THE SUSTAINABLE LIVELIHOODS APPROACH TO THE DEVELOPMENT OF FISH FARMING IN RURAL BANGLADESH

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Abstract

The Sustainable Livelihoods Approach (SLA), a conceptual framework that aims to reduce poverty, is applied to understanding the role of fish farming in the Mymensingh area of north-central Bangladesh. The study used the SLA framework as an analytical tool to identify ways to advance the livelihoods of fish farmers. The analysis shows how, fish farmers can achieve sustainable livelihoods through access to a range of livelihood assets. Fish farming potentially provides higher economic returns and social benefits. However, lack of resources, vulnerability and poor institutional support are identified as constraints to long-term sustainability.

Keywords: Sustainable livelihoods, fish, farmers, Bangladesh

1. Introduction

In spite of steps to reduce poverty over the last three decades, Bangladesh remains one of the world's poorest and least developed countries. Bangladesh is a densely populated country with 140 million people in 144,000 km^2 area. Within the overall agro-based economy of the country, fish production is crucial for livelihoods, income and food supply. Around 400,000 ha of freshwater ponds/ditches and more than 900,000 households are involved in aquaculture (ADB, 2005). Aquaculture and fisheries is currently one of the most important sectors of the national economy, accounting for 5% of gross domestic product and 6% of export earnings. The total fish production in Bangladesh in 2006 was estimated at 2.32 million tons, of which 0.89 million tons (38%) were obtained from inland aquaculture, 0.96 million tons (41%) from inland capture fisheries and 0.48 million tons (21%) from marine fisheries (DOF, 2007).

The main production systems for freshwater aquaculture in Bangladesh are extensive and semi-intensive pond polyculture of Indian and Chinese major carps which account for 80% of the total freshwater aquaculture production. The remaining 20% are mainly from catfish, tilapia, small indigenous species (SIS) of fish and rice fish farming (ADB, 2005). There are 260 species of freshwater fish in Bangladesh of which 143 species (55%) have been classified as SIS (Mazid and Kohinoor, 2003). SIS are 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 have been cultured with carp. With the increasing demand for fish and the decline in capture fish production, SIS farming in Bangladesh is becoming more intensive (Ahmed *et al*., 2007). A current focus is on promoting viable SIS farming with carp for local food supply and to increase the income of poor farmers. SIS can be integrated into existing carp culture without negative effects (Roos, 2001; Roos *et al*., 2003).

This study seeks to understand how carp-SIS production has led to poverty reduction. The aim of this paper is to illustrate how the principles underlying the Sustainable Livelihoods Approach (SLA) (DFID, 1999) are applied to support the development of carp-SIS farming in rural Bangladesh. This study suggests that use of the livelihoods framework as a diagnostic tool can help bring a full understanding of farmer's adaptive strategies into the policy arena, and the SLA principles can then be applied in using this knowledge for development.

2. Methodology

2.1. Study area

The study was undertaken in Trishal sub-district of the Mymensingh district in north-central Bangladesh (Figure 1). Trishal was selected for this study as it is an important area for fish farming due to the availability of fish fry, favourable resources and climatic conditions, such as the availability of ponds and low lying agricultural land, warm climate, fertile soil, and cheap and abundant labour. In addition, farmers in this area received training on fish farming with the help of 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.

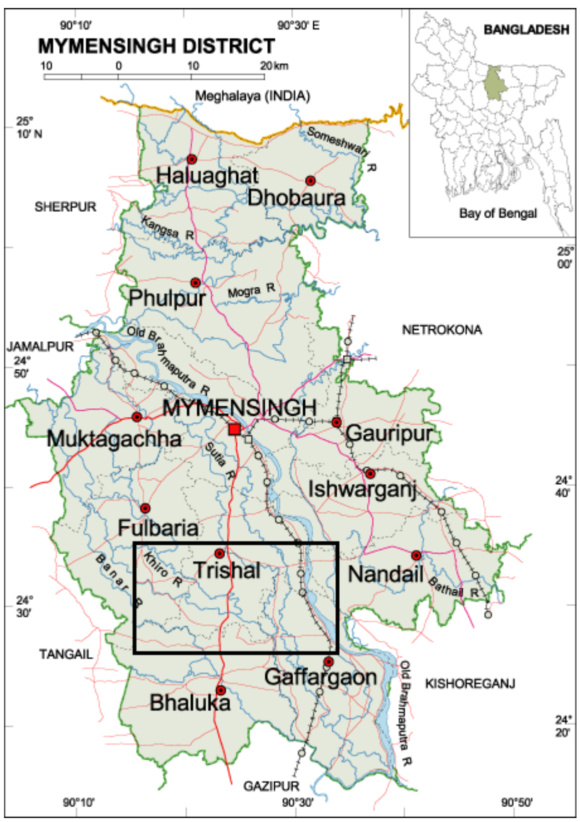

Figure 1. Map of Bangladesh showing the study area

2.2. Data collection methods

A combination of the following participatory, qualitative and quantitative methods was used for primary data collection. Data were collected for nine months from April to December 2006.

i) Questionnaire 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 in 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 versions of traditional methods called low-density and low-input systems. Semi-intensive operations employ intermediate levels of stocking and other inputs. The intensive production system is characterised 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 systems, productivity, farming constraints, production costs and returns, livelihood assets of the respondents, vulnerability concerns and livelihood outcomes.

ii) Participatory Rural Appraisal (PRA)

PRA is a group of methods to collect information in a participatory fashion from rural communities (Chambers, 1992). The advantage of PRA over other methods is that it allows wider community participation, therefore the information collected is likely to be more accurate (Chambers, 1994; Nabasa *et al*., 1995; Townsley, 1996; Villareal, 2004). For this study the PRA tool - Focus Group Discussion (FGD) was conducted with fish farmers and associated groups, such as fry traders, fish traders, day laborers including women and children. FGD was used to get an overview of particular issues such as existing fish farming systems, fish marketing and the socio-economic condition of farmers. A total of 25 FGD sessions were conducted where each group consisted of 6 to 12 persons (total 230) and duration was approximately two hours.

iii) Cross-check interviews with key informants

A key informant is someone with special knowledge on a particular topic. Key informants are expected to be able to answer questions about the knowledge and behavior of others, and about the operations of the broader systems. Cross-check interviews were conducted with District and Sub-district Fisheries Officers, researchers, relevant non-government organisation (NGO) workers and project staff. Where information was found to be contradictory, further assessment was carried out. A total of 21 key informants were interviewed.

2.3. Data analysis

Data from questionnaire interviews were coded and entered into a database system using Microsoft Excel software. A statistical method – SPSS (Statistical Package for Social Science) was used to analyse the data, producing descriptive statistics. Comparisons between different farming systems were made by ANOVA F-test and a 2-tailed $P<0.05$ indicated statistically significant differences. Economic analysis was conducted to determine production costs and returns from fish farming (Shang, 1990; Yu *et al*., 2006). The sustainable livelihoods framework was applied to analyse the qualitative and quantitative data.

2.4. Sustainable Livelihoods Approach (SLA)

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, 2) well-being and capabilities, 3) livelihood adaptation, 4) vulnerability and resilience, and 5) natural resource base sustainability.

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 increasingly being used by many development agencies and NGOs to achieve a better understanding of natural resource management systems (Allison and Horemans, 2006). The livelihoods approach seeks to improve rural development policy and practice by recognising the seasonal and cyclical complexity of livelihood strategies (Carney, 2002; Allison and Ellis, 2001). It embraces a wider approach to people's livelihoods by looking beyond income generating activities in which people engage (Chambers and Conway, 1992; Farrington *et al*., 1999; Shankland, 2000).

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). Figure 2 shows the sustainable livelihoods framework and its various factors, which constrain 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 organisational and institutional factors that influence sustainable livelihood outcomes.

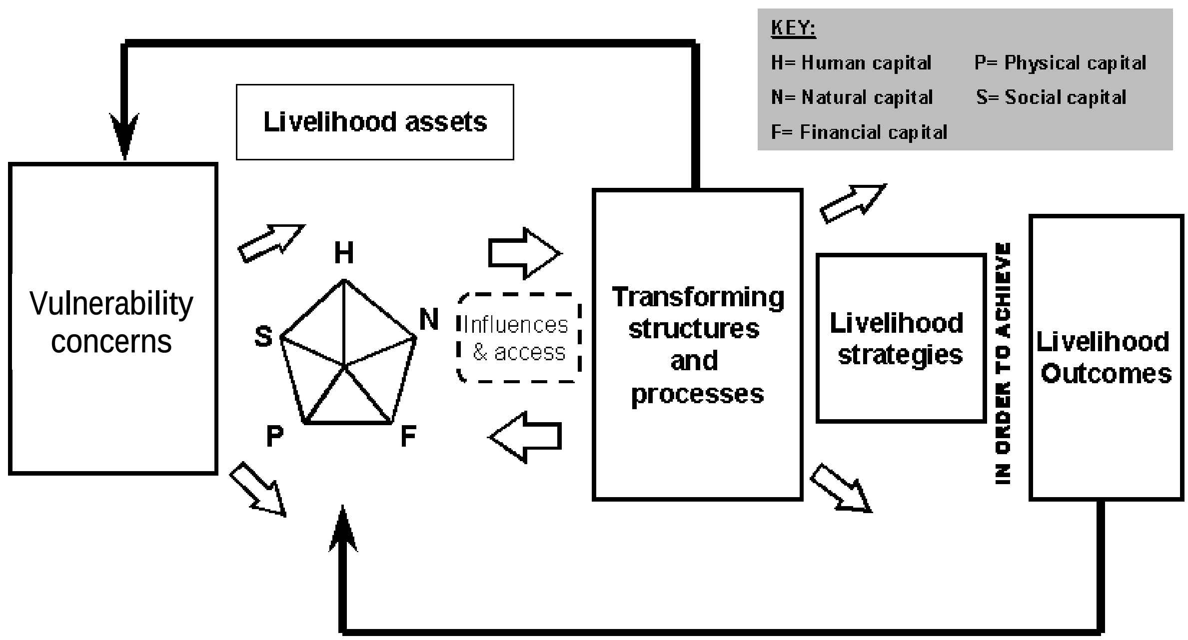

Figure 2. The sustainable livelihoods framework (source: DFID, 1999)

3. Results and Discussion

3.1. Livelihood strategies of fish farming

The livelihoods of a large number of small and marginal farmers are associated with fish farming in the study area. The peak fish farming season is from April to December, a culture period of around nine months. Fish fry are stocked in April to June and harvested primarily from October to December. Culture period is limited to one crop annually. The average pond size was 0.22 ha (Table I). The highest average pond size was in intensive farming (0.32 ha) followed by semi-intensive (0.23 ha) and extensive (0.11 ha). There was a significant difference ($P<0.05$) in pond size between the different farming systems.

A range of 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 carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). The average size of fingerlings was 5.36 cm in length and 11.8 gms in weight. Farmers did not attempt to stock any specific ratio of different carp species. The highest average stocking density was in intensive farming (11,641 per ha) followed by semi-intensive (8178 per ha) and extensive (5924 per ha).

Farmers also produced SIS with carp in their ponds. Farmers stocked wild SIS rather than hatchery produced stock as production of hatchery is limited. SIS were 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 (*Anabas testudineus*), shing (*Heteropneustes fossilis*), magur (*Clarias batrachus*), etc. The average annual stocking density of

SIS was 19,671 per ha, ranging from 15,127 in extensive farming to 19,831 in semi-intensive and 24,056 in intensive farming (Table I). There was a significant difference (P<0.05) in stocking densities between different farming systems.

A variety of feeds were used in fish production. Extensive farmers generally employed supplementary diets consisting of a mixture of locally available feed ingredients such as rice bran, wheat bran and oil cake. Intensive farmers depended on commercially manufactured pelleted feeds while the semi-intensive category refers to a feeding system of farm-made aquafeed comprising rice bran, wheat bran, oil cake, fish meal, flour, dried fish, oyster shell, salt and vitamins. The most common feeding frequency in extensive farming system was once per day, while all intensive and 62% of semi-intensive farmers reported twice per day feeding. The average annual feeding rate was 4283 kg/ha, ranging from 2919 kg/ha in extensive farming to 3827 kg/ha in semi-intensive and 6103 kg/ha in intensive farming (Table I).

Farmers used fertilisers mainly in the form of cow dung, urea and triple super phosphate (TSP) at varying rates. The purpose of using fertilizers in the ponds was to increase the production of natural feeds (phytoplankton, zooplankton), thereby increasing fish production. The use of cow dung is widespread due to being relatively cheap and available in the study area. All intensive and semi-intensive farmers used fertilisers for fish farming. However, only 35% of extensive farmers used fertiliser due to lack of technical knowledge and poor economic returns. There was a significant difference (P<0.05) in fertiliser rates between different farming systems.

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

Input and output	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Farm size (ha)	0.11 ± 0.07	0.23 ± 0.09	0.32 ± 0.12	0.22 ± 0.09
Stocking (quantity/ha/year)				
Carp	5924 ± 973	8178 ± 1069	11,641 ± 1228	8581 ± 1185
SIS	15,127 ± 2,517	19,831 ± 3,843	24,056 ± 3,292	19,671 ± 3233
Feeding (kg/ha/year)	2919 ± 481	3827 ± 662	6103 ± 945	4283 ± 694
Fertilisation (kg/ha/year)				
Cow dung	734 ± 164	832 ± 203	968 ± 254	845 ± 213
Urea	-	216 ± 69	278 ± 117	247 ± 89
TSP	-	203 ± 49	231 ± 67	217 ± 56
Fish yield (kg/ha/year)				
Carp	1249 ± 311	1923 ± 557	3359 ± 924	2177 ± 593
SIS	325 ± 76	418 ± 91	539 ± 103	427 ± 89

SD: standard deviation

Regardless of farming systems, the average annual yield of carp and SIS were estimated at 2177 and 427 kg/ha, respectively (Table I). 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 fertiliser. A number of interdependent factors also affected growth rate and productivity of fish, including environmental factors, water quality and other aspects of pond management.

The farming constraints reported by respondents included high production costs, inadequate supply of SIS fry, water pollution, poor water quality, theft and poisoning of ponds. According to the survey, 55% of respondents overall identified high production costs as their most important constraint, ranging from 64% in extensive farming to 54% in semi-intensive and 48% in intensive (Table II). Costs of fish farming were reported to have increased significantly in recent years as a result of increased costs of seed, feed, fertilisers and wage rates. Inadequate and costly finance can therefore be a major constraint to expansion of fish farming. Twenty-four percent of respondents identified an inadequate supply of SIS fry. Only 16% and 5% of farmers respectively noted poor quality of feed and lack of technical knowledge to be their most important constraint.

Table II. Key constraints in fish farming for different farming systems

Constraints	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
	n = 50	n = 50	n = 50	n = 150
High production costs	32 (64%)	27 (54%)	24 (48%)	83 (55%)
Inadequate supply of fry	9 (18%)	12 (24%)	15 (30%)	36 (24%)
Poor quality of feed	4 (8%)	9 (18%)	11 (22%)	24 (16%)
Lack of technical knowledge	5 (10%)	2 (4%)	0 (0%)	7 (5%)

n: sample size of farmers

3.2. Fish marketing

Around 80% of harvested fish are transported to the district markets in Mymensingh, 20-30 km from the study area. The rest (20%) of the under-sized fish are sold to urban and rural markets in Trishal. The average farm-gate prices of carp and SIS were US$1.08 and 1.69 kg^{-1}, respectively. Fish prices depend on size, weight, quality, seasonality, supply and demand, and distance to markets. Despite substantial improvements in roading 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 motorised 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 labourers and transporters. The market chain from farmers to consumers encompasses mainly primary, secondary and retail markets, involving local agents, suppliers, wholesalers and retailers (Figure 3). Plastic containers are commonly used for containing the fish during transport. Fish are traded whole, un-gutted and fresh without processing apart from sorting and icing.

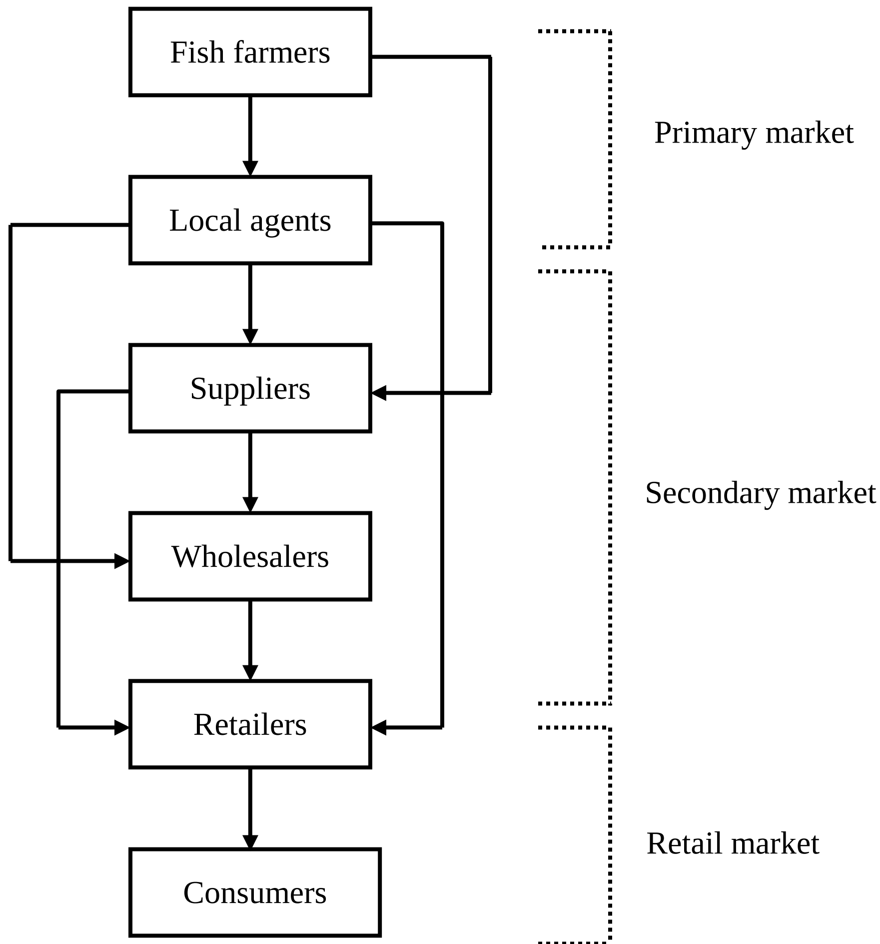

Figure 3. Fish marketing systems from producers to consumers

3.3. Economics of fish farming

Table III shows that total annual costs of fish farming over all sample farmers averaged US$1486 per ha, ranging from US$1034 in extensive farming to US$1495 in semi-intensive and US$1934 in intensive farming. There was a significant difference ($P<0.05$) in total costs between different farming systems. Regardless of farm category, the average annual variable costs and fixed costs were US$1172 (79%) and US$314 (21%) per ha, respectively. Among the variable costs, feed dominated all other costs representing 42% of total costs, varying from 40% in extensive farming to 41% in semi-intensive and 43% in intensive farming. Under fixed costs, the average annual depreciation cost (i.e. water pump, nets and feed machines), interest on operating capital and land use cost or lease money were estimated at US$38, US$151 and US$126 per ha, respectively.

Table III. Average production costs and returns of fish farming

Cost and return (US$/ha/year)	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
Variable costs (VC)				
Seed (carp and SIS)	223 (21%)	341(23%)	429 (22%)	331 (22%)
Feed	409 (40%)	612 (41%)	837 (43%)	619 (42%)
Fertilizer	32 (3%)	56 (4%)	84 (5%)	57 (4%)
Labour (family and hired)	102 (10%)	136 (9%)	153 (8%)	130 (9%)
Harvesting and marketing	29 (3%)	35 (2%)	42 (2%)	35 (2%)
Sub-total	795 (77%)	1180 (79%)	1545 (80%)	1172 (79%)
Fixed costs (FC)				
Depreciation[1]	21 (2%)	38 (3%)	54 (3%)	38 (3%)
Interest[2]	99 (9%)	151 (10%)	203 (10%)	151 (10%)
Land use cost[3]	119 (12%)	126 (8%)	132 (7%)	126 (8%)
Sub-total	239 (23%)	315 (21%)	389 (20%)	314 (21%)
Total costs (TC=VC+FC)	1034 (100%)	1495 (100%)	1934 (100%)	1486 (100%)
Gross revenue[4] (GR)				
Carp	1349 (71%)	2076 (75%)	3628(80%)	2351 (76%)
SIS	549 (29%)	706 (25%)	911 (20%)	722 (24%)
Total	1898 (100%)	2782 (100%)	4539 (100%)	3073 (100%)
Net return (NR=GR-TC)	864	1,287	2,605	1,587
Benefit-cost ratio (BCR=GR/TC)	1.83	1.86	2.34	2.06

Parentheses indicate as a percent of total
[1] (purchase price - salvage value) / economic life
[2] Interest on operating capital at 15% per annum
[3] Valuation of land at its rental price
[4] Productivity x farm-gate price

The average annual gross revenue was estimated at US$3073 per ha, varying from US$1898 in extensive farming to US$2782 in semi-intensive and US$4539 in intensive farming (Table III). The highest average gross revenue was reported by intensive farmers due to relatively high production, whilst 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 US$2,605 per ha, compared with semi-intensive (US$1,287 per ha) and extensive farming (US$864 per ha). There was a significant difference ($P<0.05$) in net return between the different farming systems.

A benefit-cost ratio (BCR) or profitability index of one means that the operation is at break-even position. The BCR values were 1.83, 1.86 and 2.34 for extensive, semi-intensive and intensive farms, respectively (Table III). The findings showed the extensive farms recovering US$1.83 per US$1 of investment while semi-intensive and intensive farms generate returns of US$1.86 and US$2.34, respectively.

3.4. Livelihood assets of fish farmers

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

i) Human capital

Human capital represents the skills, knowledge, ability to work and good health that enable people to pursue 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 their own knowledge. Farmers interviewed had an average of 12.3 years of experience in fish farming (Table IV). Amongst the surveyed group of fish farmers, the reported illiteracy rate was 33%. Most farmers were quite young, with an average age estimated at 39 years ranging from 26 to 58. The average family size was estimated at 5.8 members, and almost all members over 12 years were engaged in income generating activities such as fish farming, fish marketing, agriculture, homestead gardening and poultry rearing.

ii) Natural capital

Natural capital in the form of 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 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.

iii) 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 US$1587 per ha. The average annual farmer's income was estimated at US$408 (Table IV). Farmers spent most of their incomes on basic items (food, housing, clothing, medication), marriage of their sons and daughters, dowry payments and fish farming. Although most of the respondents (71%) used their own money for fish farming, 29% received loans from NGOs, moneylenders and banks. The *Grameen* Bank, a specialized bank providing micro credits that was awarded the Nobel Peace Prize for 2006, is active in several villages in fish farming areas. However, due to lack of education farmers often go to moneylenders and pay high interest rates of 10% monthly (i.e. 120% yearly). The average amount of credit received by a farmer was estimated at US$106 per year from all sources.

Table IV. Key components of farmers' livelihood assets by production systems

Livelihood assets	Farming systems			All categories
	Extensive	Semi-intensive	Intensive	
Age of farmers (years)	41	38	39	39
Literacy rate (%)	18	36	44	33
Family size (persons)	6.4	5.8	5.2	5.8
Fish farming experience (years)	10	12	15	12.3
Income from fish farming (US$/farmer/year)	95	296	834	408
Credit received by farmers (%)	42	30	14	29
Own tube-well facilities (%)	8	16	44	23
Electricity facilities (%)	4	12	28	15
Received training on fish farming (%)	18	34	56	36

iv) 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 severe health and sanitary problems with no medical facilities, and people often suffered from diarrhea, cholera and lack of nutrition. Although all households used tube-wells for drinking water, only 23% had their own tube-well (Table IV), the rest using government tube-wells, or those belonging to schools or neighbors. Electricity supply is limited despite the work of the rural electrification board and only 15% 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.

v) Social capital

Social capital in the form of networks, cultural norms and other social attributes have significantly helped in exchanging experiences, sharing of knowledge and cooperation among rural households (Fine, 1999; Stirrat, 2004). However, lack of social capital has affected the livelihood of farmers. According to the survey, only 36% of farmers received training on fish culture from the MAEP, Department of Fisheries and various NGOs. Other farmers stated that neighbours, relatives and friends who had received training were the main source of technical assistance. Nevertheless, most respondents who got training reported that it was not good enough for them to raise fish with confidence.

3.5. Vulnerabilities

The vulnerability concerns refers to: i) shocks, ii) adverse trends and iii) unfavourable seasonal patterns that can affect the livelihood of fish farmers (Table V). All these can have major impacts on capital assets of households and individuals, 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.

i) 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 V. Common shocks, trends and seasonality faced by 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 prices of fish	+ +	+	+
Of employment opportunities	+ +	+ +	+
Shortage of food	+ +	+	-

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

ii) 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 reduction in individual access to natural resources. As poor farmers' access to local natural resources declines, they are forced to use more less sustainable resources.

iii) Seasonality

Various types of seasonal stress emerge in fish production systems. Seasonal shifts in fish farming are one of the greatest and most enduring sources of hardship for poor farmers. Fish farming communities with predominantly natural resource-based livelihoods are subject to seasonal cycles 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 sources of income.

3.6. Transforming structures and processes

Transforming structures and processes are the institutions, organisations, 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 VI). 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 approaches are required to build capital. Government agencies, NGOs and the private sector can provide technical support to poor farmers. Private and public institutions can catalyse and facilitate aquaculture sector development. However, these institutions have not played much of a 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 VI. Components of transforming structures and processes to the development of fish farming

Component	Example
1. Policies	i. Pertinent government policies (technical support)
	ii. Rules and regulations 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 initiatives, entrepreneurship development, fish marketing)
3. Service and facilities	i. Extension services and training facilities
	ii. Credit facilities
	iii. Infrastructure development (communication, roads, markets)
4. Social culture	i. Conflict prevention (poisoning ponds, poaching fish, dowry payments)
	ii. Minimise power relation (poor farmers, rich farmers, moneylenders)
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)

3.7. Livelihood outcomes

Transforming structures and processes directly influence livelihood strategies as well as livelihood outcomes. Livelihood resources, institutions and organisations, and vulnerabilities are key determinants of livelihood outcomes in fish farming (Figure 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 87% of farmers have improved their social and economic conditions through fish production. The highest percentage of positive response was from intensive farms (98%) followed by semi-intensive (88%) and extensive (76%). There was a significant difference ($P<0.05$) in farmers improved circumstances between different farming systems.

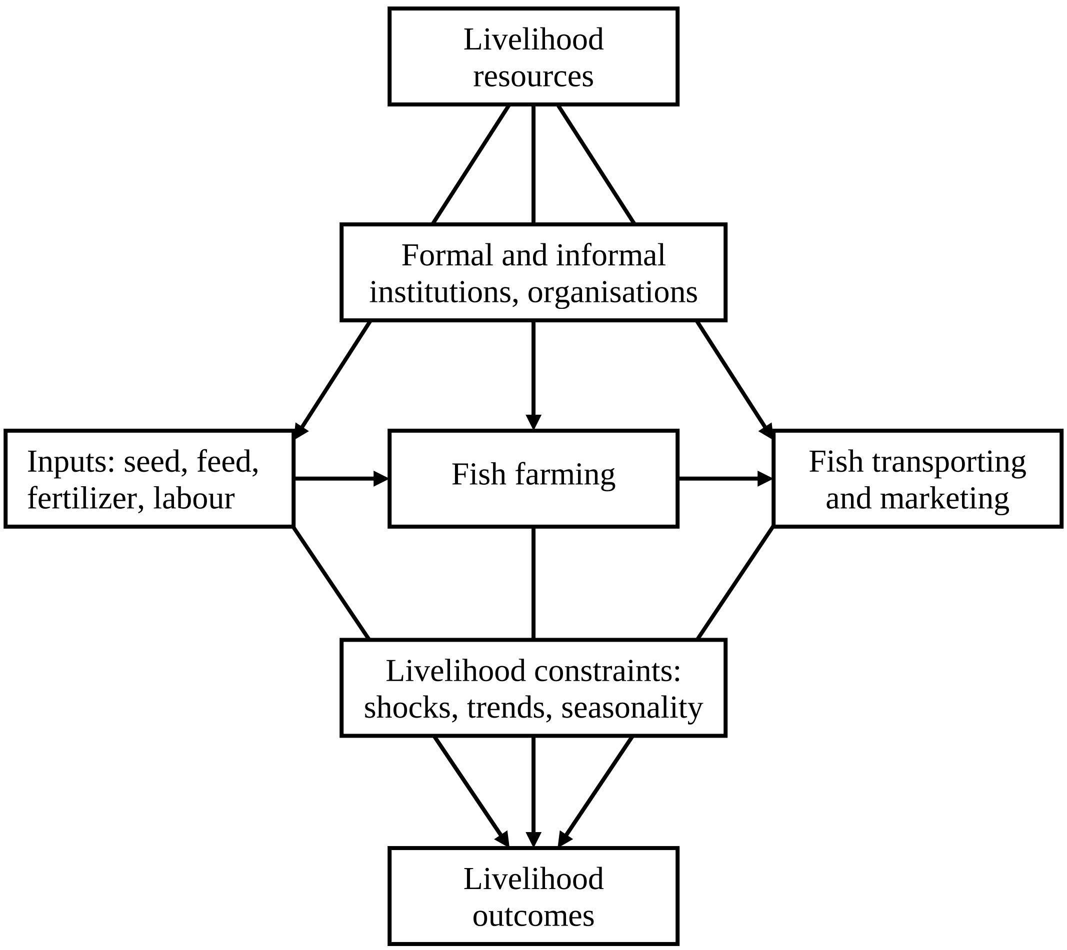

Figure 4. A schematic diagram of livelihood outcomes in fish farming

The study 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.

It was evident that intensive farmers who had large ponds and used high inputs made good profits due to high production, while extensive farmers who had small ponds and few inputs made lower profits, but 24% of farmers had not improved their profits. Semi-intensive farmers with medium sized ponds made adequate profits, but for 12% of farmers their profits were unchanged or had deteriorated. These disadvantaged farmers had incomes that left them vulnerable. Most of these less successful farmers explained that due to lack of technical knowledge, floods, poaching of fish and poisoning of ponds were the principal reasons for their disadvantaged situation.

4. Conclusions

The study shows that all farmers made a profit from fish production. The gross revenue, net return and BCR for the different farming systems are relatively sound from an economic perspective. The study confirmed that most farmers have improved their socio-economic conditions through fish production which plays an important role in increasing income, food production and employment opportunities. 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 credit facilities 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, organisational, and government support for sustainable fish farming.

Input services also need strengthening. Although many SIS are self-generating species, the present reliance 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 (Mazid and Kohinoor, 2003). 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 farmer's profit margins.

The provision of low-interest credit would help to reduce the risks for small and marginal farmers. Farmers require credit at low interest rates from the government and national banks. This is particularly the case for extensive farmers so that they can shift from extensive to semi-intensive farming systems. Better training and extension services would also help to improve profitability and reduce risks. Farmer training and extension activities are relatively low cost methods of increasing production efficiency (ADB, 2005).

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