	6
Bhaluka	37	16	2
Total	139	243	80

The farmers were also asked when they started integrating fish culture with rice farming (Table 3.3). Rice-fish farming appears to be steadily expanding. It is noteworthy that two farmers had been culturing since 1984.

3.2.2. *Profile of rice-fish farmers*

3.2.2.1. Household size

All the farmers interviewed were male. Women are normally not involved in the cultivation of rice in Bangladesh and hence they did not play any role in rice-fish farming. The mean age of farmers interviewed was 40.5 years.

The mean household size for the entire sample was 9.44, consisting of 3.72 men, 2.72 women and 3 children (under 15 years of age). There were no striking differences in household size or composition among the three thanas surveyed (Table 3.4). However, the household size of farmers surveyed was much higher than the national average household size of 5.48 (BBS 1995), which is statistically significant. In many cases, the availability of sufficient family labor to prepare the rice plot prior to stocking is a deciding factor whether or not to culture fish.

3.2.2.2. Literacy

Of the total number of farmers surveyed, five farmers (10.6%) were illiterate, four (8.5%) could read, but had not completed primary school level, 13 (27.7%) had completed only primary level and another 22 (46.8%) had completed secondary or higher secondary level. Three farmers (6.4%) had post-secondary training.

Table 3.3. Year and season of commencement of integrated rice-fish farming by farmers surveyed.

Year	No. of farmers		
	Boro	*Aman*	Total
1984	0	2	2
1990	1	2	3
1991	3	2	5
1992	3	7	10
1993	10	2	12
1994	4	11	15
All years	21	26	47

Table 3.4. Household size and composition by seasonal pattern of integrated rice-fish farming. Standard deviations are in parentheses[a].

Season of practice	No. of cases	Household size			
		Men	Women	Children	Total
Boro only	4	4.00 (3.37)	2.75 (2.87)	3.75 (2.87)	10.50 (9.04)
Aman only	17	4.35 (2.00)	3.00 (1.12)	2.65 (1.77)	10.00 (3.52)
Both	20	3.30 (2.15)	2.10 (0.97)	3.20 (1.99)	8.60 (4.32)
Neither	5	3.00 (1.87)	4.20 (1.64)	2.80 (1.64)	10.00 (3.16)
Total	46	3.72 (2.18)	2.72 (1.44)	3.00 (1.92)	9.44 (4.38)

[a]In this and other tables, season of practice refers to 1994 only. Farmers who practiced in "neither" season discontinued rice-fish farming in 1994.

There were differences in educational background between the former five cooperator farmers and the new adopters. Of the 20 former cooperator farmers, only five (25%) had education beyond primary level, while 74.1% of the new farmers had education beyond primary level, indicating adoption of the technology was higher among literate farmers.

3.2.2.3. Landholding

Mean landholding for the entire sample of farmers was 1.97 ha, of which, an average of 1.44 ha was cultivated (Table 3.5), as against national average landholding per farm household of 0.914 ha and the average of 0.913 ha for Mymensingh district. The majority of farmers did not mortgage land in or out. Eleven farmers (19.1%) had land mortgaged or leased in, and 15 (31.9%) had land leased or mortgaged out. Mean area leased or mortgaged in for the entire sample of 47 farmers was 0.16 ha; mean area leased or mortgaged out was 0.16 ha. There was no noticeable difference in holdings between former cooperator farmers and new adopters, except that cooperator farmers had, on average, greater areas mortgaged in (0.24 ha vs 0.98 ha) and out (0.23 ha vs 0.11 ha).

While there was considerable overlap in cultivated landholdings among all four classes of farmers, the relatively smaller areas held by those who cultured fish in both seasons (1.18 ha against 2.28 ha of farmers culturing fish in *boro* season and 1.49 ha of farmer culturing fish during *aman* season only) is of interest. Farmers with limited areas tended to feel a greater need to intensify the output from their holdings.

All but two farmers (95.3%) reported farming as their primary or sole occupation. Twenty farmers (58.8% of the sample from which data were available) reported no secondary occupation. Among secondary occupations, shopkeeping was the one most frequently mentioned (23.5% of cases).

All but one of the 47 farmers (97.9%) planted *aman* rice crop, and 43 farmers (91.5% of the total) planted *boro* crop. However, only 22 farmers (46.8%) planted an *aus* crop. Jute was planted by 24 farmers (51.1% of the total) and various vegetables by 33 farmers (70.2% of the total). Jute was typically planted in March and April and harvested four to five months later. Vegetables were normally a winter crop planted in small areas near the homestead. Other crops mentioned included mustard, sugar cane, banana and tree nurseries. The cropping intensity (total cropped area as a percentage of cultivated area) was 190% as against the national average of 170% and the average of 193% for Mymensingh district. Table 3.6 gives the mean areas planted for the three rice crops, jute and vegetables for the sample of 47 farmers.

Table 3.5. Pattern of ownership of cultivated land by seasonal pattern of integrated rice-fish farming.

Season of culture	Cultivated area owned by farmer (ha)		Area shared, leased or mortgaged in (ha)		Area shared, leased or mortgaged out (ha)	
	No. of cases	Mean area	No. of cases	Mean area	No. of cases	Mean area
Boro only	4	2.28 (1.82)	4	0	4	0.10 (0.20)
Aman only	17	1.49 (1.26)	18	0.13 (0.29)	18	0.21 (0.49)
Both	19	1.18 (0.82)	20	0.25 (0.90)	20	0.17 (0.27)
Neither	5	1.62 (1.10)	5	0	5	0
All	45	1.44 (1.13)	47	0.16 (0.61)	47	0.16 (0.35)

3.2.3. Production environment

Agricultural land in Bangladesh has been estimated at 8.16 million ha (BBS 1995) and has been classified into five types: (i) high land, land above normal flood level; (ii) medium high land, normally inundated up to 90 cm deep; (iii) medium low land, normally inundated between 90 and 180 cm; (iv) low land, normally inundated between 180-300 cm; and (v) very low land, inundation more than 300 cm. The land in Muktagacha thana where 16 of the 18 villages surveyed were located, is flat with very gentle undulations and slopes. According to the criteria followed in Bangladesh, the majority of these plots come under the category of medium high lands.

The levels of gross annual income reported by farmers were probably not reliable. There appeared to be a tendency to underestimate income in a number of cases. Hence, the data has not been analyzed.

There are no striking differences in area devoted to rice-fish farming among farmers who cultured fish in one season, and those who cultured in both the seasons in terms of areas devoted to rice-fish farming. Farmers who cultured in only one season appear to devote a larger proportion of their rice growing area to rice-fish farming, but firm conclusions cannot be drawn (Table 3.7).

The mean percentages of rice-growing area under rice-fish farming appeared to be higher than could be predicted from the data given in Table 3.6. In two cases in the *aman* season and one case in the *boro*, where the entire rice growing area was under rice-fish farming, ditch area added significantly to the area under rice-fish farming (more than 10%). As a result, total area under rice-fish farming exceeded rice growing area for these farmers.

New adopters tended to have larger rice-fish farming operations, both in absolute terms and as a proportion of total rice growing area, compared to the former cooperator farmers (Table 3.8). Overall, *boro* season rice-fish plots had a mean area of 0.22 ha and occupied on average 34.83% of the farmer's total *boro* rice growing area. The average *aman* rice-fish plot was slightly larger (0.28 ha) and occupied on average 37.6% of the farmer's total *aman* area. The responses to why the farmers were not using their entire rice growing area for rice-fish farming are in Table 3.9. Farmers who did not culture fish in the *boro* or *aman* season or whose rice-fish farming area was the same as their entire rice growing area are not included in the data.

Table 3.6. Mean areas planted under major crops and as a percentage of total landholding. Standard deviations are in parentheses. "Total holding" includes cultivated and noncultivated land.

Crop	Mean area per farm (ha)	Mean % of total holding
Boro rice	0.958 (0.805)	53 (30)
Aus rice	0.244 (0.373)	13 (18)
Aman rice	1.206 (0.924)	63 (23)
Jute	0.12 (0.309)	4 (7)
Vegetables	0.081 (0.106)	4 (5)

Table 3.7. Mean areas under rice-fish farming by seasonal pattern of integrated rice-fish farming. Standard deviations are in parentheses.

Seasonal pattern	*Boro*			*Aman*		
	No. of cases	Mean plot area (ha)	Mean % of total *boro* area	No. of cases	Mean plot area (ha)	Mean % of total *aman* area
Boro or *aman* only	4	0.194 (0.153)	44.44 (59.29)	17	0.350 (0.264)	48.37 (49.32)
Both seasons	18	0.229 (0.146)	32.69 (32.44)	20	0.215 (0.138)	28.01 (27.49)
Both	22	0.222 (0.144)	34.83 (37.09)	37	0.277 (0.214)	37.63 (40.14)

Table 3.8. Mean areas under rice-fish farming among former cooperator farmers and new adopters by season. Standard deviations are in parentheses.

Category of farmers	*Boro* No. of cases	Plot area (ha)	% of total *boro* area	*Aman* No. of cases	Plot area (ha)	% of total *aman* area
Former cooperators	11	0.20 (0.13)	33.39 (42.35)	12[a]	0.19[a] (0.11)	21.99* (25.65)
New adopters	11	0.25 (0.16)	36.27 (33.02)	24	0.32 (0.24)	45.44 (44.12)
All	22	0.22 (0.14)	34.83 (37.09)	36	0.28 (0.21)	37.63 (40.14)

[a]One plot under communal rice-fish farming was dropped, since it included the holdings of 15 farmers, only one of whom was interviewed.

Table 3.9. Factors limiting area under integrated rice-fish farming. Number of farmers and percentages are in parentheses. Percentages are not additive because of multiple answers.

Factor	*Boro* (n = 20)	*Aman* (n=38)
Insufficient water in other plots	7 (35)	14 (36.8)
No high dikes in other plots	6 (30)	13 (34.2)
Other plots are remote	9 (45)	10 (26.3)
Risk of flood in other plots	1 (5)	5 (13.2)
No ditch in other plots	2 (10)	5 (13.2)
Insufficient money to prepare other plots	1 (5)	1 (2.6)
Risk of theft in other plots	2 (10)	4 (10.5)
Insufficient labour to prepare other plots	1 (5)	1 (2.6)
Other plots are too high	2 (10)	6 (15.8)
Wants to test limited area first	0 (0)	2 (5.3)

The distribution of factors limiting the area farmers used for rice-fish farming was similar for both seasons. Insufficient water was the most common response, followed by the absence of high dikes in other plots. Low dikes retain limited water and do little to prevent flooding. Remoteness of plots was relatively more important in the *boro* season, when rice could only be grown in the areas sufficiently irrigated by tubewells. The risk of flood was relatively more important as a limiting factor in the *aman* season, but applied in one case in the *boro* season. Rains in late *boro* season can seriously affect plots in low lands.

Ditches used in the *boro* season had a mean area of 179 m^2 and occupied, on average, 8.1% of the total plot area. Those used in the *aman* season averaged 519 m^2 and occupied on average 10.7% of the plot area. In six cases during the *aman* season, ditch area equalled or exceeded 1 000 m^2; in two of these cases, the ditches were communal ponds of 4 000 m^2. If these six cases are eliminated from consideration, the mean ditch area drops to 226 m^2, and ditches occupy a mean 4.7% of the plot area (Table 3.10). Ditches in the plots of new adopters tended to be larger.

Mean age of ditches used in *boro* season rice-fish farming was 3.7 years, and for *aman* season culture it was 6.4 years. While most ditches were excavated either for capturing or for culturing fish, some were excavated for other purposes, as indicated in Table 3.11.

An existing ditch in a rice field could save the farmer considerable investment in excavation. Total labor costs for plot preparation (cash and noncash) averaged Tk 787 per farmer (Tk 5 765·ha^{-1}) for *boro* plots and Tk 731 per farmer (Tk 1 649·ha^{-1}) for *aman* plots. Family labor provided an average of 34.3% for *boro* plots and 36.25% for *aman* plots.

Table 3.10. Ditch and plot area of rice-fish plots by season and category of farmers. Standard deviations and number of farmers are in parentheses.

Category of farmer	Ditch area (m^2)		Plot area (ha)	
	Boro	*Aman*	*Boro*	*Aman*
Former cooperators	129 (59) (n=11)	438* (1104) (n=14)	0.197 (0.128) (n=11)	0.753[a] (2.116) (n=14)
New adopters	229 (175) (n=11)	566 (824) (n=24)	0.248 (0.161) (n=11)	0.325 (0.241) (n=24)
Both classes	179 (138) (n=22)	519 (894) (n=38)	0.222 (0.144) (n=22)	0.483 (1.286) (n=38)

[a]The sample includes one communal plot of 8 ha with a ditch of 4 000 m^2. If this plot is dropped from consideration, mean ditch area for this sample is 165 m^2, and mean plot area is 0.187 ha.

Table 3.11. Purpose of ditch excavation in rice field. Percentages are in parentheses.

Purpose	*Boro*	*Aman*
Fish culture	17 (70.8)	22 (56.4)
Jute retting	2 (8.3)	5 (12.8)
Fish capture	5 (20.8)	6 (15.4)
House construction	0	3 (7.7)
Road construction	0	3 (7.7)
Total	24	39

3.2.4. *Management practices*

3.2.4.1. Stocking

During the *boro* season, farmers stocked fingerlings, on average, 29 days after transplantation of rice. In the case of *aman* season, stocking was done 25 days before transplantation, on average. Thirteen out of 35 farmers (37%) stocked fish in ditches prior to transplanting rice during the *aman* season to have a longer growing season which would allow the fish to reach its marketable size. The actual growing season for *aman* rice-fish farming is normally from August to November.

Farmers were asked what factors prevented them from stocking earlier. Their responses, which were not predictable, are outlined in Table 3.12.

In the *boro* season, the most common factor affecting date of stocking was insufficient water in the plot (45.5% of cases). While this was mentioned frequently in the *aman* season, the most frequent limiting factor in the latter season (33.3% of cases) was the need to wait until the rice crop was well-established in the plot (30.6% of cases). Fingerling availability limited stocking dates in 27.3% of the cases in *boro* season and 25% of the cases in *aman* season. Plot preparation delayed stocking in 30.6% of cases in the *aman* season, but in only 13.6% of the cases in *boro* season.

3.2.4.2. Species cultured

Species stocked during the two seasons included *C. carpio, B. gonionotus, O. niloticus, C. catla, L. rohita, C. mrigala, H. molitrix*, and other species, which included African catfish (*Clarias gariepinus*) in one *boro* plot; and local species such as climbing perch (*Anabas testudineus*), walking catfish (*Clarias batrachus*) and catfish (*Heteropneustes fossilis*) in one *aman* plot (Table 3.13).

C. carpio was the species predominantly stocked in the *boro* season and Indian major carps in the *aman*. In the *boro* season, *C. carpio* accounted for 55% of the fish stocked, tioned in Table 3.14, including confidence that the plot could accommodate more fish, a wish to maximize income and a wish to experiment could apply. In addition, the most common source of seed was from vendors and it is not always possible to control stocking rate when the vendors deliver fish because they tempt the farmers to buy and stock more fingerlings. Finally, several farmers indicated ignorance of recommended stocking rates and how stocking rates could be applied to a plot of a particular size. Familiarity with pond culture systems may have induced farmers to manage their rice fields in a similar way to ponds.

3.2.4.5. Irrigation

Additional irrigation for the fish is sometimes needed during rice-fish farming in the *boro* season. Out of the 20 respondents, only five said they had to provide additional irrigation specifically for fish: two farmers reported irrigating twice, one farmer three times, one farmer four times, and the fifth farmer reported providing additional irrigation at weekly intervals, or an estimated 15 times. This farmer had stocked the plot with fish at the time of transplantation in mid-January and provided water to his plot twice a week, once for rice and once for fish. The average number of times water was added for fish was estimated to be 1.3 for the entire sample of 20 farmers.

When farmers irrigated the rice, the quantity of water was often increased to maintain the fish. Of 20 farmers interviewed, six said that integration of fish culture did not impose additional water requirements. Four of these farms benefited from seepage from adjacent irrigation canals and the fifth had a low-lying plot which was stocked late in the season (mid-April). Most farmers, however, indicated that after fish were stocked, additional water needs increased by 25 to 100%.

When the entire sample of 20 farmers was considered and allowances made for the difference between rice transplantation date and fish stocking date, the average additional water requirement for fish was estimated at 26% more than for rice.

Table 3.16. Fingerling sources by season. Number of farmers are in parentheses.

Source	Farmers responding (%)	
	Boro (n=22)	*Aman* (n=37)
Vendor	50	45.9
Private hatchery	31.8	32.4
Government hatchery	13.6	10.8
Own pond	22.7	27.0
Delivered by extension agents	13.6	2.7
Village pond	0	2.7
Total	29	45

Table 3.17. Stocking densities by season. Standard deviations are in parentheses.

Class of farmer	Season			
	Boro		*Aman*	
	Mean density per ha	No. of cases	Mean density per ha	No. of cases
Former cooperators	8 709 (6 916)	8	5 202 (4 161)	12
Adopters	14 281 (10 401)	8	20 996 (17 306)	19
Both	11 495 (9 005)	16	14 882 (15 723)	31

3.2.4.6. Supplementary feeds and fertilizers for fish

Farmers were asked which feeds and fertilizers were applied for the fish, frequency of application and quantities applied each time. Total quantities were rough estimates, but the contrast between former cooperator farmers and the adopters is interesting (Table 3.18). Mean weights are based on entire sample of farmers, for which quantitative data is available.

The inputs most commonly applied were rice bran and cattle manure. Rice bran was applied in 92% of the *boro* plots and 82% of the *aman* plots at mean rates of 665 and 649 $kg{\cdot}ha^{-1}$ for the respective seasons. Cattle manure was applied in 92% of the *boro* plots and 74% of the *aman* plots at respective mean rates of 1 267 and 1 146 $kg{\cdot}ha^{-1}$. Mustard oil cake was reportedly given by 71% of the *boro* farmers and 66% of the *aman* farmers at respective mean rates of 189 and 202 $kg{\cdot}ha^{-1}$. A minority of farmers gave other inputs, including duckweed, inorganic fertilizers and various other feeds. Differences in feeding intensity between the two culture seasons appear negligible.

In general, farmers who adopted the technology tended to apply inputs more intensively than former cooperator farmers. For example, former cooperators applied cattle manure at mean rates of 764 and 774 $kg{\cdot}ha^{-1}$ in *boro* and *aman* seasons, respectively, while adopters applied manure at 1 725 and 1 373 $kg{\cdot}ha^{-1}$ during *boro* and *aman* seasons. This indicates a tendency among the adopters to manage their systems more intensively, more along the lines of a pond than a rice field.

3.2.4.7. Rice varieties planted

The rice varieties transplanted in integrated rice-fish plots are shown in Table 3.19. Pajam was the only rice variety planted in both seasons, and was the predominant variety in the *boro* season (55% of the plots). BR-11 was the variety most commonly planted in the *aman* season (37% of the plots). The relative importance of a local variety, aloi (32% of cases in the *aman* season), deserves note. This is a flood-tolerant variety, common in Muktagacha. Similar comments apply to Kumri, which was planted in Trishal and Bhaluka thanas. Altogether, almost half the plots planted in the *aman* season (47.7%) were planted with local varieties of rice (Table 3.19). The reasons for the selection of different rice varieties are given in Tables 3.20 and 3.21. While farmers applied a variety of criteria in selecting rice varieties for rice-fish farming, the relative importance of these criteria appears to vary between *boro* and *aman* seasons. The most common criterion in the *boro* season was high yields (59% of cases), followed by flood tolerance (27%) and a tendency not to lodge (23%). In the *aman* season, these three criteria remained important, but tolerance to flooding became predominant (55% of cases), followed by high yields (45%), and a tendency not to lodge (26%). While the number of cases from the *boro* season is small, it is still interesting to note that resistance to pests was an important criterion in 14% (3) of the cases, while it applied in only 2.6% (1) of the cases in the *aman* season.

3.2.4.8. Pesticide use

Pest infestations were reported by 14% of the farmers during *boro* rice-fish farming, and 32% of the farmers culturing in the *aman* season. Pesticides (diazinon and basudrin) were applied in only two of the three affected *boro* farms. In the *aman* season, pesticides were used in eight of the 12 affected farms (21% of the total sample). Basudrin was used in four of these farms, dimicron in two and diazinon in one. One farmer selected sumithion specifically because of its low toxicity to fish.

Table 3.18. Pattern of feed and fertilizer application by season and type of farmer. Standard deviations are in parentheses.

Feed/fertilizer	Farmer category	Total no. of farmers		Farmers applying (%)		Quantity (kg·ha⁻¹)			
		Boro	*Aman*	*Boro*	*Aman*	*Boro*		*Aman*	
Rice bran	Former cooperators	12	14	92	79	561	(450)	562	(457)
	Adopters	12	24	92	83	759	(1 277)	700	(725)
	Both	24	38	92	82	665	(958)	649	(636)
Cattle manure	Former cooperators	12	14	92	86	764	(743)	774	(695)
	Adopters	12	24	92	67	1 725	(2 712)	1 373	(2 124)
	Both	24	38	92	74	1 267	(2 041)	1 146	(1 738)
Duckweed	Former cooperators	12	14	42	21	2.9	(8.4)	137.0	(335.0)
	Adopters	12	24	42	21	33.5	(85.8)	10.2	(34.8)
	Both	24	38	42	21	19.1	(62.9)	60.7	(218)
Mustard oil cake	Former cooperators	12	14	58	50	101	(160)	68.7	(129)
	Adopters	12	24	83	75	260	(538)	278	(331)
	Both	24	38	71	66	189	(412)	202	(291)
Inorganic fertilizer	Former cooperators	12	14	25	21	0	6.7	(19.7)	
	Adopters	12	24	50	46	50.6	(84.0)	55.6	(118.0)
	Both	24	38	37.5	37	27.8	(66.2)	37.9	(96.9)
Others (termites, wheat, bran, kitchen waste, etc.)	Former cooperators	12	14	33	29	11.1	(33.4)	27.5	(79.5)
	Adopters	12	24	50	29	125	(288)	423	(1 250)
	Both	24	42	38	29	73.7	(218)	280	(1 011)

Table 3.19. Rice varieties planted in *boro* and *aman* seasons. Percentages total more than 100, as some farmers planted two varieties in their plots.

Rice variety	Farmers who planted (%)	
	Boro (22 cases)	*Aman* (38 cases)
Pajam	55	26
BR-11	0	37
BR-14	27	0
Aloi[a]	0	32
Kumri[a]	0	7.9
Purbachi	14	0
Fizer	4.5	0
BR-12	4.5	0
Basiraj[a]	0	2.6
Garolatiya[a]	0	2.6
Nazisail[a]	0	2.6
BR-10	0	2.6

[a]Local varieties

The comparatively high prevalence of pests reported in the *aman* season is unusual. Previous experience suggests that pesticides are used more in the *boro* season when there are more pest outbreaks. Five of the eight *aman* farmers applying pesticides did so in response to local infestations of pests, in three cases for stem borer, and in the other two, "chungi pukha". Eight of the 12 farmers reported stem borer and "chungi pukha" infestations.

3.2.5 Production

3.2.5.1. Fish production and utilization

Most farmers harvested fish several times during the season. In the *boro* season, the mean date for initial harvest was May 16 and May 27 for final harvest. For the *aman* crop, mean initial harvest date was October 28, and mean final date November 25.

Table 3.20. Farmers' reasons for selecting rice varieties during *boro* season. Since rice varieties were often selected for more than one reason by individual farmers, percentages are not additive.

Rice variety	High yields	Flood tolerance	Nonlodging tendency	High market price	Early maturation	Resistance to pests
Pajam (12 cases)	42	50	8	25	0	8
BR-14 (6 cases)	100	0	33	17	0	33
Purbachi (3 cases)	33	0	67	0	0	0
BR-12 (1 case)	100	0	0	0	0	0
Total (21 cases)	59	27	23	18	4.5	14

Table 3.21. Farmers' reasons for selecting rice varieties during *aman* season. Since rice varieties were often selected for more than one reason by individual farmers, percentages are not additive.

Rice variety	High yields	Flood tolerance	Nonlodging tendency	High market	Early maturation	Resistance to pests	Rotation with other variety	Late planting	Need to experiment	Availability	Differing land elevation in the farms	Plant habit, which makes easy access for fish
Pajam (10 cases)	30	40	20	20	20	0	10	0	10	0	0	0
BR-11 (14 cases)	79	21	50	0	0	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Aloi (12 cases)	17	75	0	0	0	0	0	8.3	0	25	8.3	0
Kumri (3 cases)	0	100	0	0	0	0	0	0	0	0	0	0
Garolatiya (1 case)	0	100	0	0	0	0	0	0	0	0	0	0
Basiraj (1 case)	100	0	0	0	0	0	0	100	0	0	0	0
Nazirsail (1 case)	0	100	0	0	0	0	0	0	0	0	0	0
BR-10 (1 case)	1	0	100	0	0	0	0	0	0	0	0	0
Total (38 cases)	45	55	26	5.3	5.3	2.6	5.3	7.9	5.3	10.5	5.3	2.6

Farmers were asked what factors prevented them from rearing fish for a longer period of time. Each farmer was influenced by several factors in deciding when to harvest the fish (Table 3.22). In both seasons, the most common factor affecting date of harvest was the drying of plot (67% of *boro* cases and 77% of *aman* cases). The need for cash induced 22% of the farmers to harvest during *boro* season, but only 8.6% farmers during *aman* season. Family need for fish was a common inducement to harvest during both seasons: it was mentioned by 17% of the *boro* farmers and 23% of the *aman* farmers. The need to plant the next crop of rice induced 17% of the *boro* farmers to harvest fish from their plots, but only 5.7% of the *aman* farmers. The *boro* crop is confined to irrigated areas, whereas the *aman* crop is planted more widely. *Aman* transplanting would normally begin in the plots which would first be inundated with water. These are often the plots most suitable for fish culture. Anticipated flooding led 17% of the *boro* farmers to harvest since the *boro* crop is harvested just before the rainy season, which ends about a month before the *aman* harvest. Another point of contrast between the two seasons was that anticipated or actual disease did not affect the timing of harvesting during *boro* season, but influenced 11.5% of the farmers during *aman* season.

The fish production figures given in Table 3.23 are not considered accurate since they are based on farmers' recollections. Nevertheless, they do provide some interesting contrasts between the former cooperators and the adopters of the integrated farming.

While the absolute values of the productions presented are open to question, it is clear that fish productions reported by former cooperator farmers are considerably lower than those reported by adopters, because as mentioned above, adopters tended to stock and feed more intensively than former cooperator farmers. In several cases, their ditches were larger than 0.1 ha in area. Such plots were not selected for the farmer implemented on-farm research.

Details of rice plot and ditch sizes for the farms represented in Table 3.23 are given in Table 3.24.

Cultured fish production from many rice fields can be increased with more intensive stocking and feeding, particularly if there is a sufficient and reliable source of water.

While differences in cultured fish productivity between the farmers who cultured in only one season and those who cultured in two seasons are less marked than differences between former cooperator farmers and adopters, farmers who cultured in both seasons did achieve higher fish production (Table 3.25). One reason may be a tendency among farmers to hold stock from one season for culture in the subsequent season. Six of the farmers who cultured in both seasons reported holding most of their *boro* season stock for culture in the *aman* season and seven of the 38 farmers culturing in the *aman* season (including three who had not cultured in the previous *boro* season) planned to hold most of their stock for culture during *boro* season. This would, in effect, lengthen the culture period of the fish, leading to bigger fish at final harvest. Culture period had a strong effect on size of fish at harvest in rice fields as in the case of ponds.

Farmers were asked about the disposal pattern of fish produced. There was wide variation among individuals, but relatively little between former cooperator farmers and adopters. Seasonal pattern of rice-fish farming appeared to have some effect on utilization pattern, as indicated in Table 3.26. On average, about 25% of fish produced was consumed by the households each season and between 5% and 7% was given away. The main point of contrast lies between the relative importance of sales and fish kept for restocking. In the *boro* season, 42% of the fish were kept for restocking; this percentage is considerably lower (25%) for the three farmers who did not culture in the subsequent *aman* season. Sales accounted on average for 28% of the *boro* fish production, but 40% of the fish caught by the three farmers who cultured only in the *boro* were sold. In the *aman* season, a lower percentage of fish were restocked (31%) and a greater proportion (38%) was sold. This is not surprising; in the absence of rains, there is less

Table 3.22. Factors affecting time of fish harvest. Percentages and number of farmers are in parentheses. Percentages are not additive.

Factor	Number of times harvesting affected	
	Boro (n = 18)	*Aman* (n = 35)
Water drying in plot	12 (67)	27 (77)
Flooding expected	3 (17)	0
Market price high	2 (11)	1 (2.9)
Opportunity to sell	1 (5.6)	1 (2.9)
Family need for fish	3 (17)	8 (23)
Family need for cash	4 (22)	3 (8.6)
Needed to thin overcrowded stock	0	4 (11)
Had to plant rice, so caught fish	3 (17)	3 (5.7)
Wanted to deepen pond	0	1 (2.9)
Fear of theft	0	2 (5.7)
Need to restock elsewhere	1 (56)	1 (2.9)
Disease encountered or anticipated	0	4 (11.5)
Total	29	54

Table 3.23. Cultured fish production from rice-fish plots as reported by farmers. Standard deviations and sample size are in parentheses.

Category of farmer	Fish production ($kg{\cdot}ha^{-1}$)		Fish production ($kg{\cdot}farmer^{-1}$)	
	Boro	*Aman*	*Boro*	*Aman*
Former cooperators	442 (471) (n=9)	303 (238) (n=13)	62.9 (59.1) (n=9)	96.6 (145) (n=13)
Adopters	1 856 (2 393) (n=8)	1 534 (2 417) (n=20)	330 (495) (n=8)	626 (1 128) (n=20)
Both classes	1 107 (1 774) (n=17)	1 049 (1 966) (n=33)	188 (357) (n=17)	417 (913) (n=33)

Table 3.24. Ditch and plot area of integrated farms from which fish productions were reported. Standard deviations and number of farmers are in parentheses.

Category of farmer	Ditch area (m^2)		Rice area (ha)	
	Boro	*Aman*	*Boro*	*Aman*
Former cooperators	109 (41) (n=9)	463[a] (1 069) (n=13)	0.178 (0.088) (n=9)	0.798[a] (2.196) (n=13)
Adopters	215 (206) (n=8)	559 (886) (n=20)	0.222 (0.138) (n=8)	0.348 (0.253) (n=20)
Both categories	159 (150) (n=17)	521 (947) (n=33)	0.198 (0.113) (n=17)	0.525 (1.377) (n=33)

[a]Among former cooperators plots, one communal plot of 8 ha had a ditch of 4 000 m^2. If this plot is dropped from consideration, mean ditch area for this sample is 168 m^2 and mean plot area is 0.190 ha.

scope for fish culture in the *boro* season, as compared to *aman* season.

Farmers were asked to give reasons for their utilization patterns. Their replies are summarized by season in Table 3.27.

The growth of fish in rice fields is dependent on the growing period. The size of fish after three months' rearing is often smaller than that preferred by the market. As a result, the frequency with which farmers restocked some fish to culture to marketable size is not surprising. The percentage of farmers who practiced this at the end of the *boro* season (53%) is considerably higher than at the end of the *aman* season (36%). The percentage of *boro* farmers whose families consumed a large proportion of their catch (26%) also contrasts with the percentage at the end of the *aman* season (9.1%). Fish are in short supply and expensive at the end of the *boro* season, while at the end of the *aman* season, fish tend to be more available in the markets,

Table 3.25. Reported cultured fish production from integrated rice-fish farms by seasonal pattern of rice-fish farming. Standard deviations and sample size are in parentheses.

Category of farmer	Fish production ($kg{\cdot}ha^{-1}$)		Fish production ($kg{\cdot}farmer^{-1}$)	
	Boro	*Aman*	*Boro*	*Aman*
Boro or *aman* only	804 (185) (n=3)	736 (836) (n=16)	167 (85.0) (n=3)	297 (385) (n=16)
Cultured both seasons	1 172 (1 960) (n=14)	1 343 (2 623) (n=17)	193 (395) (n=14)	531 (1 224) (n=17)
Both classes	1 107 (1 774) (n=17)	1 049 (1 966) (n=33)	188 (357) (n=17)	417 (913) (n=33)

Table 3.26. Utilization of cultured fish production by season. Standard deviations are in parentheses; deviations from 100% are due to rounding error.

Culture season	No. of cases	% of utilization			
		Consumed by family	Sold	Restocked	Given away
Boro only	3	32.33 (28.57)	39.67 (40.38)	25 (25)	3.0 (2.65)
Both seasons/*boro*	18	23.72 (20.38)	25.78 (27.44)	44.61 (37.13)	5.89 (5.9)
All *boro*	21	24.95 (21.07)	27.76 (28.77)	41.81 (35.83)	5.48 (5.6)
Aman only	17	22.54 (28.30)	41.84 (36.51)	30.64 (31.64)	4.98 (5.33)
Both seasons/*aman*	18	26.67 (22.81)	34.17 (33.86)	30.72 (30.13)	8.44 (12.46)
All *aman*	35	24.66 (25.30)	37.94 (34.87)	30.67 (30.41)	6.73 (9.71)

with fish from floodplains adding to the supply. The percentage of *aman* farmers who sold fish because neither their families nor their water resources could absorb the fish production from the drying plot (21%) is also interesting. No *boro* farmer reported selling fish for this reason.

3.2.5.2. Rice production

Mean rice production was reported as 4 639 $kg{\cdot}ha^{-1}$ from *boro* rice-fish plots and 2 936 $kg{\cdot}ha^{-1}$ from *aman* plots. Of 20 *boro* rice-fish farmers, 8 (40%) reported no change in rice yields, following integration of fish with rice, 11 (55%) reported an increase, and one (5%) reported a decrease. Of 37 *aman* rice-fish farmers, seven (19%) reported no change in rice yields, 19 (51%) reported increases and 11 (30%) reported decreases.

3.2.6. Farmers' perceptions

3.2.6.1. Rice cultivation and integrated rice-fish farming

Farmers were asked whether integration of fish culture with rice had in any way affected their methods of rice cultivation. A number of farmers had difficulty in understanding this question and 32 farmers (68%) indicated that rice farming practices were not affected (Table 3.28). Sample sizes were small and the farmers were usually not prompted to give specific answers. It is suspected that the frequency of many of these responses are underestimates.

Farmers were asked as to the probable reasons for the changes in rice yields they had reported under section 3.2.5.2. The farmers' perceptions of the causes of these changes in yields are given in Table 3.29.

The causes most commonly advanced by farmers for increase in rice yields are related to the fertilizing effects of additional inputs given for fish and of fish excreta. Of the *boro* farmers reporting increases, 45% indicated each of these as a cause; among *aman* farmers reporting

Table 3.27. Farmers' reasons for fish utilization pattern during *boro* and *aman* seasons. Number of farmers are in parentheses.

Reason for utilization	Farmers responding (%)	
	Boro (n=19)	*Aman* (n=34)
Restocked to culture to marketable size	52.6	36.4
Need for household consumption	26.3	9.1
Needed money, so sold	26.3	21.2
Needed a continuous supply of fish for home consumption	5.3	12.1
Kept to sell later when prices rise	0	6.1
Consumed to save money from fish purchase	0	6.1
Could not restock or consume entire catch, so sold	0	21.2
Needed to pay netting party, so sold	0	3.0
Needed to repay debts, so sold	0	6.1

Table 3.28. Effects of rice-fish farming on rice farming practices. Percentages are not additive as some farmers modified their practices in more than one way.

Effect on rice farming	Farmers responding (%)			Total
	Boro only (4 farmers)	*Aman* only (18 farmers)	Both seasons (20 farmers)	
None	75.0	72.2	55.0	68.0
More water needed	25.0	5.6	25.0	15.0
No pesticide used	0	0	10.0	4.3
Less fertilizer used	0	0	15.0	6.4
Less weeding	0	11.1	0	4.2
Line planting of rice	0	5.6	5.0	4.2
More fertilizer used	0	0	5.0	2.1
Planted local variety	0	11.1	0	4.2

Table 3.29. Causes of changes in rice yields as reported by farmers[a].

Cause of change in yield	Farmers reporting (%)			
	Boro		*Aman*	
	Yield increase (n=11)	Yield decrease (n=1)	Yield increase (n=19)	Yield decrease (n=11)
Fish inputs fertilized rice	45.5	0	47.4	0
Fish excreta fertilized rice	45.5	0	52.6	0
Took greater care of plot	18.2	0	31.6	0
Line planting	9.1	0	0	0
Fish controlled pests	27.3	0	15.8	0
Fish stirred soil, releasing nutrients	18.2	0	15.8	0
Deep water inhibited yields	0	100	0	27.3
Pest problems	0	100	0	0
Deep water increased yields	18.2	0	0	0
Fish controlled weeds	18.2	0	36.8	0
Rice damaged by fish	0	0	0	36.4
Low rainfall	0	0	0	9.1
Different variety	0	0	5.3	18.2
Late transplantation	0	0	0	9.1

[a]Some farmers advanced several causes for the changes in yields, so percentages are not additive.

Table 3.31. Benefits from integrated rice-fish farming as ranked by farmers. Percentages of responses are in parentheses.

Benefit	No. of times benefit was ranked				Total
	First	Second	Third	Fourth	(n=46)
Extra income	17	11	3	1	32 (69.5)
More food for family	10	14	3	0	27 (58.7)
Savings on time and/or money in search of food	3	0	1	1	5 (10.9)
Can catch fish whenever needed	1	4	6	0	11 (23.9)
Higher rice yields	2	0	3	0	5 (10.9)
Possibility of fish culture without pond	0	1	4	3	8 (17.4)
Fewer insect pests	1	0	0	1	2 (4.3)
Efficient use of resources	8	3	3	5	19 (41.3)
High returns on low investment	2	1	0	0	3 (6.5)
Diversified sources of income	0	1	0	0	1 (2.2)
Hobby/pleasure	0	1	0	0	1 (2.2)
Low-cost	0	0	1	1	2 (4.3)
Better social relations	0	0	3	1	4 (8.7)
Simple technology	0	0	1	0	1 (2.2)
Rapid returns	0	0	0	1	1 (2.2)
Provides money to invest in future culture activities	0	0	0	1	1 (2.2)
None	2	10	18	31	2 (4.3)

Table 3.32. Constraints to integrating fish culture with rice farming during *boro* season as ranked by farmers. Percentages are in parentheses.

Problem	No. of times problem was ranked				
	First	Second	Third	Fourth	Total (n=21)
Flooding	1	1	0	0	2 (9.5)
Insufficient water	6	0	1	0	7 (33)
Disease	1	1	0	0	2 (9.5)
Unexplained mortalities	1	0	0	0	1 (4.8)
Large fingerlings not available	1	0	1	0	2 (9.5)
Seed fish not available	1	2	0	0	3 (14)
High cost of plot preparation	1	1	1	0	3 (14)
Escape of fish	1	0	0	0	1 (4.8)
High costs in general	1	0	0	0	1 (4.8)
Predators	0	1	0	0	1 (4.8)
Pesticide mortalities	0	1	0	0	1 (4.8)
High labor demand	0	1	0	0	1 (4.8)
Damage by rats	0	2	0	0	2 (9.5)
Dense rice impeded fish growth	0	1	0	0	1 (4.8)
Poor quality fish seed from vendors	0	1	0	0	1 (4.8)
High water demand	0	1	1	1	3 (14)
Theft	0	0	1	0	1 (4.8)
Lower rice yields	0	0	1	0	1 (4.8)
Fish damaged rice	0	0	1	0	1 (4.8)
None	7	8	14	20	7 (33)

Table 3.33. Constraints to integrating fish culture with rice farming during *aman* season as ranked by farmers. Percentages are in parentheses.

Problem	Number of times problem was ranked				Total for problem (n=38)
	First	Second	Third	Fourth	
Flooding	1	3	0	1	5 (13)
Insufficient water	13	5	2	1	21 (55)
Disease	4	0	3	1	8 (21)
Unexplained mortalities	2	1	1	0	4 (10.5)
Large fingerlings not available	0	1	1	0	2 (5.3)
Seed fish not available	1	2	1	0	4 (10.5)
High plot preparation costs	1	1	1	0	3 (7.9)
Escape of fish	1	0	0	0	1 (2.6)
High costs in general	0	2	0	0	2 (5.3)
Predators	1	0	1	2	4 (10.5)
Pesticide mortalities	0	2	1	0	3 (7.9)
High labor demand	0	0	1	0	1 (2.6)
Damage by rats	1	1	0	0	2 (5.3)
Poor quality seed from vendors	0	0	1	0	1 (2.6)
Theft	0	2	1	1	4 (10.5)
Lower rice yields	1	0	0	0	1 (2.6)
Fish damage rice	2	1	0	1	4 (10.5)
High seed fish costs	1	0	0	0	1 (2.6)
Insufficient time to manage operation	1	0	0	0	1 (2.6)
Water too deep for rice	2	0	0	0	2 (5.3)
Cannot use pesticides	0	2	0	0	2 (5.3)
Dike damage from rain	0	1	1	0	2 (5.3)
Dike damage from crabs	0	1	0	0	1 (2.6)
None	6	13	23	31	6 (15.8)

In terms of adverse effects on the family, 29 farmers or 63% of the total indicated that their families did not encounter any inconvenience from integrating fish culture with rice farming (Table 3.34). Loans to support the expenses of establishing the practice were taken by 21.7% of the respondents. Five respondents (10.9% of the total) said their families had less food for some time. Encouraging farmers to make this response more quantitative was difficult. In most cases, the inconvenience was minor, but one farmer of very limited means indicated that his family had only eaten two meals a day, instead of three, for about a month.

Reasons in order of importance for why farmers did not culture fish in either or both seasons are given in Tables 3.35 and 3.36.

Lack of water was the main reason for not integrating fish culture during the *boro* season. Irrigation is necessary and the additional water needed for fish culture could entail additional cost in some cases. Flooding of low-lying plots can put the fish crop at risk at the end of the dry season, as was indicated by 9% of the respondents. Fingerlings shortage is likely to impose another limitation, since the *boro* season precedes and overlaps with the breeding season of most cultured fish species. *C. carpio* is the only species which is normally bred prior to the *boro* season.

The risk of flooding as well as too little water were given as the most common reason for not culturing fish during *aman* season. Rainfall in 1994 was lower than average. In a normal year, lack of water would be less of a problem.

Of the five farmers who did not undertake rice-fish farming in 1994, risk of flood was indicated as the prime reason by two of the farmers in each season. Fingerlings shortage was the main factor preventing the other three from culturing in the *boro* season, and two in the *aman* season. One farmer did not culture fish in the *aman* season due to insufficient water. Finally, one farmer cited financial constraint as a secondary reason for not culturing fish.

There were additional factors discouraging integrating fish culture with rice, which, while not mentioned by the farmers, were observed in the course of the field work. Three of the five

Table 3.34. Adverse effects of integrated rice-fish farming on the households. Percentages are in parentheses.

Problem	No. of times problem was ranked		Total (n=46)
	First	Second	
Less food for family before fish harvesting	4	1	5 (10.9)
Had to take loan	10	0	10 (21.7)
Had to reorganize family to accommodate new activity	1	0	1 (2.2)
Reduced expenses for various family needs	0	1	1 (2.2)
Conflicts in use of land	1	0	1 (2.2)
Had to hire help	1	0	1 (2.2)
None	29	44	29 (63.0)

Table 3.35. Reasons for not integrating fish culture with rice farming in *boro* season. Percentages are in parentheses.

Reason	No. of times reason was ranked			Total (n=25)
	First	Second	Third	
Insufficient water	12	3	0	15 (60.0)
Risk of flood	3	0	0	3 (12.0)
Fingerlings not available	3	1	0	4 (16.0)
Insufficient money	1	1	1	3 (12.0)
Was considering technology	0	2	1	3 (12.0)
Was not aware of technology	1	0	0	1 (4.0)
Plot too remote	1	0	0	1 (4.0)
Poor waterholding capacity of plot	1	0	0	1 (4.0)
Was preparing plot	2	0	0	2 (8.0)
Risk of theft	0	0	1	1 (4.0)
Sharecropped out plot	1	0	0	1 (4.0)

Table 3.36. Reasons for not integrating fish culture with rice farming in *aman* season. Percentages are in parentheses.

Reason	No. of times reason was ranked		Total (n=9)
	First	Second	
Insufficient water	3	0	3 (33.3)
Risk of flood	3	0	3 (33.3)
Fingerlings not available	2	0	2 (22.2)
Insufficient money	1	1	2 (22.2)

people in question were not full-time farmers and had limited time to care for their operations. Villagers cited conflicts with outside work as the reason why two other former cooperator operators (who could not be interviewed) had stopped rice-fish farming. In one case, the plot formerly used for rice-fish farming had been divided into two, leaving an area too small (about 600 m^2) in the farmer's judgement to bring under rice-fish farming. Finally, two farmers had been discouraged by flooding in their plots at the end of the *boro* season. One of them, having seen the more recent success of a neighbor, had decided to culture fish once again, but in a different rice field.

3.2.6.6. Farmers' future plans for rice-fish farming

Farmers were asked whether they planned to continue integrated rice-fish farming in the future or not. Of the 46 respondents, 41 (89%) responded positively, and the other five were uncertain. These five farmers gave various reasons for their uncertainty of continuing rice-fish farming (Table 3.37).

The sample of farmers covered (5) is too small to draw firm conclusions. The lack of time to manage the operation is probably more of a constraint than indicated here. On two or three occasions, the authors could not meet the farmers who had abandoned rice-fish farming, and were told that the farmers in question had stopped because they had outside jobs, and lacked the time to give the activity the attention it needed.

The farmers who expressed their intention to continue, when asked for reasons why they want to continue, 34% referred to the benefits they had already mentioned. Another 27% planned to continue because of the profitability of the enterprise. Increased income was indicated as a deciding factor for 27% of the farmers. Increased food for the family and the availability of fish when needed helped 17% of the farmers to decide to continue. Other factors listed were mentioned by smaller proportions of farmers (Table 3.38).

Table 3.37. Reasons for uncertainty of continuing rice-fish farming in the future. Percentages are in parentheses.

Reason	No. of times reason was ranked		Total
	First	Second	(n=25)
Not profitable	1	0	1 (20)
Money needed to strengthen dikes	3	0	3 (60)
Will depend on farmer health	1	0	1 (20)
Insufficient water	0	1	1 (20)
May lack the time to manage the operation	0	1	1 (20)
None	0	3	0

Table 3.38. Reasons for continuing with rice-fish farming. Percentages are in parentheses.

Reason	No. of times reason was ranked				Total
	First	Second	Third	Fourth	(n=41)
Benefits already mentioned	14	0	0	0	14 (34)
More food for family	1	5	0	1	7 (17)
Profitable	11	0	0	0	11 (27)
Can catch fish whenever needed	1	6	0	0	7 (17)
Higher rice yields	0	0	2	0	2 (4.9)
Needs to regain investment	1	1	0	0	2 (4.9)
Fewer insect pests	0	1	0	0	1 (2.4)
More efficient use of resources	0	1	0	0	1 (2.4)
High returns on low investment	1	0	0	0	1 (2.4)
Diversified source of income	1	0	0	0	1 (2.4)
Peace of mind/enjoyable	0	1	1	0	2 (4.9)
Greater overall benefits	1	1	0	0	2 (4.9)
Can gift neighbors	0	1	1	1	3 (7.3)
More income	7	1	3	0	11 (27)
Sees potential of technology	2	1	0	0	3 (7.3)
Shortage of fish	1	0	1	0	2 (4.9)
Assures children's future	0	1	0	0	1 (2.4)
Convenient source of fish and rice	0	1	0	0	1 (2.4)
Relieves unemployment	0	2	0	0	2 (4.9)
Saves money in rice farming	0	0	1	0	1 (2.4)
Can encourage others to culture	0	0	1	0	1 (2.4)
None	0	18	31	39	0

3.2.6.7. Action needed by government and other agencies

Given the enthusiastic response shown towards rice-fish farming by most farmers, they were asked what the government or other agencies should do to promote the technology (Table 3.39).

Short-term, low-interest loans, primarily to support earth work (ditch excavation and dike strengthening) and water supply costs were suggested by 65% of the farmers (Table 3.39). To benefit poor farmers, such loans should be easily available because the amounts involved would be very small: a few hundred to a few thousand taka. Given the frequency with which this suggestion was voiced, it should be of interest to NGOs involved in providing small loans for income generating activities.

Training in the technology was suggested by 39% of the group. One farmer commented that the loans would be wasted if the farmers did not first understand the technology; any loan program should go hand-in-hand with a training program, with granting of loans conditional upon successful completion of the training.

Application of training given was also commented on. For example, farmers quoted that they could not calculate the number of fingerlings to be stocked in their plots.

Reliable, convenient supplies of quality fingerlings were indicated as a concern by 26% of the farmers. Muktagacha thana, where most of these interviews were carried out, is relatively well-supplied with hatcheries and nurseries. The need would probably be greater in other areas as fish culture grows in popularity.

Table 3.39. Farmers' recommendations for promoting rice-fish farming. Percentages are in parentheses.

Recommendation	Frequency
Low-interest, short-term loans needed	30 (65.2)
Training in rice-fish farming	18 (39.1)
More cooperation/monitoring between government and farmers	5 (10.9)
Reliable/timely supply of fingerlings	9 (19.6)
Research to improve quality of fingerlings	1 (2.2)
Research on fish diseases	4 (8.7)
Training on integration of fish with other crops, besides rice	1 (2.2)
Training in calculation of stocking rates	2 (4.3)
Support for rat control	1 (2.2)
Research on appropriate pesticides and fertilizers in rice-fish farming	1 (2.2)
More publicity for rice-fish farming	2 (4.3)
Make available *B. gonionotus* fingerlings for *boro* carp	1 (2.2)

3.3. Conclusion

The average landholding of the farmers who adopted the technology was 1.97 ha, which is much higher than the national average of 0.914 ha and average of 0.913 ha in the study area. In addition, the cropping intensity of farms surveyed at 190% was much higher than the national average of 179%.

Researchers had recommended a stocking density of 3 000 fingerlings per ha but the farmers during the on-farm trials stocked their farms at an average density of 3 864 per ha. The present survey indicated that the farmers further intensified the operations by increasing stocking density on an average 11 495 per ha (Table 3.17). Combined with this increase in stocking density, farmers used greater inputs such as supplementary feeds and fertilizers (Table 3.18).

A comparison of former cooperator farmers and the new adopters surveyed indicated that the adopters used larger areas for integrated farming (0.33 vs 0.19 ha in the *aman* season) (Table 3.8), higher stocking densities (14 281 vs 8 709 in the *boro* season and 20 996 vs 5 202 in the *aman* season) and higher use of feeds and fertilizers (example, adopters used 1 725 $kg \cdot ha^{-1}$ of manure during *boro* season vs 764 $kg \cdot ha^{-1}$ by former cooperator farmers) (Table 3.18). This has resulted in higher fish productions and benefits.

In 1992, when on-farm trials were initiated, fingerlings were not available to the farmers in the study area and they had to buy them from BFRI, which was far from the study area. The survey has revealed that during 1994, 50% of the farmers met their seed requirements by purchasing from vendors and 32% from private hatcheries/nurseries. This clearly indicates that successful demonstration and adoption of the technology had created a demand for the fingerlings which has been met by enterprising farmers who have taken to hatchery and nursery operations for production of fingerlings, creating employment in the rural areas.

The study has clearly indicated the viability of integrating fish culture with rice farming during rainfed and irrigated seasons in the area studied. The study also revealed that the more prosperous farmers have taken greater advantage of the technology as evident from their higher literacy rate, larger landholdings, higher cropping intensity and intensified operations (higher stocking densities and input use), resulting in higher benefits. Of the farmers surveyed, the smallest landholding was that of a farmer who reported owning 0.2 ha rice land. This suggests that, without institutional support, even a low-cost technology such as rice-fish farming can favor the better-off farmers.

The possible reasons for marginal farmers becoming less involved in rice-fish farming could be various: (i) lack of financial resources needed for integrating fish culture; (ii) unwillingness to take risk (loss of fish due to flooding, poaching, etc.); (iii) lack of labor time for strengthening dikes, construction of fish refuge, particularly among farmers who depend on off-farm employment or wage earnings; (iv) inability to avail of credit for the extra investment needed for integration; and (v) the perception that the extension workers focus their efforts more on richer and more literate farmers.

While the study has revealed the viability of integrating fish culture with rice farming in the area studied, further work is needed in other regions of the country with different agroecological conditions from the study area. More attention needs to be paid by the development agencies to bring the benefits of the technology to marginal farmers.

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ANNEXES

Annex 1. Monitoring Sheet for Integrated Rice-fish Farming

A. Identification

1. Name of farmer: ______
2. Village: ______ 3. Mouza: ______
4. Union: ______ 5. Upazila: ______
6. Name of block supervisor: ______
7. Landholding of farmer (acres[a]): ______
8. Occupation: ______
9. Has farmer cultured fish in rice field before? (Yes/No): ______
10. If yes, for how many years? ______

B. Particulars of rice-fish plot

11. Land type (high/medium/low): ______
12. Soil type [clay, loam, silt, sand, other (specify)]: ______
13. Area of rice plot including ditch (m^2): ______
14. Area of ditch (m^2): ______
15. Depth of ditch (cm): ______
16. Age of ditch (years): ______
17. Purpose for which ditch was dug?: ______
18. Rice variety: ______
19. Date(s) transplanted: ______

C. (i) Rice farming activities and inputs (land preparation, fertilization, transplantation, weeding, pesticide application, irrigation, harvesting, etc.)

Date	Activity or inputs	No./kg	Labor	Time spent (hours)	Cost (Tk)	Source (own/hired/ purchased	Remarks
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______

[a]1 acre = 4 050 m^2

(ii) Pesticides used

Date	Amount (kg or ml)	Cost (Tk)	Method of application	Remarks

D. (i) Stocking particulars

Date	Species	No.	Average length (cm)	Average weight (g)	Cost (Tk)	Remarks

(ii) Activities or inputs for fish culture (ditch excavation, fingerlings, feed (give type), cattle manure, lime, harvesting)

Activities or inputs				Labor spent (person-days)	Time spent (hours)	Source (own/ purchased)
Date	Input	Quantity (kg)	Cost (Tk)			

E. Fish production

Date of harvesting	Species	No.	Average weight (g)	Total weight (kg)	How used				Income (Tk) if sold
					Sold (kg)	Consumed (kg)	Given away (kg)	Restocked (kg)	

Note: Include catch of wild and culture fish.

F. Rice yield

From stocked field (kg): ____________ Value/kg (Tk): ____________
Amount of this variety sold (kg): ____________
Income from this sale (Tk): ____________

Water Depth Monitoring Sheet

Date	Depth of water in field (cm)	Depth of water in ditch (cm)	% of field under water

Note: Install graduated measuring sticks at three places in the field and take average depth.

Annex 2. Monitoring Sheet for Control Rice Plots (Without Fish)

A. Identification

1. Name of farmer: ____________________
2. Village: ____________________ 3. Mouza: ____________________
4. Union: ____________________ 5. Upazila: ____________________
6. Name of block supervisor: ____________________
7. Landholding of farmer (acres): ____________________
8. Occupation: ____________________

B. Particulars of rice field

9. Area of rice plot (m^2): ____________________
10. Land type (high/medium/low): ____________________
11. Soil type [clay, loam, silt, sand, other (specify)] : ____________________
12. Rice variety: ____________________
13. Date(s) transplanted: ____________________

C. Rice farming activities (land preparation, fertilization, transplantation, weeding, pesticide application, irrigation, harvesting, etc.)

Date	Activity or inputs	No./kg	Labor	Cost	Source (own/hired/ purchased	Remarks

D. Pesticides used

Date	Amount (kg or ml)	Cost (Tk)	Method of application	Remarks

E. Rice yield

Quantity (kg): ______________________ Value/kg (Tk): _______________
Amount sold (kg): ____
Income from the sale (Tk): ____

Annex 3. Survey Format to Assess the Adoption and Impact of Integrated Rice-fish Farming in Mymensingh District

I. BACKGROUND

Farmer's identification number |__|__|__| V1

Name of farmer: ____________________
Village: ____________ Block: ____________
Thana: ____________ |__|__| V2
Age: ____________ |__|__| V3
Sex: ________ (Male = 1, Female =2) |__| V4

Household size: Male (15 and over): |__|__| V5
Female (15 and over): |__|__| V6
Children (under 15): |__|__| V7

Education: ____________ |__| V8
(Illiterate=1, Can read=2, Primary=3, Secondary=4,
Higher secondary=5, Post-secondary=6)

Principal occupation: ____________ |__| V9
Secondary occupation: ____________ |__| V10
Occupations:
[(Farmer=1; Shopkeeper=2; Rickshaw driver=3;
Day laborer=4; Extension agent=5; Teacher=6;
Ricemill operator=7; Housekeeper=8;
Others (specify above)]

Approximate gross annual income: (Tk)
from own farm: ________ |__|__|__|__|__|__|__| V11
from off farm: ________ |__|__|__|__|__|__|__| V12

Total area of landholding (dec): _____ |__|__|__|__|__| V13

Cultivated area (dec[b]):
Owned by farmer: |__|__|__|__|__| V14
Shared/leased/mortgaged in: |__|__|__|__|__| V15
Shared/leased/mortgaged out: |__|__|__|__|__| V16

Rice-growing area (dec[b]) *aman*, 1994:
Owned by farmer: |__|__|__|__|__| V17
Shared/leased/mortgaged in: |__|__|__|__|__| V18
Shared/leased/mortgaged out: |__|__|__|__|__| V19

[b] 1Decimal = 40.5 m^2

Cropping Pattern for 1994:

Crop	Area (dec)	From (month)	To (month)	Land type	Soil type
	____	____	____	____	____
Boro rice	____	____	____	____	____
Aus rice	____	____	____	____	____
Aman rice	____	____	____	____	____
Jute	____	____	____	____	____
	____	____	____	____	____
	____	____	____	____	____
	____	____	____	____	____
	____	____	____	____	____

Notes:

(1) Land type: upland=1; medium land=2; lowland=3
(2) Soil type: clay=1; loam=2; sand=3; clay-loam=4; sandy clay=5; sandy loam=6; others (specify) =7
(3) Indicate with an asterisk land and soil types used for rice-fish culture each season, if rice was grown on more than one soil or land type.

|__|__|__| V20	|__|__| V21	|__|__| V22	|__| V23	|__| V24
|__|__|__| V25	|__|__| V26	|__|__| V27	|__| V28	|__| V29
|__|__|__| V30	|__|__| V31	|__|__| V32	|__| V33	|__| V34
|__|__|__| V35	|__|__| V36	|__|__| V37	|__| V38	|__| V39
|__|__|__| V40	|__|__| V41	|__|__| V42	|__| V43	|__| V44
|__|__|__| V45	|__|__| V46	|__|__| V47	|__| V48	|__| V49
|__|__|__| V50	|__|__| V51	|__|__| V52	|__| V53	|__| V54
|__|__|__| V55	|__|__| V56	|__|__| V57	|__| V58	|__| V59
|__|__|__| V60	|__|__| V61	|__|__| V62	|__| V63	|__| V64
|__|__|__| V65	|__|__| V66	|__|__| V67	|__| V68	|__| V69
|__|__|__| V70	|__|__| V71	|__|__| V72	|__| V73	|__| V74

II. STATUS OF PRACTICE

1. Did farmer culture fish in rice field in 1994 *aman* season? (Yes=1; No=0) |__| V75
   Farmer began rice-fish culture in ____ (season), _____ (year) |__|__| V76-V77
   Farmer cultured fish in rice field in: 1994 *boro* ( ) 1994 *aman* ( ) both ( ) neither ( ) |__| V78

   No. of seasons (*aman* and *boro*) rice-fish culture practiced: ______ |__|__| V79

2. What influenced the farmer to begin culturing fish in rice field? (Number in order of importance)

   Direct observation of an example ( ) |__| V80
   Demonstration plot operator ( ) |__| V81
   Training ( ) |__| V82
   Motivation by extension workers ( ) |__| V83
   Discussions with other farmers ( ) |__| V84
   Radio ( )
   Books or pamphlets ( )
   Curiosity/desire to experiment ( )
   Other (specify) ________________________ ( )

If farmer has/had research plot, specify season (s) and year (s)
(Yes=1; No=0) ________________________________ |__| V85

3. If farmer did not culture fish in either/both 1994 season(s), give reasons.

Number in order of importance for:	*Boro*	*Aman*	
Was not aware of technology	( )	( )	|__|__| V86-V87
Was still considering technology	( )	( )	|__|__| V88-V89
Insufficient water	( )	( )	|__|__| V90-V91
Risk of flood	( )	( )	|__|__| V92-V93
Risk of theft	( )	( )	
Low water holding capacity	( )	( )	
Plot too far away	( )	( )	
Non-availability of fingerlings	( )	( )	
Fingerlings size too small	( )	( )	
Risk of predators	( )	( )	
Risk of fish disease	( )	( )	
Pesticides needed	( )	( )	
Dike/ditch construction too costly	( )	( )	
Insufficient money	( )	( )	
Insufficient labor	( )	( )	
Conflict with other work	( )	( )	
Has no land	( )	( )	
Conflicts with other owners	( )	( )	
Conflicts with neighbors	( )	( )	
Others (specify): ______________	( )	( )	
____________________________	( )	( )	
____________________________	( )	( )	

4. Have your rice farming methods changed because of rice-fish farming? (Yes=1; No=0)
   If yes, describe how: ____
   ____
   ____

   |__|__|__|__|__|__| V94

5. Does the farmer use the same plot for both *boro* and *aman* rice-fish farming?
   Yes ( ) No ( ) Does not culture both seasons ( ) |__| V95

Boro fish culture plot is:
- (a) solely owned by farmer ( ) |__| V96 |__|__| V97
- (b) owned with others ( ). If so, how many? ____
- (c) leased or mortgaged by farmer ( )
- (d) sharecropped by farmer ( )

Aman fish culture plot is:
- (a) solely owned by farmer ( ) |__| V98 |__|__| V99
- (b) owned with others ( ). If so, how many? ____
- (c) leased or mortgaged by farmer ( )
- (d) sharecropped by farmer ( )

6. *Boro* plot:
   - Ditch age (years) : _______ |__|__|__| V100
   - Ditch area (dec.) _____ |__|__|__| V101
   - Ditch depth (m) ___ |__|__| V102
   - Ditch position: corner ( ) side ( ) middle ( ) |__| V103
   - Purpose for which ditch was dug:
     ______________________________ |__|__| V104

Aman plot:
Ditch age (years): ______ |__|__|__| V105
Ditch area (dec.) ______ |__|__|__| V106
Ditch depth (m) ___ |__|__| V107
Ditch position: corner ( ) side ( ) middle ( ) |__| V108
Purpose for which ditch was dug:
______________________________ |__|__| V109

7. Other remarks on status of rice-fish system

____
____
____

|__|__|__|__|__| V110

(If farmer did not culture fish in rice fields in 1994, go directly to Section IV.)

IIIa. DETAILS OF 1994 *BORO* RICE-FISH FARMING SYSTEM

A. Plot area (dec.): ________ |__|__|__| V111

If this is less than total *boro* rice area, give reasons why fish were not cultured in entire rice-growing area:

Risk of flood in other plots ( ) |__|__|__|__| V112
Insufficient water in other plots ( )
Other plots did not have high dike ( )
Other plots did not have ditch ( )
Other plots are far from house ( )
Ownership problems in other plots ( )
Insufficient labor to prepare larger area ( )
Insufficient money to prepare larger area ( )
Wants to test this limited area first ( )
Did not want to take risk in a larger area ( )
Others (specify) ______________________________

B. Preparation

Did plot preparation for boro rice-fish include :
Ditch-excavation? Yes ( ) No ( ) |__| V113
Dike-repair? Yes ( ) No ( )
Drain construction? Yes ( ) No ( )

If yes, approximate labor needed for the above:

	Own	Hired		
Laborers (no.)	_____	_____	|__|__| V114	|__|__| V115
Time spent (hour)	_____	_____	|__|__|__|__| V116	|__|__|__|__| V117
Cost (Tk)	_____	_____	|__|__|__|__| V118	|__|__|__|__| V119

C. Stocking

1. Stocking date (closest approximation): |__|__|__| V120

Why this stocking date?
Rice not established before this date ( ) |__|__| V121
Insufficient water before this date ( )

Fingerlings not available before this date ( )
Had money for fingerlings by this date ( )
Plot construction completed by this date ( )
Others (specify)________________________ ( )

2. Stocking composition (closest approximation):

Species	Number	Size (cm)	Cost (Tk)
________	______	______	______
________	______	______	______
________	______	______	______
________	______	______	______
________	______	______	______
________	______	______	______
________	______	______	______

|__|__|__|__| V122 |__|__|__| V123 |__|__|__| V124
|__|__|__|__| V125 |__|__|__| V126 |__|__|__| V127
|__|__|__|__| V128 |__|__|__| V129 |__|__|__| V130
|__|__|__|__| V131 |__|__|__| V132 |__|__|__| V133
|__|__|__|__| V134 |__|__|__| V135 |__|__|__| V136
|__|__|__|__| V137 |__|__|__| V138 |__|__|__| V139

Reasons for choice of species:

High market price ( ) |__|__|__| V140
Low price of fingerlings ( )
Nonavailability of other species ( )
Good survival ( )
Good growth ( )
Easy to culture ( )
Disease resistant ( )
Suggested by extension agent ( )
Others (specify):________________

3. Seed fish sources: From own pond ( ) Vendor ( ) |__|__| V141
NGO ( ) Private hatchery ( )
Government hatchery ( )
Supplied by project ( ) |__|__|
Others (specify) ________________________

Were fingerlings available at the farm site? Yes ( ) No ( )
If no, what was the distance to the fingerling source (km)? |__|__| V142
How much time did it take to get the fingerlings (hour)? V143

Labor needed for stocking activities :

	Own	Hired				
No. of laborers	_____	_____	|__|__|	V144	|__|__|	V145
Time spent (hour)	_____	_____	|__|__|	V146	|__|__|	V147
Cost (Tk)	_____	_____	|__|__|__|	V148	|__|__|	V149
Packing/transport costs (Tk)	_____	_____	|__|__|__|	V150		

D. Rice

1. Variety(ies):________________________ |__|__| V151

Reasons for selecting this variety:

(1) ____

(2) ____

|__|__| |__|__|__|__| V152

2. Date transplanted (closest approximation): ______________ |__|__|__|__| V153

3. Was there any pest infestation in the plot in *boro* season? Yes ( ) No ( ) |__| V154

If yes, name of pest: ______________________ V155

Was any pesticide used in the plot in *boro* season? Yes ( ) No ( )

If yes, name of pesticide: _______ Quantity used: _______

Cost (Tk): ___________ When applied? ___________

|__| V156 |__|__|__|__|__| V157 |__|__|__|__| V158 |__|__|__|__| V159

E. Management of fish stock

1. How many times did farmer irrigate plot for rice? ________
   How many times did farmer irrigate plot for fish? ________

|__|__| V160 |__|__| V161

Water source: shallow tubewell ( ) deep tubewell ( )
others (specify) ______________ |__| V162

Irrigation power source: electricity ( ) diesel ( ) others ( ) ____________

Irrigation charge (Tk/ha) : ___________ + fuel ____________

Extra charge for water for fish (if any): ______________

|__| V163 |__|__|__|__|__| V164 |__|__|__|__| V165

2. Feeds and fertilizers used specifically for fish (approximate as possible):

Type	Frequency	Quantity (kg)	Cost/kg (Tk)	Source (own/purchased)
Rice bran				
Cattle manure				
Duckweed				
Wheat bran				
Urea				
TSP				
Others (specify):				

|__|__|__| V166	|__|__|__| V167	|__|__|__| V168	|__| V169
|__|__|__| V170	|__|__|__| V171	|__|__|__| V172	|__| V173
|__|__|__| V174	|__|__|__| V175	|__|__|__| V176	|__| V177
|__|__|__| V178	|__|__|__| V179	|__|__|__| V180	|__| V181
|__|__|__| V182	|__|__|__| V183	|__|__|__| V184	|__| V185
|__|__|__| V186	|__|__|__| V187	|__|__|__| V188	

3. Labor needed for feeding and fertilizing:

	Own	Hired		
No. of laborers	______	______	|__|__|__| V189	|__|__|__| V190
Time spent (hour)	______	______	|__|__|__| V191	|__|__|__| V192
Cost (Tk)	______	______	|__|__|__| V193	|__|__|__| V194

4. Labor needed for harvesting fish:

	Own	Hired		
No. of laborers	______	______	|__|__|__| V195	|__|__|__| V196
Time spent (hour)	______	______	|__|__|__| V197	|__|__|__| V198
Cost (Tk)	______	______	|__|__|__| V199	|__|__|__| V200

F. Production

1. Approximate fish harvest dates: From: _______ To: ______

|__|__|__| V201
|__|__|__| V202

Reasons for harvesting at this time:

Water drying in field	( )	|__|__|__| V203
Flooding expected	( )	
Market price high	( )	
Opportunity to sell	( )	
Family need for fish	( )	
Family need for cash	( )	
Social occasion	( )	
Disease anticipated	( )	
Others (specify): ________________	( )	

2. Estimated production (as possible):

Species	No.	Av. weight (g)	Total weight (kg)
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______

|__|__|__| V204

3. Approximate percentage of catch:

Consumed	Restocked	Given away	Sold	Income from sales (Tk)
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
|__|__| V205	|__|__| V206	|__|__| V207	|__|__| V208	|__|__|__|__| V209

Reasons for this utilization:

____
____
____

|__|__|__|__| V210

4. Approximate rice production from rice-fish field (kg) ________ |__|__|__|__| V211

Was production higher than ( ), lower than ( ), or about
the same as ( ) *boro* rice production from this field before rice-fish farming

|__| V212

If production has gone up or down, give reasons:

____
____
____

|__|__|__|__| V213

5. Rank problems with culture of fish in rice fields in order of importance:

		Comments
Flood	( )	________
Insufficient water	( )	________
Disease	( )	________
Predators	( )	________
Theft	( )	________
Mortality from pesticides	( )	________
Unexplained mortalities	( )	________
Small stocking size	( )	________
Nonavailability of seed fish	( )	________
Cannot use pesticides	( )	________
Lower rice yields	( )	________
Fish disturb rice	( )	________
High construction costs	( )	________
High labor demand	( )	________
Conflicts with other work	( )	________
Conflicts with neighbors	( )	________
Conflicts with other owners	( )	________
Demands of landlord	( )	________
Others (specify):		________
________	( )	________
________	( )	________

|__|__| V214 |__|__| V215 |__|__| V216 |__|__| V217 |__|__| V218

6. Other comments on this farmer's *boro* rice-fish system:

____
____
____

|__|__|__|__| V219

IIIb. DETAILS OF 1994 *AMAN* RICE-FISH FARMING SYSTEM

A. Plot area (dec.) ________ |__|__|__| V220

If this is less than total *aman* rice area, give reasons why fish were not cultured in entire rice-growing area:

Risk of flood in other plots	( )	|__|__|__|__| V221
Insufficient water in other plots	( )	
Other plots did not have high dike	( )	
Other plots did not have ditch	( )	
Other plots are far from house	( )	
Ownership problems in other plots	( )	
Insufficient labor to prepare larger area	( )	
Insufficient money to prepare larger area	( )	
Wants to test this limited area first	( )	
Did not want to take risk in a larger area	( )	
Others (specify)________________________	( )	

B. Plot preparation

Did plot preparation for *aman* rice-fish include:
Ditch excavation? Yes ( ) No ( ) |__| V222
Dike repair? Yes ( ) No ( )
Drain construction? Yes ( ) No ( )

If yes, approximate labor needed for the above:

	Own	Hired		
Laborers (no)	_____	_____	|__|__| V223	|__|__| V224
Time spent (hour)	_____	_____	|__|__|__|__| V225	|__|__|__|__| V226
Cost (Tk)	_____	_____	|__|__|__|__| V227	|__|__|__|__| V228

C. Stocking

1. Stocking date (closest approximation):
________________ |__|__|__| V229

Why this stocking date?

Rice not established before this date	( )	|__|__|__| V230
Insufficient water before this date	( )	
Fingerlings not available before this date	( )	
Had money for fingerlings by this date	( )	
Plot construction finished by this date	( )	
Others (specify)________________________	( )	

2. Stocking composition (closest approximation):

Species	Number	Size (cm)	Cost

|__|__|__|__| V231 |__|__|__| V232 |__|__|__| V233
|__|__|__|__| V234 |__|__|__| V235 |__|__|__| V236
|__|__|__|__| V237 |__|__|__| V238 |__|__|__| V239
|__|__|__|__| V240 |__|__|__| V241 |__|__|__| V242
|__|__|__|__| V243 |__|__|__| V244 |__|__|__| V245
|__|__|__|__| V246 |__|__|__| V247 |__|__|__| V248

Reasons for choice of species:

High market price ( ) |__|__|__| V249
Low price of fingerlings ( )
Nonavailability of other species ( )
Good survival ( )
Good growth ( )
Easy to culture ( )
Disease-resistant ( )
Suggested by extension agent ( )
Others (specify):__________________

3. Fish seed sources: From own pond ( ) Vendor ( ) |__|__| V250
NGO ( ) Private hatchery ( )
Government hatchery ( )
Supplied by project ( )
Others (specify) ________________________

Were fingerlings available at the farm site? Yes ( ) No ( )
If no, what was the distance to the fingerling source (km)? |__|__| V251

How much time did it take to get the fingerlings (hour)? _______ |__|__| V252

Labor needed for stocking activities:

	Own	Hired		
No. of laborers	_____	_____	|__|__| V253	|__|__| V254
Time spent (hour)	_____	_____	|__|__| V255	|__|__| V256
Cost (Tk)	_____	_____	|__|__|__| V257	|__|__| V258
Packing/transport costs: (Tk):	_____	_____	|__|__|__| V259	

D. Rice

1. Variety(ies): ____

|__|__| V260

Reasons for selecting this variety:
(1) ____
(2) ____

|__|__|__| V261

2. Date transplanted (closest approximation): ____________ |__|__|__| V262

3. Was there any pest infestation in the plot in *aman* season?
Yes ( ) No ( ) |__| V263
If yes, name of pest |__|__| V264
Was any pesticide used in the plot in *aman* season? Yes ( ) No ( )
If yes, name of pesticide: _______ Quantity used: ________________
Cost (Tk.): ____________ When applied? ________________

|__| V265 |__|__|__|__| V266 |__|__|__| V267 |__|__|__| V268

E. Management of fish stock:

1. How many times did farmer irrigate plot for rice? _______
   How many times did farmer irrigate plot for fish? _______ |__|__| V269 |__|__| V270

   Water source is shallow tubewell ( ) deep tubewell ( )
   others (specify)________________________________ |__| V271
   Irrigation power source: electricity ( ) diesel ( ) ________________________ ( )
   Irrigation charge (Tk/ha): _______________+fuel ______________
   Extra charge for water for fish (if any): ______________________________

   |__| V272 |__|__|__|__| V273 |__|__|__| V274

2. Feeds and fertilizers used specifically for fish (approximate as possible):

Type	Frequency	Quantity (kg)	Cost/kg (Tk)	Source (own/purchased)
Rice bran	______	______	______	______
Cattle manure	______	______	______	______
Duckweed	______	______	______	______
Wheat bran	______	______	______	______
Urea	______	______	______	______
TSP	______	______	______	______
Others (specify):	______	______	______	______
______	______	______	______	______
______	______	______	______	______

|__|__|__| V275	|__|__|__| V276	|__|__|__| V277	|__| V278
|__|__|__| V279	|__|__|__| V280	|__|__|__| V281	|__| V282
|__|__|__| V283	|__|__|__| V284	|__|__|__| V285	|__| V286
|__|__|__| V287	|__|__|__| V288	|__|__|__| V289	|__| V290
|__|__|__| V291	|__|__|__| V292	|__|__|__| V293	|__| V294
|__|__|__| V295	|__|__|__| V296	|__|__|__| V297	

Labor needed for feeding and fertilization:

	Own	Hired		
No. of laborers	_____	_____	|__|__|__| V298	|__|__|__| V299
Time spent (hour)	_____	_____	|__|__|__| V300	|__|__|__| V301
Cost (Tk)	_____	_____	|__|__|__| V302	|__|__|__| V303

3. Labor needed for harvesting fish:

	Own	Hired		
No. of laborers	_____	_____	|__|__|__| V304	|__|__|__| V305
Time spent (hour)	_____	_____	|__|__|__| V306	|__|__|__| V307
Cost (Tk)	_____	_____	|__|__|__| V308	|__|__|__| V309

F. Production

1. Approximate fish harvest dates: From: _______ To: ______ |__|__|__| V310 |__|__|__| V311
   Reasons for harvesting at this time :

   Water drying in field ( ) |__|__|__| V312
   Flooding expected ( )
   Market price high ( )
   Opportunity to sell ( )
   Family need for fish ( )
   Family need for cash ( )

Social occasion ( )
Disease anticipated ( )
Others (specify): ____________________ ( )

2. Estimated production (as possible):

Species	No.	Av. weight (g)	Total weight (kg)

|_|_|_| V313

3. Approximate percentage of catch:

Consumed	Restocked	Given away	Sold	Income from sales (Tk)
|_|_| V314	|_|_| V315	|_|_| V316	|_|_| V317	|_|_|_|_| V318

Reasons for this utilization:

____
____
____

|_|_|_|_| V319

4. Approximate rice production from rice-fish field (kg) ________ |_|_|_|_| V320

Was production higher than ( ), lower than ( ), or about the same as ( ) *aman* rice production from this field before rice-fish culture? |_| V321

If production has increased or decreased, give reasons:

____
____

|_|_|_|_| V322

5. Number problems for culture of fish in rice fields in order of importance:

		Comments
Flood	( )	________________
Insufficient water	( )	________________
Disease	( )	________________
Predators	( )	________________
Theft	( )	________________
Mortality from pesticides	( )	________________
Unexplained mortalities	( )	________________
Small stocking size	( )	________________
Nonavailability of seed fish	( )	________________
Cannot use pesticides	( )	________________
Lower rice yields	( )	________________
Fish disturb rice	( )	________________

High construction costs ( ) ______________________
High labor demand ( ) ______________________
Conflicts with other work ( ) ______________________
Conflicts with neighbors ( ) ______________________
Conflicts with other owners ( ) ______________________
Demands of landlord ( ) ______________________
Others (specify):
______________________ ( ) ______________________
______________________ ( ) ______________________

|__|__| V323 |__|__| V324 |__|__| V325 |__|__| V326 |__|__| V327

6. Other comments on this farmer's *aman* rice-fish system:
____
____
____
____
____

|__|__|__|__| V328

IV. EFFECTS ON HOUSEHOLD AND FARMING SYSTEM

1. Has rice-fish culture been beneficial (for both farm and family) or not? ____ If yes, in what ways? (number in order of importance):

Extra income	( )	|__|__|__|	V329
More food for family	( )	|__|__|__|	V330
Savings in time/money spent on getting food	( )	|__|__|__|	V331
Can catch fish whenever needed	( )	|__|__|__|	V332
Low cost	( )	|__|__|__|	V333
Fish culture possible without pond	( )		
Rapid returns	( )		
Better social relations	( )		
Higher rice yields	( )		
Fewer weeds	( )		
Fewer insect pests	( )		
Fewer rice diseases	( )		
No need for pesticides	( )		
Simple technology	( )		
More efficient use of resources	( )		
Other (specify) ______________	( )		

2. Did supplying feed and fertilizer cause any shortages for other activities? _______ If so, specify activities:
____
____
____

|__|__|__|__|__| V334

Estimate how much income was given up from these activities. |__|__|__|__|__| V335

If no income was lost, how much was production reduced? _______ |__|__|__|__|__| V336

Has the work and money spent on rice-fish farming taken labor or money away from other activities? Yes ( ) No ( ).
If yes, name the activities :

____
____
____

|__|__|__|__| V337

Estimate how much income was given up from these activities (Tk). |__|__|__|__| V338

If no income was lost, by how much, if any, was production reduced? ________

|__|__|__|__| V339

3. Has rice-fish farming caused the farm or the family any other problems? Yes ( ) No ( ). If yes, list in order of importance:
   (1) ______________________________
   (2) ______________________________
   (3) ______________________________
   (4) ______________________________
   (5) ______________________________

|__|__| V340 |__|__| V341 |__|__| V342 |__|__| V343 |__|__| V344

4. Does farmer plan to culture in future? Yes ( ) No ( ) Perhaps ( ) |__| V345

5. Give reasons for this decision (list in order of importance):
   (1) ______________________________
   (2) ______________________________
   (3) ______________________________
   ____
   ____

|__|__| V346 |__|__| V347 |__|__| V348 |__|__| V349 |__|__| V350

6. Farmers' comments on research and development work which should be done by the government or other development agencies:

____
____
____

|__|__|__|__|__| V351

V. OTHER FARMERS

1. List other farmers you know who are doing rice-fish farming.

Name	Address
________	________________
________	________________
________	________________
________	________________
________	________________
________	________________
________	________________
________	________________

2. Indicate with an asterisk (*) the farmers who decided to culture after seeing this farmer's rice-fish system.

3. List farmers you know who have stopped doing rice-fish farming.

Name	Address
________________	____________________________________
________________	____________________________________
________________	____________________________________
________________	____________________________________
________________	____________________________________
________________	____________________________________
________________	____________________________________

VI. OTHER COMMENTS FROM FARMER

____

____

____

____

____

____

____

|__|__|__|__|__| V352

VII. OTHER COMMENTS FROM INTERVIEWER

____

____

____

____

____

|__|__|__|__|__| V353

Interviewer: ________________ Date of Interview: __________

Integrating aquaculture with rice farming in Bangladesh: feasibility and economic viability, its adoption and impact. M.V. Gupta, J.D. Sollows, M.A. Mazid, A. Rahman, M.G. Hussain and M.M. Dey. ICLARM Tech. Rep. 55, 90 p.

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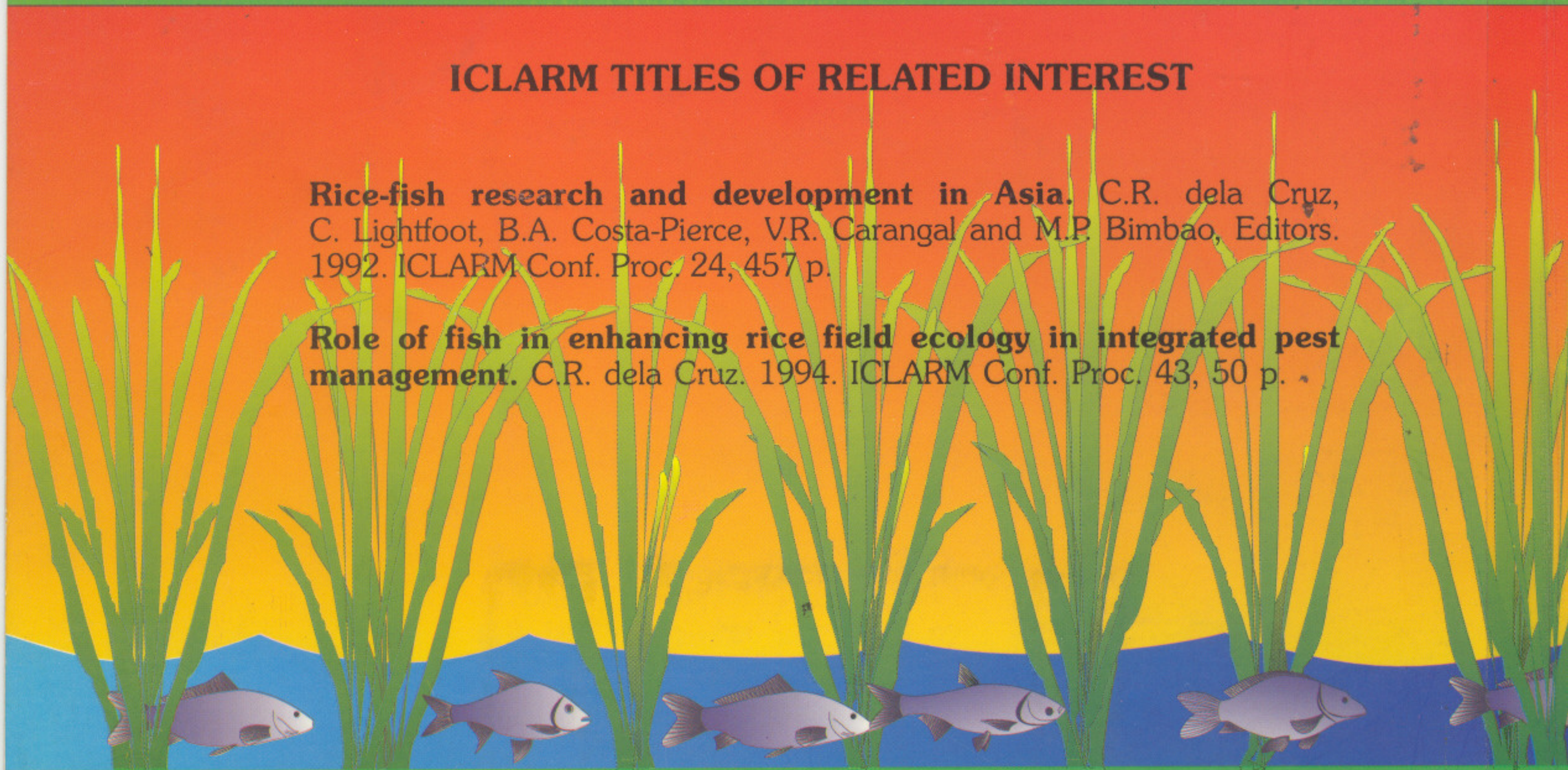

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