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Assessment of aquaculture as a means of sustainable livelihood development in Fulpur upazila under Mymensingh district

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Abstract

A study was conducted to identify how aquaculture assists in developing sustainable livelihood to the fish farming community in rural Bangladesh during the period from January to December, 2009. The Sustainable Livelihood Approach (SLA), a conceptual framework that aims to ameliorate poverty was applied to understanding the role of aquaculture in the Mymensingh area of the North-central Bangladesh. The study used the SLA as a foundation or main basis of analytical tool to identify the means and ways to enhance the livelihood of fish farmers. The analysis reveals how fish farmers can achieve positive sustainable livelihood through access to a wide range of livelihood assets. Higher economic return (BDT 1,19,360/ha/year) and social benefits were found to be gained by the fish farming community through human capital development. Lack of operating capital, vulnerability and insufficient institutional support were identified as major constraints to long term sustainability.

Keywords: Sustainable livelihood approach, Aquaculture, Small indigenous species

Introduction

Aquaculture and fisheries currently is one of the most important potential sectors of the national economy, accounting to 5% of gross domestic product and 6% of foreign export earning. Labor employment in this sector has been increasing by 6% approximately. No other sector in Bangladesh illustrates development potential more clearly than fisheries. The total fish production in Bangladesh in 2011 was estimated at 2.8 million tons, of which 1.14 million tons (41%) were obtained from inland aquaculture, 1.08 million tons (38%) from capture fisheries and 0.58 million tons (21%) from marine fisheries (DoF, 2011).

Of all the global food production systems, aquaculture is widely perceived as an important weapon in the global fight against poverty and hunger. Aquaculture production, especially pond aquaculture may be a dependable source of obtaining increased fish production in order to supply and feed the ever increasing population of the world (FAO, 2010).

In Bangladesh, the main production system for freshwater aquaculture is extensive and semi-intensive pond polyculture of Indian and Chinese major carps which account for 80% of the total freshwater production.The rest 20% are mainly from catfish, tilapia, small indigenous species of fish and rice fish farming (ADB, 2005, DoF, 2010). There are 260 species of freshwater fish in Bangladesh of which 143 species have been classified as SIS (Mazid and Kohinoor, 2003). SIS is species attaining a maximum length of 25 cm (Felts *et. al.,* 1996). In the past, SIS were regarded as weed fish and eradicated from ponds using pesticides (Wahab, 2003). However, recently SIS has been cultured with carp. With the increasing demand for fish and decline in capture fish production, SIS farming in Bangladesh is becoming more intensive in the homestead pond as an important valuable cheap protein and vitamin suppliers (Ahmed *et.al.* 2007). A current focus is on promoting viable SIS with carp for local food supply and increase the cash income of poor farmers. SIS can be integrated into existing carp culture without negative environmental effect and low cost ways (Roos, 2001; Roos *et.al.,* 2003).

Materials and Methods

Study area: The study was carried out in Fulpur Upazila under Mymensingh district during the period from January to December 2009 (Fig. 1). Fulpur was selected for this study as it is an important area for fish farming due to the abundant of ponds, favorable resource and climatic condition, low lying agricultural land, fertile soil, availability of fish fingerling, cheap labor and good communication system. Moreover, the farmers of this area received training on fish farming from Mymensingh Aquaculture Extension Project (MAEP), funded by Danish International Development Assistance (DANIDA). As a result, there has been a dramatic increase in fish production over the last several years.

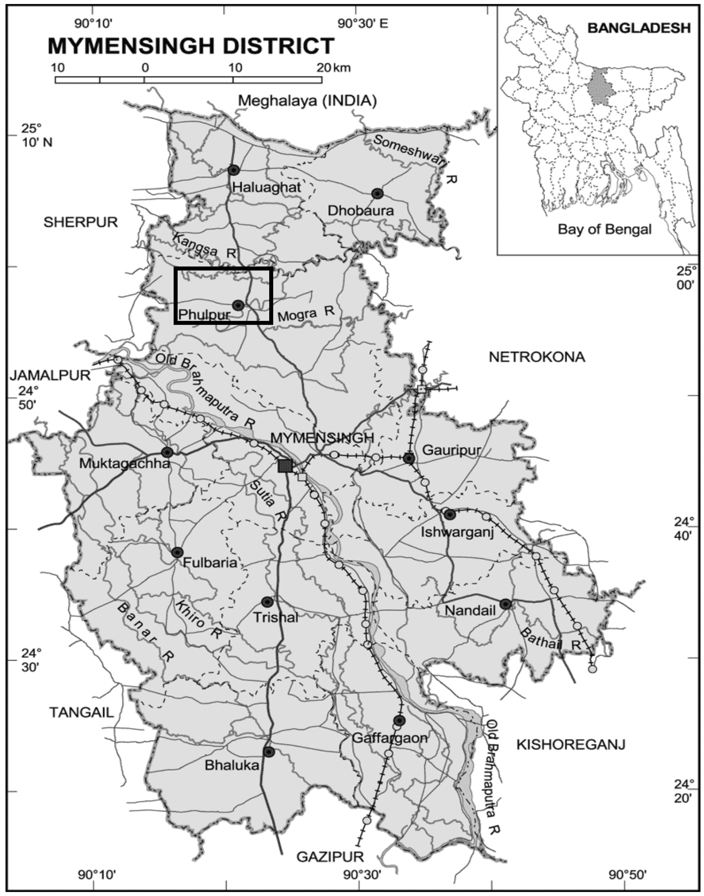

Fig. 1. Map of Bangladesh showing the study area

Data collection methods

A series of participatory, qualitative and quantitative methods was applied for primary data collection.

Questionnaires interviews: Questionnaire interviews with fish farmers were preceded by preparation and testing of the questionnaire, use of statistical procedures to determine the sample size and sampling method, and the use of enumerators to fill the questionnaires. The pre-survey activities included reconnaissance for the pilot survey, revision of survey instruments and preparation of the sampling frame. Farmers were selected using stratified random sampling based on production systems such as, extensive, semi-intensive and intensive. Extensive farming typically employs slightly modified version of traditional methods called low-density and low-input systems. Semi-intensive operations employ intermediate levels of stocking and inputs. The intensive production system is characterized by relatively high stocking and high inputs (Shang and Tisdell, 1997; Shang *et.al*., 1998). A total of 150 farmers, 50 in each farming system, were interviewed at their houses and /or farm sites.The interviews, lasting about two hours focused on fish production system, productivity, farming constraints, production costs and return, livelihood assets of the respondents, vulnerability concern and livelihood outcomes.

Participatory rural appraisal (PRA): For this study the PRA tool- Focus Group Discussion (FGD) was conducted with farmers and associated groups such as, fry traders, fish traders, day laborers including women and children. Focus Group Discussion (FGD) was used to get an overview of particular issues such as existing fish farming systems, fish marketing and the socio-economic condition of fish farmers. A total of 25 FGD sessions were conducted where each group consisted of 8 to 12 persons and duration was approximately two hours.

Cross check interviews with key informants: Cross-check interviews were conducted with District and Upazila Fisheries Officer (UFO), researchers, relevant non-government organization (NGO) workers and project staff. A total of 20 key informants were interviewed.

Data analysis

Data from questionnaire were coded and entered into a database system using Microsoft Excel software. A statistical method- SPSS was used to analyze the data, producing descriptive statistics. Comparison between different farming system were made by ANOVA F-test and a 2 tailed P<0.05 indicated statistically significant differences. Economic analysis was performed to determine production cost and returns from fish farming (Shang, 1990; Yu *et.al.,* 2006)

Sustainable livelihood approach (SLA)

The SLA is prominent in recent development programs that aim to reduce poverty and vulnerability in communities engaged in small scale aquaculture and fisheries (Edwards *et. al.,* 2002; Neiland and Bene, 2004). It is being used by development agencies and NGOs to achieve a better understanding of natural resource management systems (Allison and Horemans, 2006). The livelihood approach seeks to improve rural development policy and practice by recognizing the seasonal and cyclonal complexity of livelihood strategies (Carney, 2002; Allison and Ellis, 2001). It embraces a wider approach to people's livelihood by looking beyond income generating activities in which people engage (Chambers and Conway, 1992; Farrington *et.al*.,1999; Shankland, 2000). A livelihood comprises the capabilities, assets and activities needed for a means of living (Scoones, 1998). A livelihood is sustainable when it can cope with and recover from stresses and shocks, and maintain or enhance its capabilities and assets, both now and in the future, while not undermining the natural resource base (DFID, 1999). According to Scoones (1998) five key indicators are important for assessing sustainable livelihoods: 1) poverty reduction, 21) well-being and capabilities, 3) livelihood adaptation, 4) vulnerability and resilience, and 5) natural resource base sustainability. The sustainable livelihoods framework helps in thinking holistically about the things that poor might be very vulnerable to, the assets and resources that help them thrive and survive, and the policies and institutions that impact on their livelihoods (DFID, 1999).

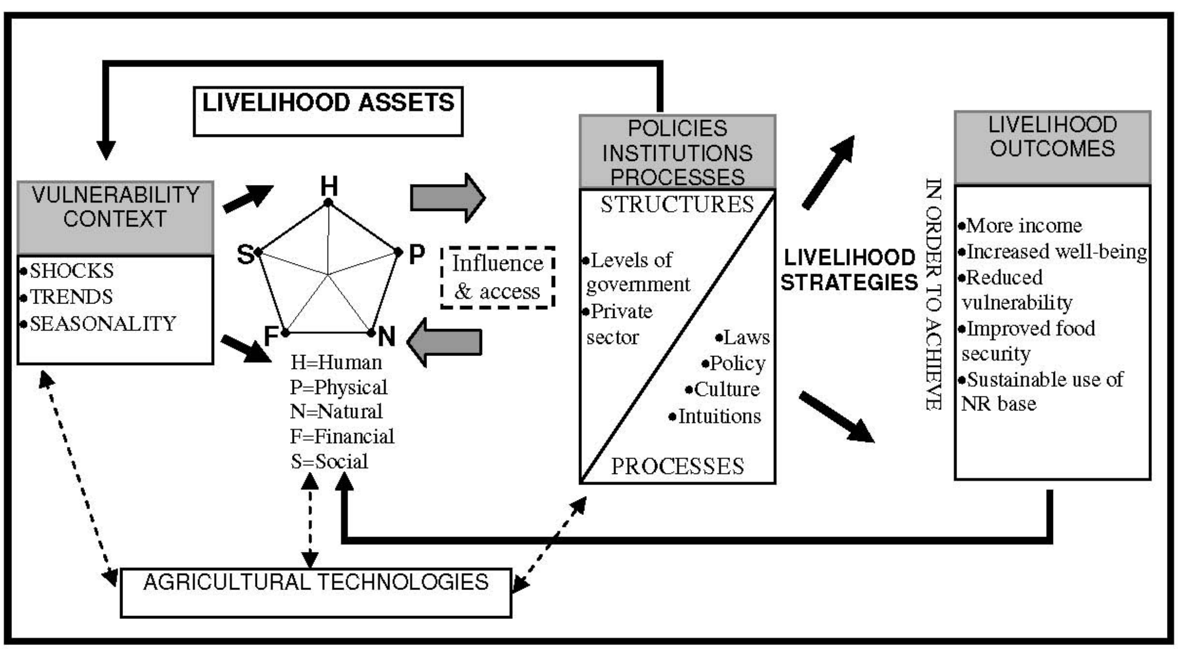

Fig. 2.The sustainable livelihood framework (source: DFID, 1999, Adato and Meinzen Dick, 2002)

DFID distinguishes five categories of assets (or capital)- natural, social, human, physical and financial (Carney, 2002). In aquaculture, natural assets include fish species raised; physical capital includes constructed ponds, human capital includes knowledge of fish culture, financial capital includes income from selling fish, and social capital includes the use of pond water for washing, bathing etc. by other community households (Little *et.al.*, 2007). Fig. 2 shows the sustainable livelihood framework and its various factors, which constraints or enhance livelihood opportunities and show how they relate to each other. The framework provides a way of thinking through the different influences (constraints and opportunities) on livelihoods, and ensuring that important factors are not neglected (Ashley and Carney, 1999). The framework shows how, in differing contexts, sustainable livelihoods are achieved through access to a range of livelihood assets which are combined in the pursuit of different livelihood strategies. Central to the framework is the analysis of the range of formal and informal organizational and institutional factors that influence sustainable livelihood outcomes.

Results and Discussion

Livelihood strategies of fish farming

The livelihoods of a large number of small and marginal farmers were found to be associated with fish farming in the study area. The peak fish farming season was from April to December, a culture period of around nine months. Fish fingerling were stocked in April to June and harvested primarily from October to December. Culture period in most cases was limited to one crop annually with some exceptions. The average pond size was 0.18 ha (Table 1).There was a significant difference ($P<0.05$) in pond size between the different farming systems. Hatchery produced carp species were cultured in ponds. Farmers stocked Indian major carp such as, catla (*Catla catla)*, rohu (*Labeo rohita*), mrigal (*Cirrhinus cirrhosus*), and exotic carp: silver (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), Thai sorputi (*Puntius gonionotous*) and common carp (*Cyprinus carpio*). Farmers in most cases follow a specific stocking plan and ratios. The highest average stocking density was in intensive farming (13,586 per ha) followed by semi-intensive (9931 per ha) and extensive (6201 per ha) respectively. Farmers also produced SIS with carps in their homestead and other ponds. Farmers stocked wild SIS rather than hatchery stock as production of hatchery is very limited. Small Indigenous Species (SIS) was stocked from natural sources, such as old perennial ponds, floodplains and rice fields. The most common SIS are: Mola (*Amblypharyngodon mola*), Puti (*Puntius sophore*), Koi (*Anabus testudineus*), Shing (*Heteropneustes fossilis)* Magur (*Clarius batrachus*), etc.

Table 1. Inputs and outputs of fish farming by different production systems

Inputs and outputs	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
	Mean ± SD	Mean ± SD	Mean ±SD	Mean ± SD
Farm size (ha)	0.09± 0.04	0.17±0.02	0.29±0.32	0.18±0.12
Stocking (no/ha/year)				
Carp	6204± 854	9931± 1034	13586± 1104	9907± 997
SIS	14326± 2384	18532±3615	24117± 3125	18992± 3041
Feeding (kg/ha/year)	2817±352	3811±616	6023±745	4217 ↑ ±571
Fertilization (kg/ha/year)				
Cowdung	986±143	789±118	1005±113	927±125
Urea	-	224±49	296±131	260±90
TSP	-	235± 38	244±64	240±51
Fish yield (kg/ha/year)				
Carp	1286±297	2124±468	3534±841	2314±535
SIS	318±62	390±87	556±106	421±85

SD: Standard Deviation
SIS: Small Indigenous Species

The average annual stocking density of SIS was 18,992 per ha, ranging from 14,326 in extensive farming to 18,532 in semi-intensive and 24,117 in intensive farming (Table 1). There was a significant difference in stocking densities between different farming systems. A variety of feeds were used in fish production. Extensive farmers generally supplied supplementary diets consisting of a mixture of locally available ingredients such as, rice bran, wheat bran and mustard oil cake. Semi-intensive category employed a feeding system of farm-made aqua feed comprising rice bran, wheat bran, mustard oil cake, fish meal, flour, salt and vitamins while intensive farmers depend on commercially manufactured pellet feeds. The most common feeding frequency in extensive farming system was once per day, while all intensive and 71% of semi-intensive farmers reported twice per day feeding. The average annual feeding rate was 4217 kg/ha, ranging from 2817 kg/ha in extensive farming to 3811 kg/ha in semi-intensive and 6023 kg/ha in intensive farming (Table 1). Farmers used fertilizers mainly in the form of cowdung, urea and triple super phosphate (TSP) at varying rates in order to increase the production of natural foods (Phytoplankton and Zooplankton), thereby increasing fish production. The use of cowdung is widespread owing to being relatively cheap and available from homestead cow shed in the study area. All intensive and semi-intensive farmers used fertilizers for fish farming. However, 31% of extensive farmers used only chemical fertilizers due to lack of technical knowledge and got poor economic returns. There was a significant difference ($P<0.05$) to fertilizers rates between different farming systems. Regarding farming systems, the average annual yield of carp and SIS were estimated at 2314 and 421 kg/ha, respectively (Table 1). There was a significant difference ($P<0.05$) in fish yields between different farming systems with a higher mean value in intensive systems followed by semi-intensive and extensive. This is mainly due to a combination of larger ponds and higher inputs of fish seed, feed and fertilizer. A number of interdependent factors also affected growth rate and productivity of fish, including environmental factor, water quality and other aspect of pond management. The farming constraints reported by respondents included lack of operational capital, high production costs, inadequate supply of quality fish fingerlings, impure and poor quality of feed, and lack technical knowledge due to shortage of counsel services. According to survey, overall 72% and 57% of respondent identified lack of operational capital and high production costs as their most important constraints (Table 2). Costs of fish farming were reported to have increased significantly in recent years as results of increased costs of seed, feed, fertilizers and wage rates. Inadequate and weekly credit repayment system therefore be a major constraint to expansion of fish farming that were provided by the NGOs in the study area. On an average, sixty three percent (63%) of respondents identified an inadequate supply of SIS fry is one of the most constraints for rapid expansion of SIS culture in the study area (Table 2).

Table 2. Key constraints in fish farming in different farming systems.

Constraints	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
	N= 50	N= 50	N= 50	N= 150
Lack of operational capital	36 (72%)	33 (66%)	39 (78%)	108 (72%)
High production costs	23 (46%)	32(64%)	31 (62%)	86 (57%)
Inadequate supply of quality fish fingerlings	15 (30%)	26 (52%)	22 (44%)	63 (42%)
Poor quality of feed	3 (6%)	39 (78%)	41 (82%)	83 (55%)
Lack of adequate technical knowledge	7 (14%)	3 (6%)	2(4 %)	12(8%)

N: Sample size

Fish marketing

Around 80% of the harvested fish are transported to the district markets in Mymensingh, 28-32 km from the study area. The rest (20%) of the under sized fish are sold to rural market in Fulpur. The average farm-gate prices of carp and SIS were BDT 85 and 135 kg-1 respectively. Fish prices depend on size, weight, quality, seasonality, supply and demand, and distance to markets. Despite substantial improvements in road condition particularly in peri-urban areas, remote villages still face an accessibility problem, which in turn affects the quality and price of fish. Heavy rains often destroy the muddy roads in villages making them eventually inaccessible for the rickshaws, vans and mechanized vehicles to carry fish to the markets. This leads to high transport costs and hence low profit margins. In addition to these problems, farmers are in a particularly weak position in relation to intermediaries. A large number of rural poor including women and children operate in the fish marketing chain as intermediaries, day laborers and transporters. The market chain from farmers to consumers encompasses mainly primary, secondary and retail markets, involving local agents, suppliers, wholesalers and retailers (Fig. 3). Plastic containers are commonly used for carrying the fish during transport. Fish are traded whole, un-gutted and fresh without processing apart from sorting and icing.

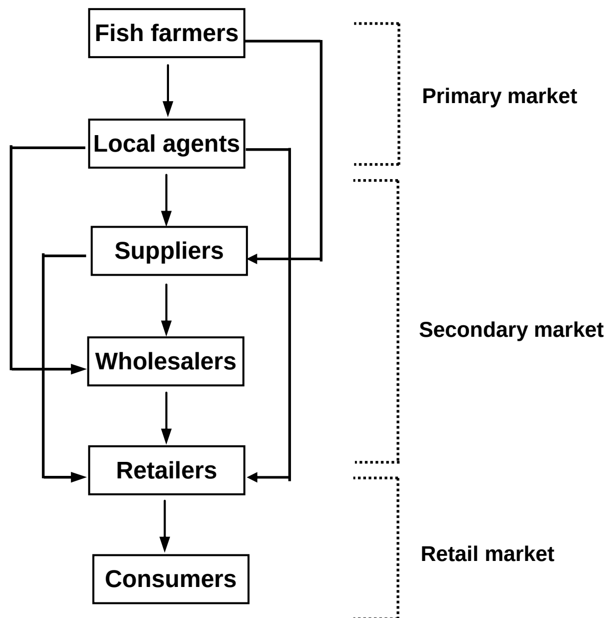

Fig. 3. Fish marketing system from producers to consumers.

Economics of fish farming

Table 3 shows that the total annual costs of fish farming overall sample farmers averaged BDT1,19,280 per ha, ranging from BDT 81,760 in extensive farming to BDT 1,18,240 in semi-intensive and BDT 1,57,920 in intensive farming. There was a significant difference (P<0.05) in total costs between different farming systems. Regardless of farm category, the average annual variable costs and fixed costs were BDT 94,240 (79%) and BDT 25,040 (21%) per ha respectively. Among the variable costs, feed dominated all other costs representing BDT 48,840 (41%) of total costs, varying from 38% in extensive farming to 41% in semi-intensive and 44% in intensive farming. Under fixed costs, the average annual depreciation costs (i.e. water pump, nets and feed machines), interest on operating capital and land use cost or lease money were estimated at BDT 3,600, BDT 11,920 and BDT 9,520 per ha, respectively.

The average annual gross revenue was estimated at BDT 2,38,640 per ha, varying from BDT 1,21,360 in extensive farming to BDT 2,24,720 in semi-intensive and BDT 369760 in intensive farming (Table 3). The highest average gross revenue was achieved by intensive farmers due to distinguishingly high production, while the lowest was found for extensive farmers due to relatively low production. Despite higher production costs per ha, the average annual net return was highest in intensive farming at BDT 2,08,400 per ha, compared with semi-intensive (BDT 2,38,640 per ha) and extensive (BDT 2,38,640 per ha). There was a significant difference (P<0.05) in net return between the different farming systems. A benefit-cost-ratio (BCR) or profitability index (PI) of one means that the operation is at break-even position. The BCR values were 1.78, 1.90 and 2.34 for extensive, semi-intensive and intensive respectively (Table 3). The research findings showed the extensive farms recovering BDT 1.78 per BDT 1 of investment while semi-intensive and intensive farms generate returns of BDT 1.90 and BDT 2.34, respectively.

Table 3. Costs and returns of fish farming

Cost and return (BDT/ha/year)	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
Variable costs (VC)				
Seed (Carp and SIS)	16320 (20%)	27200(23%)	34720(22%)	26240(22%)
Feed	31040(38%)	48480(41%)	69520(44%)	48880(41%)
Fertilizer	3280(4%)	4720(4%)	7920(5%)	6000(5%)
Labor(family and hired)	9040 (11%)	10640(9%)	12640(8%)	10720(9%)
Harvesting and marketing	2480 (3%)	2400(2%)	3120(2%)	2400(2%)
Sub-total =	62160(76%)	93440(79%)	127920(81%)	94240 (79%)
Fixed costs (FC)				
Depriciation1	2480(3%)	3520(3%)	4720(3%)	3600(3%)
Interest on operating capital[2]	7360(9%)	11840(10%)	15760(10%)	11920(10%)
Land use cost[3]	9760 (12%)	9440(8%)	9520(6%)	9520(8%)
Sub-total =	19600(24%)	24800 (21%)	30000(19%)	25040(21%)
Total costs (TC=VC+FC)	81760 (100%)	118240(100%)	157920 (100%)	119280 (100%)
Gross revenue[4]				
Carp	106080 (73%)	168560 (75%)	292080 (79%)	188880 (76%)
SIS	39280 (27%)	56160 (25%)	77680 (21%)	49760(24%)
Total	145360 (100%)	224720 (100%)	369760 (100%)	238640 (100%)
Net return (NR=GR-TC)	63600	106480	211840	119360
Benefit-Cost-Ratio (GR/TC)	1.78	1.90	2.34	2.00

Figure within parentheses indicate as a percent of total
[1](Purchase price-salvage value)/economic life
[2]Interest on operating capital at 12.5% per annum
[3]Valuation of land at its rental price
[4]Productivity × farm-gate price
1 US$ = BDT 80

Livelihood assets of fish farmers in the study area

People require a range of assets to achieve their positive livelihood outcomes (Scoones, 1998). Different combinations and components of livelihood capital assets are required for farmers to engage in successful fish production. The presence or absence of various components of capital assets can facilitate or hinder in the attainment of livelihood success. The sustainable livelihood framework draws attention to five types of capital upon which farmers livelihood depends:

Human capital: Human capital represents the skills, knowledge, ability to work and good health that together enable people to pursuit their livelihood strategies and achieve their livelihood objectives (DFID, 1999). Fish farming practice has developed as an indigenous technology and farmers have built up skills through aquaculture training and their own knowledge. The interviewed farmers had an average of 12.6 years of experience in fish farming (Table 4). Amongst the surveyed group of farmers, the reported literacy rate was 34%. Most farmers were quite young, with an average age estimated at 39 years ranging from 25 to 56. The average family size estimated at 5.4 members, and almost all members over 12 years were involved in income generating activities such as fish farming, fish marketing, agriculture, homestead gardening and dairy and poultry rearing.

Natural capital: Natural capital in the form of cultivable land, water, wild fry and wider environmental goods are critical for farmers in fish production. Small ponds, water and natural resources have been used for fish production. Farmers relied on rainfall, ground water and sometimes canal water for fish farming. Rapid population growth in recent years in fish farming communities has accelerated natural capital depletion that has affected fish production. As noted earlier SIS culture is fully dependent on wild fry and large-scale collection of SIS fry is likely to affect the production of wild fish, biodiversity and as a whole on the aquatic environment.

Social capital: Social capital in the form of networks, connectedness, cultural norms and others social attributes have significantly helped in exchanging experiences, sharing of knowledge and cooperation among rural households (Fine, 1999, Stirrat, 2004). However, lack of proper social capital has affected the livelihood of farmers. According to the survey, only 40% of farmers received training on fish culture from the MAEP, Department of Fisheries and various NGOs. Others farmers stated that neighbors, relatives and friends who had received training were the main source of technical assistance. Nevertheless, most respondents who received training reported that it was not good enough for them to raise fish with confidence.

Physical capital: Transport, road, market, electricity, water supply, sanitary and health facilities are the physical capital of fish farming that enable people to pursue their livelihood strategies.

However, the study found that farmers were often disadvantaged due to poor physical capital. Fish farming households faced sever health and sanitary problems with limited medical facilities, and people often suffered from diarrhoea, cholera and malnutrition. Although all households used tube-well for drinking water, only 34% had their own tube-well (Table 4), the rest using neighbors tube-well. Electricity supply is limited despite the work of the rural electrification board and only 29% of farmers had electricity. Lack of electricity supply meant risk of losses through poaching of fish and poisoning of ponds. These incidents were reported to be significant in the study area.

Table 4. Key components of farmers' livelihood capital or assets by fish farming systems

Livelihood capital or assets	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
Age of farmers (years)	42	36	39	39
Literacy rate (%)	22	37	43	34
Family size (persons)	6.3	5.2	4.8	5.4
Fish farming experience (years)	11	12	15	12.6
Income from fish farming (US$/farmer/year)	92	297	852	414
Credit received by farmers (%)	48	45	26	40
Own tube-well facilities (%)	16	27	58	34
Electricity facilities (%)	9	21	56	29
Training received on fish farming (%)	21	38	61	40

Financial capital: Financial capital refers to incomes, savings and credit. Fish culture has the potential to generate considerable amounts of financial capital, on average an annual net return of BDT 1,26,960 per ha. The average annual farmer's income was estimated at BDT 32,640(Table 3). Farmers spent most of their income on basis items (food, housing, education, clothing, and medication), marriage of their sons and daughters, dowry payments and fish farming. Although most of the respondents (60%) used their own money for fish farming, about 40% received credit from NGOs, money lenders and banks. There are many NGOs providing micro-credit in the study area but lack of education farmers very often go to local money lenders and pay high interest rates of 10% monthly (i.e. 120% yearly). The average amount of credit received by a farmer was estimated at BDT 8480 per year from all sources.

Vulnerabilities

The vulnerability concerns refers to : shocks, adverse trends and unfavorable seasonal patterns that can affect the livelihood of fish farmers (Table 5). All these can have major impacts on capital assets of households and individual, and consequently on their abilities to generate incomes. The key attribute of them is that they are not susceptible to control by the fish farmers themselves, at least in the short term. It is therefore, important to identify means by which negative effects can be minimized- including building greater resilience and improving overall livelihood security.

Shocks: Shocks in the form of floods or droughts in fish farming communities can destroy assets. Other natural disasters (heavy rains and cyclones) can also have significant impacts on natural resources or environmental sustainability on which a farmer's livelihood heavily relies. Illness of farmers, diseases in fish and poor harvests are all shocks and make fish cultivation hazardous. Poor farmers are especially vulnerable as shocks can force them to liquidate assets.

Table 5. Common shocks, trends and seasonality faced by fish farmers

Vulnerability concerns		Farming systems		
		Extensive	Semi-intensive	Intensive
Shocks				
	Flood	+ + +	+ + +	+ + +
	Drought	+	-	-
	Illness of farmers	+ + +	+ +	+
	Disease of fish	+	+	+
Trends				
	Increasing population	+ + +	+ + +	+ + +
	Political trends including governance	+ +	+ +	+ +
	Resource trends through social conflicts	+ +	+ +	+ +
	Environmental changes	+ +	+ +	+ +
Seasonality				
	Of production	+ + +	+ +	+
	Of price of fish	+ +	+	+
	Of employment opportunities	+ +	+ +	+
	Shortage of food	+ +	+	-

+, ++, +++ : mild to strong impacts
- : no impact

Trends: Fish farmers' livelihoods can be made more or less vulnerable depending on long-term trends. Environmental changes, political conflicts and increasing population may aggravate the problem of meager incomes. Growing populations within fish farming communities can contribute to a production in individual access to natural resources. As poor farmers' access to local natural resources declines, they are forced to use more less sustainable resources.

Seasonality: Various types of seasonality stress emerge in fish production systems. Seasonal shifts in fish farming are one of the greatest and more enduring sources of hardship for poor farmers. Fish farming communities with predominantly natural resource-based livelihoods are subject to seasonal cyclones of stress. Seasonal employment opportunities such as fry trading, fish harvesting and marketing, and day laboring all affect livelihoods of poor people. These people rarely have protection against seasonal stress periods due to lack of alternative source of income.

Transforming structures and processes

Transforming structures and processes are the institution, organizations, policies and legislation that shape livelihoods. The institutions and their policies have a profound influence on access to assets (DFID, 1999). Understanding institutional processes allows the identification of barriers and opportunities to sustainable livelihoods. An absence of appropriate structures and processes is a major constraint to the development of fish farming in rural Bangladesh. The study found several major transforming structures and processes that can facilitate the generation of desirable outcomes from the fish production systems (Table 6). Appropriate policies, legal instruments and enforcement can remove constraints to the development of fish farming. Poor farmers have limited resources at their disposal, and innovative approach is required to capital. Government agencies, NGOs and the private sector can provide technical support to poor farmers. Private and public institutions can catalyze and facilitate aquaculture development. However, these institutions have not played much of role in the development of the industry in general. Thus, lack of institutional and administrative help, poor infrastructure and inadequate extension services-all have affected livelihoods of fish farmers and associated groups.

Table 6. Component of transforming structures and processes to the development of fish farming

Components	Example
1. Policies	i. Pertinent government policies (technical support)
	ii. Rules and regulation for sustainable aquaculture
	iii. Environmental protection (control pollution and diseases)
2. Institutions	i. Roles of government agencies, research institutions and NGOs.
	ii. Roles of private institutions (hatcheries, feed industries)
	iii. Public and private partnership (research initiative, entrepreneurship development, fish marketing)
	iv. Developing appropriate research-extension-farmers linkage in aquaculture.
3. Service and facilities	i. Extension service and effective training facilities
	ii. Aquaculture friendly credit facilities
	iii. Infrastructure development (communication, roads, markets)
4. Social culture	i. Conflict prevention (poisoning in ponds, poaching fish, dowry payments)
	ii. Minimize power relation (poor farmers, rich farmers, money lenders)
5. Labor market	i. On-farm employment opportunities through intensification and diversification of production systems
	ii. Off-farm employment opportunities (hatcheries, feed industries, fish processing and marketing)

Livelihood outcomes

Transforming structures and processes directly influence livelihood strategies as well as livelihood outcomes. Livelihood resources, institutions and organizations, and vulnerabilities are key determinants of livelihood outcomes in fish farming (Fig. 4). Livelihood outcomes can be thought of as the inverse of poverty. The eradication of poverty depends on equitable access to resources. In spite of poor resources, livelihood outcomes for fish farming are positive. The survey found that 88% of farmers have improved their social and economic conditions through fish production. The highest percentage of positive response was from intensive farms (99%) followed by semi-intensive (87%) and extensive (75%). There was a significant difference (P<0.05) in farmers improved circumstances between different farming systems.

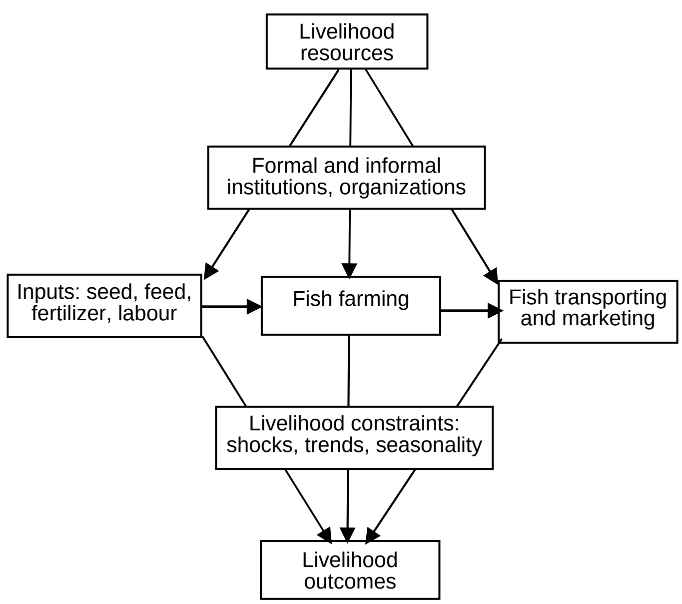

Fig. 4. A schematic diagram of livelihood outcomes in fish farming

The study ensured/confirmed that fish farming has brought about social and economic benefits. Farmers' improved socio-economic conditions can be described on the basis of qualitative indicators. These included increased food consumption and social status, improved housing facilities, child education, health and sanitary facilities. The study showed that farmers have broadly improved their standards of living, purchasing power, choice and ability as an economic sector. Most households agreed that as a result of fish farming, their food and fish consumption had increased. They had benefited from greater cash income and anticipated that they would continue to benefit from fish farming in the future.

Conclusion

The study confirmed that most farmers have improved their-socioeconomic conditions through fish production which plays an important role in increasing income, food production and employment opportunities. The study shows that all farmers made a profit from fish production. The gross revenue, net return and BCR for the different farming system are relatively sound from an economic perspective. Results show that intensive farmers have benefited the most and extensive farmers the least. While the potential benefits are great, high production costs, insufficient supply of fish fry, lack of aquaculture friendly credit support and inadequate technical assistance are constraints to the sustainability of fish farming. Moreover, poor livelihood assets, vulnerabilities and weak transforming structures and processes are identified as constraints for sustainable livelihoods of farmers and associated groups. It is therefore, necessary to provide institutional, organizational, and government support for sustainable fish farming. Input services also need strengthening. Although many SIS are self-recruiting species, the present dependency on wild fry limits further expansion of carp-SIS farming and puts pressure on the local environment. The availability of SIS fry has been declining due to destruction of their natural breeding grounds through human encroachment and environmental degradation. It is therefore necessary to explore the possibility of developing SIS hatcheries to reduce wild fry exploitation and increase wild production. In addition, the development of low-cost quality feed is essential to improve farmers' profit margin. A cost effective research-extension-farmers linkage method is prime need which may not only be a relatively low cost method of increasing production but also a means of sustainable livelihood development.

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