Technology Adoption and Economics in Aquaculture in the District of Noakhali, Bangladesh; Issues of Vulnerabilities and Resilience

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Abbreviations and Acronyms

BDT	Bangladesh Taka
BRAC	Bangladesh Rural Advancement Committee
B2B	Embassy of Denmark's Business to Business
CBO	Community Based Organization
CDSP	Char Development and Settlement Project
DANIDA	Danish International Development Assistance
DFID	Department for International Development
DoF	Department of Fisheries, Government of Bangladesh
FAO	Fisheries and Agricultural Organization of the United Nations
FFS	Farmer Field School
FGD	Focus Group Discussion
FSRFD	Fisheries Sector Review and Future Developments
GNAEP	Greater Noakhali Aquaculture Extension Project
GoB	Government of Bangladesh
GR	Gross Revenue
Ha	Hectare
Kg	Kilogram
LF	Local Facilitator
MAEP	Mymensingh Aquaculture Extension Project
MOEF	Ministry of Environment and Forests, Government of Bangladesh
NGO	Non-Government Organization
PVA	Participatory Vulnerability Assessment
PL	Post Larvae
RFLDC	Regional Fisheries and Livestock Development Component
SRL	Sustainable Rural Livelihood
TC	Total Cost
UP	Union Parishad
VBARD	Vietnam Bank for Agriculture and Rural Development

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Abstract

The study examined the role of technology to aquaculture farmers vulnerable to climate change and the study also identified common categories of aquaculture practices in the coastal district Noakhali, Bangladesh and the vulnerabilities associated with such aquaculture practices. The study focused on the sustainability of farmers' livelihood. The study used extensive field visits, interviews with the key informants of Regional Fisheries and Livestock Development Component (RFLDC) and farmers, personal communications and focus group discussion as the main procedures to collect data and information. The study also used the sustainable rural livelihood framework to show farmers' livelihood resources and transforming strategies to resilient livelihood outcome. The study found four common categories of aquaculture in the mainland, accreted and newly accreted lands of Noakhali and characterized those with technology level, size, dependencies, markets, ownership, species mix, constraints and vulnerabilities to changing climate. Average net returns from the technology induced aquaculture in community based ponds and waterlogged paddy lands were 905.33 and 362.78 USD/ha/year respectively. The study found the pond aquaculture in the newly accreted lands more vulnerable to climate change than other types. RFLDC, which is a joint collaboration project of Government of Bangladesh and DANIDA, had been involved in extending technology to the poor farmers for sustainable development of the farmers' livelihood through agricultural activities. Farmer Field Schools, Community Based Organizations (CBOs), CBO associations and Union Parishad have been found to be playing very effective role for the development of aquaculture and livelihood diversification. Diversification in the culture systems has been suggested as a management practice in the study area which can increase farmers' resilience to the vulnerabilities.

Keywords: Climate change, vulnerability, resilience, poor farmers, waterlogged paddy lands, community based ponds

1. Introduction

1.1. Background

Aquaculture is one of the fastest growing food producing sectors demonstrating continuous increase in total production throughout the last few decades in a number of developing countries. This significant expansion is due to growing demand for aquatic products and the development of new technologies for aquaculture. Aquaculture is diverse consisting of a broad spectrum of different systems and practices ranging from simple backyard, small household pond systems to large scale, highly intensive and commercially oriented practices and operations. Aquaculture sector contributes to food security, poverty alleviation and social well-being in many countries of the world. Aquaculture is one of the means to supply protein to the people in a cost-efficient way (Jia et al., 2001).

The population of Bangladesh increases with 2.2 million people annually, with an increasing need for food. Bangladesh is fortunate in having extensive water resources in the form of ponds, natural depressions, lakes, canals, rivers and estuaries covering an area of 45600 km² (DoF, 2005). Although Bangladesh is predominantly an agro-based country, people are largely dependent on fish for animal protein. Fish consumption patterns change as price and income changes. Figure 1 shows total aquaculture production in Bangladesh according to FAO fishery statistics.

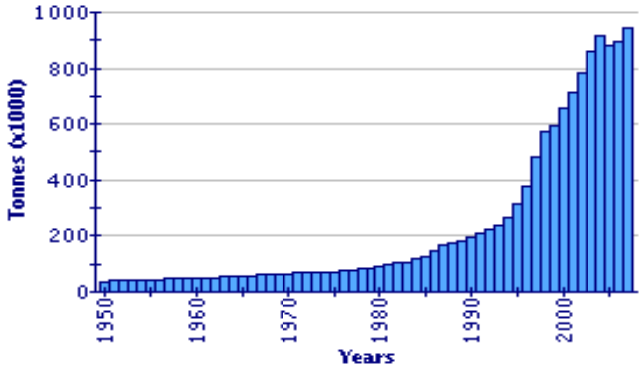

Figure 1. Total aquaculture production in Bangladesh

Source: http://www.fao.org/fishery/countrysector/naso_bangladesh/en (Accessed 15 January, 2012)

In 2009, total aquaculture production excluding aquatic plants was 1064285 tonnes in Bangladesh (FAO world fisheries production, by capture and aquaculture, by country, 2009). According to FSRFD (2003), pond aquaculture, inland capture fisheries and marine fisheries contributed 41, 32 and 26 percent respectively of the total fish production in Bangladesh. According to Akteruzzaman et al. (2006), inland fish capture production is decreasing due to heavy fishing and reduction of the flood plain area due to flood control and irrigation projects, indiscriminate use of insecticide in paddy fields and other factors. Aquaculture has therefore already become the major contributor of fish products though there is still a wide scope to increase fish production in Bangladesh by introducing more appropriate technology for aquaculture through focused extension services according to Akteruzzaman et al. (2006).

Proper management strategies to develop sustainable aquaculture practices are still in a developing stage in Bangladesh. Aquaculture activities have however been improved significantly in the recent years to increase production.

Small-scale pond aquaculture has taken off dramatically over the past thirty years especially under the influence of a number of major donor-funded aquaculture development and extension projects. The government of Bangladesh has by the support from these projects first created a network of fish hatcheries which ensured reliable supply of good quality carp seed to the farmers. Managers then identified key parameters of successful pond aquaculture production: appropriate pond preparation, including preliminary fertilization, stocking with an appropriate mix of species to utilize the different ecological niches in the pond and at the right density, judicious feeding and fertilization during grow-out, maintenance of a good pond environment to ensure efficient utilization of pond fertility and feed.

The Department of Fisheries, Government of Bangladesh despite its limitations has been responsible for overseeing the rapid development of aquaculture in Bangladesh but it has an unclear perception on poverty focus (Demaine, 2011). Most of the aquaculture development took place in a project mode on the basis of resources offered by donors and in some cases these resources were channeled through large international NGOs such as CARE, CARITAS and BRAC, which have their own specific fisheries programmes. Bangladesh has, partly as a result

of significant donor support, adopted stocking and culture-based fisheries as national strategies to feed a rapidly growing population (Valbo-Jørgensen and Thompson, 2007).

Elasha (2005) referred that climate change will affect socio-economic sectors which include water resources, agriculture, aquaculture, fisheries, human settlements, ecological systems and human health. The ecological systems which support aquaculture are already known to be sensitive to climate variability (FAO, 2008). Improved management and better aquaculture practices and diversification could be the best and most immediate form of adaptation to the effects of economic, climate change and socio-cultural factors providing a sound basis for production that could accommodate possible impacts and lead to the way of managing vulnerability context by helping people to become more resilient and better able capitalize on its positive parts.

1.2. Geography and the environmental condition of Noakhali

Noakhali is situated in the central coastal zone of Bangladesh along the northeastern coast of the Bay of Bengal. Huge quantities of sediments in the water make an essential feature of this region. Most of the land accretion and erosion occur in this coastal zone. The coastline is highly broken and there is a series of islands and accreted lands (known in Bengali as ‘char’) formed by sediment deposits, connected to the mainland of Noakhali (Ahmed and Wilde, 2011). There are also newly accreted lands emerged from the sea recently in the last 10-15 years and have not yet consolidated (Demaine, H. Personal communication, 1 January, 2012). The Noakhali river and the small Feni river have joined together with many canals, tributaries, creeks and stream corridors to flow in to the Bay. There are many canals and their tributaries which have criss-crossed. These rivers and canals are tide-fed and the tidal water can reach up to 20 km interior. The coastal zone of Noakhali consists of extensive flat, coastal and deltaic land of the Meghna river delta. The area has been changing from an actively developing delta to a semi-moribund delta partially sustained by local rivers, tributaries and canals.

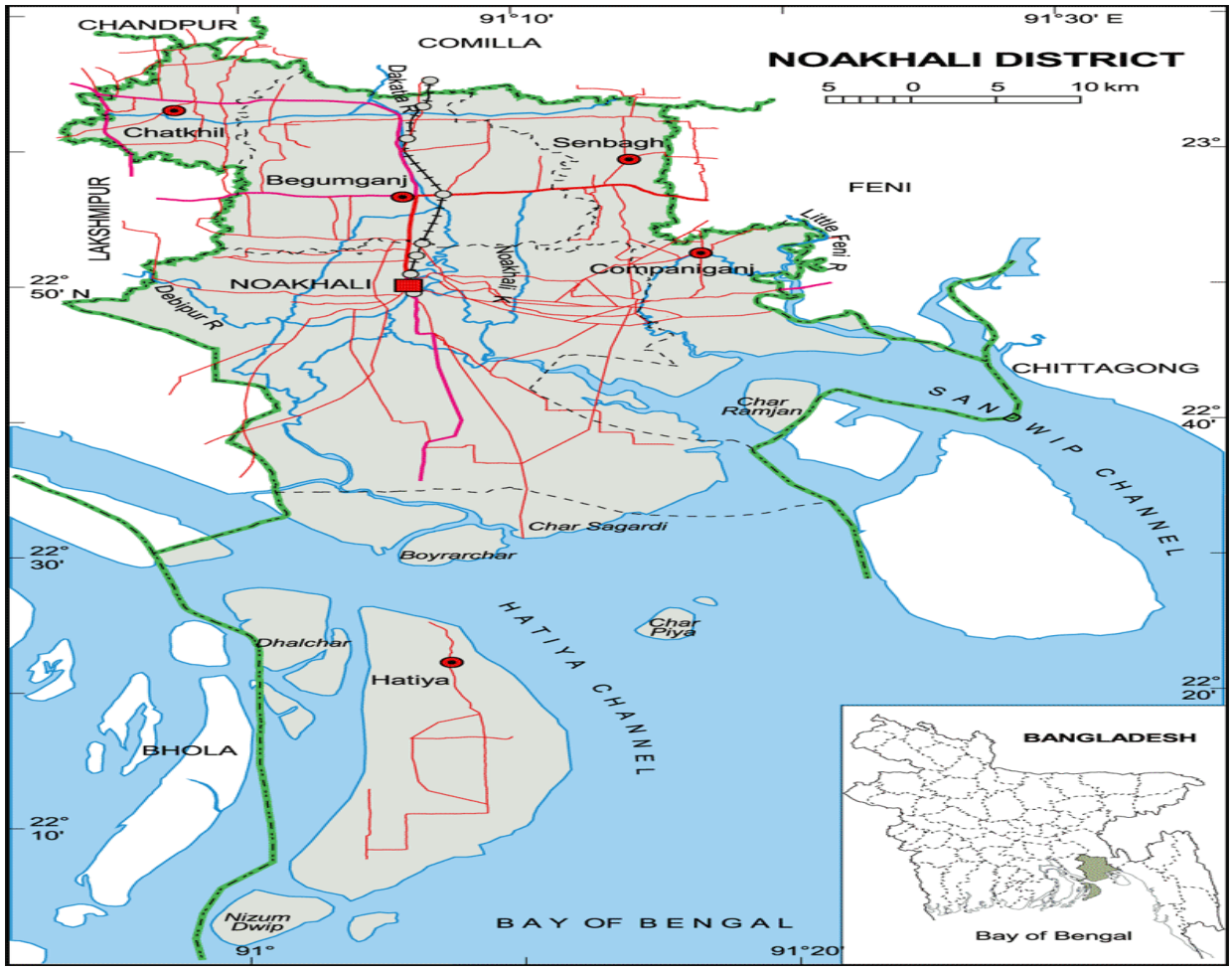

Figure 2. Map of Noakhali district

The main sources of water in the area are rain, rivers, canals, swamps and ponds. Water stagnation is a common phenomenon during heavy rainfall. As the monsoon is very active, heavy rainfall cause flood/water logging. Early rainfall causes filling of water retention areas, ponds and ditches, tributaries, lakes and low lying areas and thus additional rainfall during the ongoing rainy season just over flow or cause water logging for about 6 months (May to October) in some parts of Noakhali. There is a typical monsoon climate with a warm and dry season from March to May in Noakhali. A rainy season from May to October is followed by a cool period from November to February.

The mean annual rainfall is 2000 mm, of which approximately 70% occurs during the monsoon season. Temperature varies from 12 to 34°C. The relative humidity is high varying from 70% to 89% in July. Rainfall is abundant but seasonal. About two thirds of the annual rainfall evaporates and 15% percolates into the ground, raising the water table close to ground level. Floodwater recedes and ponds and water tables fall in the dry season. However, availability of water remains high in most of the area.

Climate change may be affecting significant changes in precipitation, temperature, frequency and intensity of some extreme events. These changes may affect natural and human systems independently or in combination with other determinants to alter the productivity, diversity and functions of ecosystems and livelihoods as anthropogenic climate change is already affecting aquatic ecosystems and the human societies that depend on them (Perry et al., 2009).

2. Development of Aquaculture in Noakhali district

Aquaculture practices in Noakhali followed an extensive system before 1998. Government of Bangladesh and DANIDA played a very important role for aquaculture development in Noakhali district.

2.1. Greater Noakhali Aquaculture Extension Project (GNAEP)

The DANIDA-funded Mymensingh Aquaculture Extension Project (MAEP) located in the north-central part of Bangladesh successfully raised yields in pond aquaculture in six districts in the region to around 3 tonnes per hectare from 1989-2003. DANIDA was encouraged by the success of MAEP to expand its involvement in small-scale aquaculture development to other parts of the country, especially the coastal belt on either side of the Meghna river estuary. The Patuakhali-Barguna Aquaculture Extension Project was initiated in the southern part of Barisal division, followed in 1998 by the GNAEP. GNAEP began as a conventional transfer of technology aquaculture extension programme, seeking to promote the improved pond polyculture systems in Noakhali region. The overall goal of such extension was to improve the lives of the poor fish farmers by raising income from their available water resources through the promotion of improved and sustainable culture practices. The main purpose was to strengthen the socio-economic position and well-being of the target group of poor men and women belonging to landless and marginal households, thus enabling them to improve their livelihood.

Initially GNAEP was strongly influenced by the experience of MAEP. It assumed that the basic technology of aquaculture was available and proposed a massive extension effort to disseminate this technology through regular training carried out by Field Trainers employed by contracted NGOs. The credit was also provided by the NGOs, without which it was assumed that the small farmers targeted by the project would not be able to invest in the necessary pond preparation, seed and feed for aquaculture. Yields of carp polyculture in ponds were raised from around 1200 kgs per hectare equivalent to around 3 metric tones through this training and credit approach to extension. As GNAEP developed, however, it was apparent that the standard carp polyculture system was not suitable and that the link with credit provision tended to reduce the attention paid

by the NGOs to follow-up activities. This link tended also to attract better-off farmers who were seeking a source of cheap credit (Demaine, 2011).

GNAEP began to explore a more overtly pro-poor approach, by focusing on the needs of resource-poor farmers and seeking to identify aquaculture interventions that would fit into their resource systems. Several possibilities for different aquaculture development systems for poorer people were identified by GNAEP from 2002, which included:

- Introduction of integrated rice-fish-freshwater prawn culture in paddy fields in the accreted lands, known in Bangladesh as 'gher' farming
- Carp poly culture in ponds
- Development of improved aquaculture in community ponds in cluster villages of accreted land areas developed under Char Development and Settlement Project (CDSP)
- Development of carp and prawn nurseries in small-seasonal ponds developed by poor households from raising the homestead platform in areas subject to flooding
- Cage culture in multiple ownership ponds and in rivers
- Aquaculture in waterlogged paddy lands in the rainy season

As Noakhali is an area where accreted lands have developed at the coastal zone, the new systems apart from the latter two were oriented towards accreted land areas though the integrated prawn farming systems in paddy fields were specifically piloted amongst 400 households in poor communities in those areas. This pro-poor intervention had considerable initial success; in particular, the specific intervention of nursing of prawn post larvae in the ponds of women headed households often enabled the women to rear two cycles of Post larvae (PL) over a six month period with a profit of around US$ 114 to 143. GNAEP also established production of very large size prawn able to be sold at the pond bank at around US$ 8.5 per kg though the deep cluster village ponds appeared not to be an ideal culture environment for prawn. GNAEP adopted an approach which was more participatory to its farmer training given the pro-poor emphasis involving young facilitators to work with the farmers and designing a number of learning sessions. Quality prawn seed supplies were ensured through the promotion of and technical assistance to private sector hatcheries. The shift to private sector investment created

one of the biggest concentrations of prawn seed production in the country. The level of efficiency enabled sale of PL at a price of US$ 0.018 per piece from 2002-2006 which was only half of the prevailing price. This competitive price for PL, which constitutes around 40% of the production costs of prawn culture, that enabled many resource-poor farmers in the Noakhali accreted land areas and elsewhere to invest in the system. GNAEP encouraged local entrepreneurs to invest in a small feed mill and, with support from the Embassy of Denmark's Business to Business (B2B) Development Programme, a modern fish and prawn processing plant in the region, alongside the hatcheries (Demaine, 2011).

2.2. Regional Fisheries and Livestock Development Component (RFLDC)

GNAEP ended in September 2006 to be replaced by a more integrated project linking GNAEP with a livestock extension component, Regional Fisheries and Livestock Development Component (RFLDC), Government of Bangladesh-DANIDA. The design and focus of RFLDC have continued to follow the approach begun under GNAEP though it was widened in scope and it slowly became clear that carp polyculture system was a relatively low return system, which did not contribute in a major way to alleviate poverty for the poor farmers and the 'gher' farming and the cage culture in the multiple ownership ponds did not prove to be very sustainable in Noakhali (Demaine, H, Personal communication, 1 Januray, 2012). The participatory learning approach developed under GNAEP has come into play particularly. GNAEP and its successor project, the RFLDC, have been and continue to be the key player in the development of aquaculture in Noakhali (Demaine, 2011).

The extension activities is playing a very important role in the development of aquaculture in Noakhali district and aquaculture is developing as a sustainable source of income and economic development for poor households and communities and a method for improving community health through increased consumption of fish – all important contributors to community resilience.

The study focused on technology extension to farmers and evaluation of the impact of farmers' access to new technology and the market for the production based on these technologies

provided by extension services. The study had its focus on the technology level, size, dependencies, owners, markets, constraints and the risks of climate change of the common categories of aquaculture practices in the study area. The vulnerabilities of the rural farmers' livelihoods and the resilience with special emphasis to climate change were also the prime focus of the study.

3. Method

3.1. Field visits and interviews

Extensive field visits, interviews and personal communications were used to survey the dominating categories of aquaculture in Noakhali. People working for RFLDC at different levels gave the information about how the technologies were being extended to the farmers, the marketing system, and they also provided data of costs and returns of aquaculture in the community based ponds and water logged paddy lands. Key informants of RFLDC also informed about the vulnerabilities, resilience and livelihoods of farmers. Informal meetings were arranged with the key informants. One Focus Group Discussion (FGD) with the farmers in a CBO office was arranged to have better ideas of the vulnerability context and their resilience to those vulnerabilities. No questionnaire was used during the interviews.

3.2. Sustainable rural livelihood framework

Sustainable rural livelihood (SRL) framework was used in the current study for studying livelihood security of the farmers. The livelihood assets of the farmers were studied which helped to identify the resilient livelihood outcome for them. According to DFID (1999), ‘‘a livelihood comprises the capabilities, assets and activities required for a means of living. 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.’’ Ashley and Carney (1999) mentioned that livelihoods are sustainable when people are resilient in the face of external shocks and stresses; are not dependent upon external support; maintain the long-term productivity of natural resources; and do not undermine the livelihoods of, or compromise the livelihood options open to others.

Figure 3 shows the sustainable livelihoods framework and its various factors, which constrain or enhance livelihood opportunities and gives the impression of how they relate to each other. The framework shows the way of thinking through the different influences (constraints and

opportunities) on livelihoods, and ensuring that important factors are not neglected (Ashley and Carney, 1999).

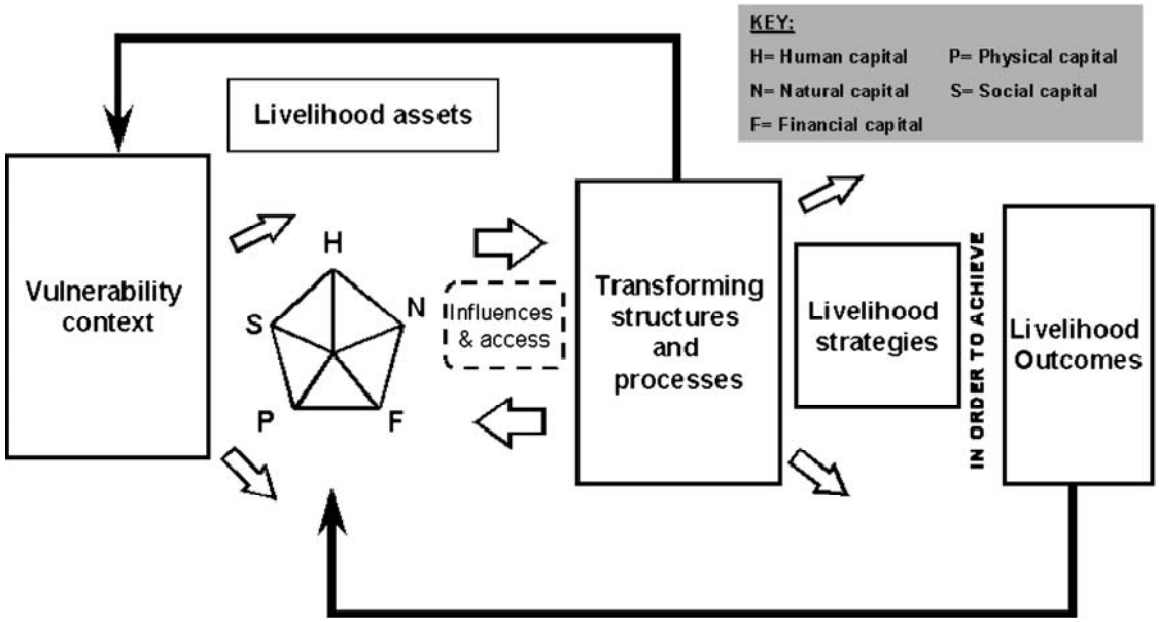

Figure 3. Sustainable rural livelihood framework (DFID, 1999)

The aim of this framework is to think holistically about the factors poor might be vulnerable to, the assets and resources that help them thrive and survive, and the policies and institutions that affect their livelihoods (DFID, 1999). The sustainable livelihood framework shows how, in differing contexts, sustainable livelihoods are achieved through access to a range of livelihood resources that are combined in the pursuit of different livelihood strategies. A range of resources are required to achieve positive livelihood outcomes. The poorest people even have resources upon which they depend. Thus, the attempt to make livelihoods more secure and sustainable has to build upon an understanding of the resources that people already have, and how they are used. Failure to do this can lead to policies that undermine or destroy the basis of peoples' livelihoods, or make more vulnerable. The sustainable livelihoods framework draws attention to human capital, natural capital, financial capital, physical capital and social capital upon which farmers' livelihoods depend.

3.2.1. Vulnerability context

According to DFID (1999), vulnerability context refers to the ability to cope with shocks, trends and seasonality. Shocks can be floods, cyclones or tidal surges, sudden increase in input costs, death in the family and civil conflicts which can destroy the resources of farmers. Events have highlighted the impact that international economic shocks, including rapid changes in exchange rates and terms of trade, can have on the very people. The increase in oil price, climate change in terms of water logging and salinity intrusion, long time illness and disease can be the trends. Trends have particularly important influence on rates of return to chosen livelihood strategies. Although trends are more predictable, they may be more benign. Changes in seasonal patterns can be more rain coming in short period or prolonged winter or rainy season. Socio-culturally seasonality may denote to seasonal migration reducing the labor force restricting what a farmer can do in that part of the year. Seasonal shifts in prices, employment opportunities and food availability are the greatest and most enduring sources of hardship for poor people in country like Bangladesh. Thus, shocks which are the non predicted events, trends and seasonality which are expected and predicted changes can have major impacts on resources of households and individuals, and consequently on their abilities to generate incomes, to benefit from employment, and to provide food and nutrition for their families, and this complex of influences is directly or indirectly responsible for many of the hardships faced by the poorest people in the world and poor aquaculture farmers are no exception. The inherent fragility of poor farmers' livelihoods makes them unable to cope with stresses and also makes them less able to manipulate or influence their environment to reduce those stresses; as a result they become more vulnerable. And even when trends move in the right direction, the poorest may be unable to benefit because they lack assets and strong institutions working for them.

In the SRL framework, vulnerability context is linked to the various elements of the livelihood framework such as impact on resources and changes in livelihood strategies and outcomes (DFID, 1999).

3.3. Assumptions

The methodology was based on the following assumptions.

- Aquaculture extension activities can improve the aquaculture practices through introduction of new technologies and ideas according to the needs of the farmers.
- Climate change can make the aquaculture systems more vulnerable.
- There is need for resilient livelihood outcome for the poor farmers.

4. Results

4.1. Transfer of technology

Major Technical assistance and support were given to the fish farmers by the Government and DANIDA in their joint collaboration project Regional Fisheries and Livestock Development Component (RFLDC). The information related to the process of technology transfer to the farmers was collected from the key informants of RFLDC working at different levels. Secondary information was also collected from unpublished reports of RFLDC.

4.1.1. Integrated Farmer Field School (FFS) approach

The integrated farmer field school (FFS) approach taken by RFLDC is a highly participatory mode of training in which groups of farmers identify what they wish to learn. The farmers undergo a process in which they discover their resources, exchange their own experiences in the best use of those resources, carry out experiments to compare possible new technologies and make their own decisions on adoption. Farmers join FFS because they want to learn and adopt in the FFS. Table 1 lists the objectives of FFS.

Table 1. List of FFS objectives

1. To provide an environment in which farmers could acquire appropriate knowledge and skills.
2. To be able farmers to make sound crop (in the fields of aquaculture, livestock and vegetables) management decisions.
3. To sharpen farmers' abilities to make critical decisions that can make their farming activities more profitable and sustainable.
4. To improve farmers' problem solving abilities.
5. To show farmers the benefits of working in groups and encourage group activities.
6. To empower farmers to become "experts" on their own farms and to be more confident in solving their own problems.

The FFS approach is teaching the farmers not to adopt only but also to adapt. This approach deals with whatever the resources the farmers have and making them more resilient with those available resources. Farmer Field Schools follow a demand-driven curriculum that is determined by the priority constraints identified during needs assessment. FFS encourages farmer experimentation as part of discovery learning. Each farmer field school is organized for about 25 households with common interests, who can support each other, both with their individual experience and strengths and to create a 'critical mass'.

4.1.2. Community Based Organization (CBO)

The Community-based Organizations (CBOs) have been developed as a vehicle for promoting knowledge and skill related to the production and development of aquaculture, livestock and vegetable cultivation, and livelihoods in general by organizing FFSs. Table 2 describes the role of CBOs.

Table 2. The role of CBOs

1. Identifying pro-poor demand-led development and production oriented services related to aquaculture, livestock and crop production.
2. Enabling resource poor farmers to involve in appropriate improved production activities by enhancing capacities through FFSs.
3. Linking to private sector enterprises of input supplies.
4. Playing the role of actors of marketing chains for having fair prices of their products.
5. Acting as Water Management Groups.
6. Having linkages to local government institutions like Union Parishad (UP) for governance.
7. Sustainable integration with the national development policies and activities.

4.1.3. CBO association

The CBO associations were developed as the apex community organizations for establishing the rights and privileges of the component CBOs through bargaining and dialogue to various government and private level organizations. Alongside of policy advocacy the associations have also been involved in rendering various services (Table 3).

Table 3. Various services of CBO Associations

1. Ensuring free flow of production inputs to component CBOs 2. Networking with the input and output markets to the component CBOs 3. Developing private entrepreneurships for quality fish feed production and also establishment of local nursery

4.1.4. Union Parishad (UP)

Union Parishad (Parishad is a Bengali word which means ‘council’), the smallest and rural administrative effective local government institution working with the people at a local level, was also involved by RFLDC to its programme for coordinating the development agendas to the policies and strategies of the government rural level. Under the Local Government Act-1983, Peoples Republic of Bangladesh each Union Parishad (UP) has 13 standing committees, of which one standing committee is related to fisheries, livestock and agriculture. The standing committee is supposed to consist of five UP members and a co-opted representative from CBOs working under the Union Parishad. The committee meets every month to identify problems related to fisheries, livestock and crop, and takes decisions regarding the relevant issues. The committee also verifies, approves and forwards the block grant proposals of CBO to RFLDC and monitors the CBO activities especially the block grant project activities implemented under the UP. Beyond monitoring CBO block grant project activities, the committee prepare own projects related to fisheries, livestock and crop for block grant from RFLDC and implement it under direct supervision of the committee. The involvement of UP as local government institution at the grass root level is supposed to enhance the sustainability of the CBO programmes in terms of

linkage with government development strategies and transparency of implementation by involving the local representatives for long-term sustainable national development.

4.1.5. Local Facilitators (LF)

The Local Facilitators (LF), the master trainers of FFS were observed to play an important role in imparting technical knowledge and skill to the farmers. During field visit, they were observed to be the practicing role models in the communities and their performances were keys to successful implementation of the extension programmes. They were young men and women who conducted the FFSs. According to the staffs of RFLDC, 40% of them were women and the LFs were selected from the farming households in the local community for their social acceptance and communication skills. LFs were trained by four-month season long learning by RFLDC staffs in which they were taught how to run field school.

4.2. Dominating categories of aquaculture in the study area

Aquaculture in water logged paddy lands and community based aquaculture in ponds were the most common types of aquaculture in Noakhali. In the newly accreted lands of the study area, there were some very extensive aquaculture practices in ponds specially with dykes and no or broken dykes. Some households even used ponds for retaining water for household use. From field survey and interviews with the key informants of RFLDC, this study categorized four common types of aquaculture practices in the study area. According to the Senior Advisor of RFLDC, these were small-scale (Demaine, H. Personal communication, 1 January, 2012). Table 4 describes the technology level, size, dependencies, markets, ownership and species mix of these four common categories of aquaculture practices. Traditionally, the carp poly culture in ponds was very popular in the study area. But a species mix containing prawn has become more popular these days. According to the key informants, inclusion of prawn did not increase the costs of poly culture that much. But there has been a very good market for prawn in the study area and the prawn PLs have also been available due to the development of prawn hatcheries in the area. Aquaculture in water logged paddy fields are practiced in the mainland of Noakhali.

Community based ponds are in the accreted lands. Last two categories of aquaculture practices in ponds and ditches described in Table 4 are found in the newly accreted lands.

Table 4. Characteristics of different categories of aquaculture practices

Categories of aquaculture	Technology level	Size (Ha)	Dependencies	Markets	Ownership	Species mix
Aquaculture in waterlogged paddy lands	Semi-intensive	2.02-17	Capital, quality feed and quality seeds	Sell to the local market and use for own consumption (prawns go to the mega city markets and processors)	Communal	Carp, prawn, small indigenous species, and aquatic vegetation
Aquaculture in Community based ponds	Semi-intensive	0.28-1.13	Capital, quality feed and quality seeds	Sell to the local market and use for own consumption (prawns go to the mega city markets and processors)	Communal	Carp, Tilapia, prawn and small indigenous species
Aquaculture in ponds with dykes in newly accreted lands	Technically weak/very much extensive	0.08-0.20	Only rice bran used	Sell to the local market and use for own consumption	Private	Carp and tilapia. Very few households stock prawn
Aquaculture in ponds with no or broken dykes in newly accreted lands	Traditional/ Technically weak/very much extensive	0.08-0.20	Only rice bran used	Mainly for household consumption; rests for sale	Private	Wild fish and few carp species

Extensive aquaculture technologies do not follow proper stocking method and need very little or no external inputs other than seed, and growth of fish depends absolutely on naturally available

feed. On the other hand semi-intensive practices in community based ponds and waterlogged paddy lands use more systematic stocking approaches and use fertilizers and supplementary feeds to promote fish growth. During field survey it was observed that there were additional water management and monitoring practices including control of predatory fish species, regular observation of fish behavior, liming and control of aquatic weeds in the semi-intensive practices.

4.2.1. Constraints

Property rights of water logged paddy lands and community based ponds have been well ensured by the Government while the property rights in the new accreted lands have totally been in a vulnerable condition because of lack of Governance and influence of musclemen (Demaine, H. Personal communication, 22 February, 2012). A number of other constraints were reported in all these aquaculture types which included-

- lack of capital,
- marketing problems,
- lack of quality fingerlings,
- diseases,
- natural disasters (flood, excessive rainfall, drought/lack of water, which are important in the waterlogged zone),
- poaching and
- poisoning.

The problem over finance and need for credit arise quite often as capital is very often scarce in the rural areas like Noakhali. Most small farmers have no or very limited access to institutional credit. The poor farmers do not have individual transports; and icing facilities are also not available in the remote villages; and for these reasons farmers have difficulties to bring their products to the distant markets. Since aquaculture is being widespread in the area, the demand for quality fingerlings has also increased. Adequate number of nurseries is needed to cover the need for fingerlings. Diseases, mortality, reduced growth and stress in fish breeding are due to the effects of the environment on aquaculture through pollution. The poor farmers of this coastal region are in risk of natural disasters which may have adverse effect on the production. Coastal

embankments can reduce effects on the newly accreted lands. Sometimes the fish are theft from the ponds and the enemies do poisoning into the ponds for which all fish may die.

4.2.2. Production in community based ponds and waterlogged paddy lands

Community based ponds and waterlogged paddy lands are the most important areas of small-scale aquaculture practices in Noakhali. These two kinds were chosen for costs and returns data because to collect any kind of data from other categories were behind the capacity of this study. The average costs and returns from 107 community based ponds and 50 waterlogged paddy lands in 2011 were calculated in which extension services were provided (Table 5). The data were collected from RFLDC office.

Table 5. Average production costs and returns from community based ponds and waterlogged paddy lands including the benefit-cost ratio

Cost and return USD/ha/year	Community based ponds	Water logged paddy lands
Total Costs (TC)	704.96	369.60
Gross revenue (GR)	1610.29	732.38
Net return	905.33	362.78
Benefit-cost ratio	2.28	1.98

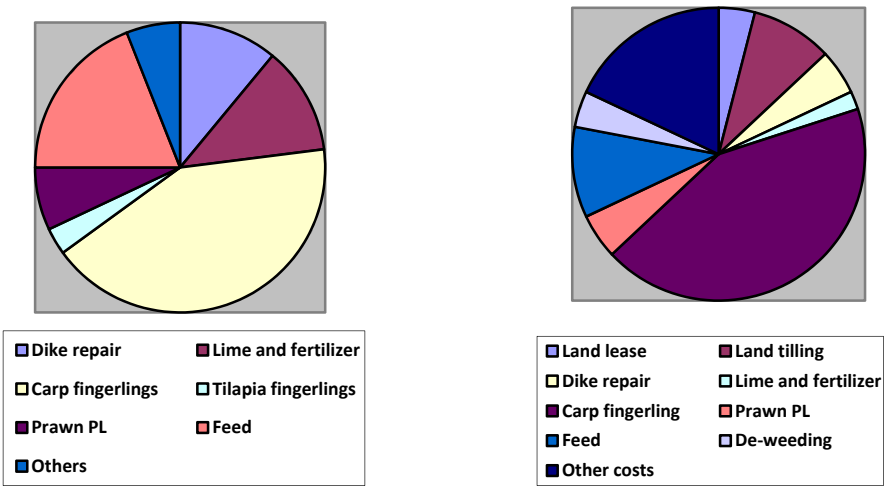

Figure 4. Pie diagram of average expenditures in community based ponds (left) and water logged paddy lands (right)

Figure 4 gives an idea of average expenditures for dike repair, feed, lime and fertilizer, fingerlings of carp, prawn and tilapia in the community based ponds and also provides average expenditures in the water logged paddy fields in the wet season.

4.3. Risks of climate variability

The key informants of RFLDC informed that many farmers had to utilize local feeds and depend on mainly streams, rivers and most importantly on rainfall for the source of water for fish farming in the study area. They have also informed that fish production has mainly been concentrated in wet season since dry season production has not been popular due to shortage of water, high mortality and also pilfering in the study area. Table 6 describes five major livelihood risks from climatic disasters which were identified during the focus group discussion with the farmers.

Table 6. Livelihood risks from climatic disasters

1. Low productivity
2. Low income
3. Starvation
4. Poor health of farmers
5. Poor standard of living

Although extreme weather events were not many in the study area, the key respondents informed that the natural disasters could increase the physiological stress on the stock being cultured affecting productivity and vulnerability to diseases of fish, and in turn, also pose risks and reduce returns to poor farmers. Floods and storm surges might create risks of escapes of farmed stock from the ponds and water logged paddy lands. According to the key respondents of RFLDC working in the study area, sea level rise can make aquaculture vulnerable by reducing the scope of freshwater aquaculture and prawn ‘gher’ systems. There have been climate change refugees due to flood affected pond aquaculture in the newly accreted lands. It is also assessed that salinity intrusion has been threatening freshwater aquaculture practice. Cyclone and storm surges have been responsible for loss of fish for overflowing the dykes of ponds. There has been huge

mortality of fish after storm surges. Water logging for prolonged period has been responsible for creating fish and animal diseases in the study area. The possible problems due to climate change on common categories of aquaculture are listed in Table 7.

Table 7. Possible problems related to climate change on aquaculture in Noakhali

Categories	Possible problems
Aquaculture in waterlogged paddy lands	1. Droughts or no rain for longer periods or prolonged winter 2. Flood or storm surges 3. Water logging for long periods 4. Excessive rainfall 5. Temperature fluctuation affecting the hatchery based fish seed
Aquaculture in community based ponds	1. Dike overflow due to flood 2. Temperature fluctuation affecting the hatchery based fish seed 3. Increased salinity 4. Excessive rainfall
Aquaculture in ponds with dykes in newly accreted lands	1. Flood 2. Cyclone or storm surge 3. Excessive rainfall 4. Increased salinity 5. Submerging of ponds due to sea level rise
Aquaculture in ponds with no or broken dykes in newly accreted lands	1. Flood 2. Cyclone or storm surge 3. Excessive rainfall 4. Increased salinity 5. Submerging of ponds due to sea level rise

Source: Demaine, H. and Uddin, K.G. Personal communication, 22 February, 2012

In Table 8, there are same problems for the aquaculture in ponds with dykes and aquaculture in ponds with no or broken dykes. But the effects can be more severe in the ponds where there are no or broken dykes. The current study has observed the aquaculture ponds in the newly accreted lands more vulnerable to cyclones and storm surges and to increased salinity. Aquaculture practices in waterlogged paddy lands are more vulnerable to drought or lack of water or prolonged winter season. Community based ponds have been mostly found in the fully

consolidated accreted lands and most of the lands have been surrounded by embankments. In some areas there are broken embankments and the community based ponds in those areas are more vulnerable to floods.

This study predicts that increased incidence of extreme events due to climate change may exacerbate the adverse effects on aquaculture operations and increase damage and disruption to coastal and riparian homes, services and infrastructure. Sea level rise and other large-scale environmental changes might have unpredictable effects on coastal and wetland environments and livelihoods in Noakhali.

4.4. Marketing channel

Community based organizations (CBOs) introduced by RFLDC were observed to be playing a vital role in the fish marketing systems in the area (Figure 5). CBOs were found to help the farmers to get a good price for their fish by linking to local markets. They were playing the role of middlemen though reducing the influence of other local agents as middlemen have always been a challenge for the CBOs.

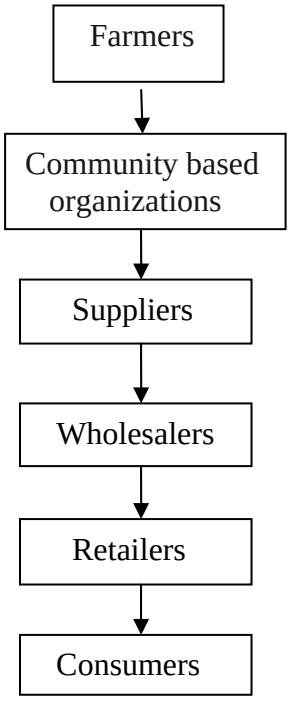

Figure 5. Marketing channel from producers to consumers through CBOs

Since the CBOs have been farmers' own organizations, these organizations help the farmers get more profit instead of the local agents in other areas of the country where there have been no such CBOs. A list of overall marketing challenges in Noakhali has been placed in Table 8.

Table 8: List of overall marketing challenges in Noakhali

1. Reduce the influence of the middle men by creating provisions for bulk buying and selling through capacity building of fishers' association and CBOs because of too many intermediaries in the fishery marketing chain.
2. Development of infrastructure at fish landing stations, light house, market, roads and communication.
3. Ensure maximizing profit by matching situations with optimized production options.

4.5. Farmers livelihood

4.5.1. Shocks, trends and seasonality pattern

Shocks, trends and seasonality make the farmers more vulnerable and these are big challenge for the better aquaculture management in the area. The common shocks, trends and seasonality pattern of vulnerability context faced by farmers in Noakhali have been listed in Table 9.

Table 9. Shocks, trends and seasonality faced by farmers in Noakhali

Vulnerability context	Type
Shocks	i. Natural disasters (floods, heavy rains, droughts in the dry season, storm surges) ii. Illness, food deficits, malnutrition of farmers iii. Conflict for assets due to lack of property rights iv. Fish and prawn diseases
Trends	i. Population trends (increasing population, migration of household head to another job, e.g., brick fields) ii. National/International economic trends iii. Natural resource trends (including environmental changes) iv. Trends in governance (including politics)
Seasonality	i. No production ii. Less employment opportunities iii. Off prices for the produced fish

Source: Focus Group Discussion

4.5.2. Livelihood assets

4.5.2.1. Human capital

The aim of the FFS approach has also been to help the farmers according to their demands. The illiteracy rate was found to be 60 % among the farmers and most farmers were quite young, with a range from 20 to 65 in the study area (Uddin, K.G. Personal communication, 2 January, 2012).

4.5.2.2. Natural capital

Large areas of land, water, and natural resources have been used for fish and prawn production. However, according to farmers during focus group discussion, rapid population growth in such farming communities have led to accelerated natural capital depletion.

4.5.2.3. Financial capital

According to farmers, their major incomes came from fish and prawn farming, agricultural and livestock activities. Few respondents at FGD mentioned that some farmers used their own money for farming, and few got block grants from RFLDC and few got from microcredit system. However, some farmers sometimes had harvest failures because of flood, outbreak of disease, or other unavoidable reasons, and as a result they could fall into cycle of debt.

4.5.2.4. Physical capital

Farmers often had to fall behind because of the limited physical capital. Many of the farmers lived in poor housing condition. They faced severe health and sanitary problems with not adequate medical facilities; people often suffer from diarrhea, cholera, and lack of nutrition. Apart from salinity, arsenic is also a common problem for drinking water in Noakhali area. Moreover, electricity supply is limited there.

4.5.2.5. Social capital

There are possibilities of unfavorable social environments posing risk of losses through theft or poaching of fish and prawn and poisoning ponds. Sometimes jealous people throw poison into ponds at night, after which all the fish may die. Theft risks usually increase when ponds are too far from farmers' homes to allow surveillance. There are some other negative social impacts for aquaculture as a result of the increased income. For example, gambling and the consumption of alcohol and drugs by a few farmers have increasingly been reported. Some women had to live alone with their young children because their husbands had married again and abandoned them. Dowry payments have also increased as result of increased fish farming.

4.5.3. Transforming structures and processes to the development of farmers livelihood

The study found that Department of Fisheries, Government of Bangladesh through donor project Regional Fisheries and Livestock Development Component, GoB-DANIDA was involved in providing technical support to the poor farmers in the study area. Appropriate policies and enforcement of legal instruments can facilitate the development of sustainable farming system. Technical assistance given to the farmers could remove the constraints to the sustainable development of rural livelihood. Block grants provided to the farmers by RFLDC were also found to be very effective for demonstrating benefits from the farming in community based ponds and also in the waterlogged paddy lands. The study found that RFLDC in this phase had been emphasizing on integration of aquaculture with agricultural and livestock activities so that farmers could earn from other agricultural and livestock activities also to make the farmers more resilient to the vulnerabilities.

5. Discussion

5.1. Technology adoption

According to RFLDC (2011), production from aquaculture had increased by 74% after the FFS interventions, with the best performance in the waterlogged lands and in some settlement areas; and fish consumption had also increased markedly, by 175%, much higher than the overall average increase of 52%. However, the best performance in terms of net income was exhibited in the waterlogged area. The number of prawn farmers was only 5.3% of the total prior to the FFS and increased to 6.1% afterwards. However, production increased very rapidly following the learning process and income from this system increased more than doubled.

The study observes that the development of the community based organizations has been the key element of the support system. The PL, feed and other input supplies required for prawn farming were channeled to the farmers through the introduction of a network of community-based organizations (CBOs) managed by groups of farmers, which acted as the agents of the hatcheries and the collaborating local feed miller (Demaine, 2011).

Although, block grant from the RFLDC is a major source of finance for these activities but the CBOs contribute a significant share of the finance from their own resources. CBOs own resources were built up from the contribution of the members, earlier block grants which have become revolving funds from RFLDC and the profits from services provided by the CBOs to its members. Wide range of beneficiaries were covered by these production and development activities that have significant impacts on the production and returns of aquaculture, livestock and vegetable cultivation, and livelihoods in general.

All member CBOs of CBO associations were found to be the beneficiaries of free flow of production inputs in competitive economic prices. Quality inputs were crucial for good production. According to the farmers attending FGD, the inputs available in the open market were not always good in quality and sometimes had been even in peak demand, and also the inputs were often not available in the local markets and the prices were usually high. The CBO

associations were ensuring quality inputs in time and in fair price to CBOs. When the association bought inputs in bulk, they got some commission from the input wholesaler companies, most of the time that amount were enough to compensate the service charge required for delivering the inputs to the stakeholders and ensured fair prices of inputs.

CBO associations were lacking financial strength to support CBOs in terms of linkage with private sector agri-business, bargaining for policy support with government and other concerning institutions. There has been lack of financial strength for maintaining regular meetings, transport, communication (cell phone bill) and infrastructures (freeze, cool boxes, vehicle, computer etc.). CBOs and CBO associations lacked experience sharing visits and exchange programmes in country and abroad. Further strengthening capacities of the CBO associations regarding linkage development, advocacy and management should be emphasized.

Despite substantial improvements of roads particularly in the mainland of Noakhali, remote villages of accreted lands still face an accessibility problem, which in turn can affect the quality and price of fish. Heavy rains often destroy the muddy roads in villages making them eventually inaccessible for the vehicles to carry fish to the markets leading to high transport costs and hence possibly leading to low profit margins. In addition to these problems, farmers were in a particularly weak position in relation to intermediaries. CBOs have been found to mitigate the problem with the intermediaries helping the farmers to get good price for their product and get inputs at a possible lower cost. Although the input costs are increasing due to vulnerabilities of hatchery based seed production and increased input costs of producing fish feed and fertilizers, CBOs have been able to create good market for the farmers' products. Technology is playing an important role in the way to reduce poverty and adapt to the vulnerabilities through such community based adaptation in the study area.

5.2. Benefit-Cost Ratio

Benefit-cost ratio (GR/TC) or profitability index of one means that the operation is at break-even point (Ahmed, 2009). Benefit-cost ratio of community ponds were 2.28 and of water logged paddy fields were 1.98 (Table 6). The findings showed that the community based ponds

recovering US$ 2.28 per US$ 1 of investment and water logged paddy fields generate returns of US$ 1.98 where the culture systems were semi-intensive. The benefit-cost ratio value of semi-intensive culture systems were 1.86 in a study conducted in the district of Mymensingh, Bangladesh (Ahmed, 2009). The benefit-cost ratio 1.82 proved catfish farms as viable enterprises in the study of Emokaro et al. (2010). Although costs of cultivation were reported to have increased significantly in recent years as a result of increased input costs, benefit-cost ratios observed in the current study show that producers can get sufficient revenues to cover the costs of aquaculture in water logged paddy lands and in community based ponds.

The main problem for the farmer is the operating capital since the costs of post larvae and feed are increasing as aquaculture is being widespread in the area and also due to increased demand for fish and prawn (Uddin, K.G. Personal communication, 23 April, 2012). This study indentifies that increase in price of fish feed, seed, fertilizers, and increase in other input costs could increase the vulnerability of the poor people of the study area if there had been no intervention of the extension activities. This study suggests that the development of rural aquaculture sector utilizing the potential aquatic resources in a sustainable way can be improved by public sector led intervention. There should be more public sector contribution to develop aquaculture in the newly accreted lands where the ponds are mostly with no or broken dykes and with extensive aquaculture practices.

Block grants of RFLDC are providing an important part of the total costs of aquaculture in community based ponds and water logged paddy fields. These block grants are given to the CBOs through Union Parishad. The management committees of these aquaculture practices are formed from the members of CBOs, owners of the paddy lands and members of the community. The management committee of these ponds and waterlogged paddy lands pay it back to the CBO each year and the CBO then use the money as revolving fund. This is a kind of help provided by the extension authorities since inadequate and costly finance is being the most important constraint for aquaculture farmers in the district. By involving all these stakeholders for such aquaculture practices in water logged paddy lands and community based ponds make communal ownership. Earlier there were not much aquaculture practices in the waterlogged paddy lands and Das and Hossain (2005) suggested that Government intervention could introduce aquaculture in

these water logged paddy lands to improve farmers' livelihoods and food security. The present study finds that RFLDC has got remarkable response from the farmers to do aquaculture in the waterlogged paddy lands and in the community based ponds.

5.3. Climate change adaptation

Coastal communities face multiple vulnerabilities which are more varied and more intensive than those faced by most of the more inland situated communities. Major threats to the people living in the coastal zone include cyclones and storm surges, floods, drainage congestion and water logging, droughts and salinity intrusion, erosion and deteriorating ecosystems, and these uncertainties are exacerbated by the inevitable consequences of climate change (Ahmed and Wilde, 2011). Adrika et al. (2011), Noakhali showed signs of increasing temperature and climatic variability and it was also observed that seven out of the 10 hottest years on record had occurred since 1990 in this area. They also found the wettest and driest monsoon seasons were on record in recent times, indicating an erratic pattern of extreme weather which might have serious consequences for agricultural practices, and they also reported an increase in the frequency of the lowest category of depressions and reduced number of working days for seagoing fishermen in 2007. Adebo and Ayelari (2011) also had similar observation like the current study that production systems and livelihoods were in risk of being affected by climate change.

Participatory Vulnerability Assessment (PVA is a tool that builds on the principles of community based adaptation by recognizing that local communities have to be intimately involved) in Noakhali conducted by Adrika et al. (2011) has been capitulated as follows.

1. Water logging (long periods of inundation) and drainage congestion were found to be vital problems; re-excavation of canals and restrictions on unplanned construction of roads and infrastructure were needed.
2. The number of cyclone shelter was not found to be adequate and there was very less existing provision for sheltering livestock.

3. There were no disaster management committees in most unions and the ones that exist did not function.
4. Cropping patterns were seriously affected by salinity intrusion, as well as water logging; a shift towards salt tolerant varieties was needed.
5. Medical facilities were not adequate and health complexes were not equipped with doctors, facilities and medicines.

Coastal polders and cyclone shelters have been built in Noakhali by the Government and it has community based approaches to reduce vulnerability to climate change (MoEF, 2008). In the current study it was observed that active participation of the communities was being ensured by Water Management Groups (WMG) created by Char Development and Settlement Project (CDSP) and these groups had been given lessons for managing the embankments, polders and cyclone shelters. This current study supports the observation of Ahmed and de Wilde (2011) that climate change and coastal development are closely linked and can not be considered as separate entities. Bangladesh has the following perspective policies pertaining to the coast.

1. Coastal Zone Policy and Coastal Development Strategy
2. The National Water Management Policy and Plan
3. Poverty Reduction Strategy Paper
4. Bangladesh Climate Change Strategy and Action Plan
5. Perspective Plan of Bangladesh 2010-2021
6. Harmonisation

This study suggests following climate change adaptive measures for sustainability in aquaculture and sustainable rural livelihood in Noakhali.

- More care in handling fish, selective breeding and genetic improvements towards temperature tolerance can adapt to the problem of rise in temperature.
- Regular monitoring can reduce the physiological stress on the farmed stock and thus can help in reducing farmed stock mortality.
- Introduction of salt tolerant species mix; specially in the ponds of newly accreted lands.

- Development of hatcheries with flood resilient infrastructures can produce more seeds of fish so that input costs do not increase for the poor farmers and they do not have to depend on seeds from natural sources.
- There should be encouragement towards development of mariculture to reduce pressure on freshwater aquaculture and to generate alternative income specially during droughts and also in the periods of excessive rainfall.
- Diversification in the culture system can build more resilience to vulnerability of aquaculture-based communities from their resource dependency and can reduce loss due to extreme weather events.

Although these are the suggested measures which can be followed by the farmers to be more resilient to climate change, faster implementation of the plans and strategies of the Government is vital for helping poor farmers to cope with climate change.

5.4. Diversification as a resilient livelihood outcome

Ecological systems are complex and dynamic, and those also exhibit a level of irreducible uncertainty and the change is often non-linear (Norberg and Cumming, 2008). Under such constraints, diversification gives critical adaptive capacity to a range of unforeseen shocks (Reardon et al., 1992, Ellis, 1998). First livelihood diversification is held up repeatedly in sustainable development/resilience circles as a vital contributor to the ability of a household to cope with shocks (Ellis, 1998, Aerts et al., 2008).

The key informants of the current study informed that incomes of those wholly reliant on aquaculture were dropping and became more vulnerable. As reflected in FGD discussion this related to direct effects from high input costs and diseases, and difficulties in marketing product due to low levels of fish and prawn production. External assistance then included the provision or subsidy of a range of inputs for both aquaculture and agriculture activities in Noakhali. Of equal importance were training, field technical supervision, and technical support services. Farmers were found to be extremely positive about the impact of external support on diversified livelihood. Mills et al. (2011) observed in his study that diverse livelihoods reduce extreme

pressure on particular ecosystem services, and the production of a diverse range of species avoids many of the environmental pitfalls associated with intensive monoculture. Overall the average income of farmers in the Noakhali region increased from a little over US$ 142.86 before the participants entered the FFS to over US$ 428.57 at the present time, an increase of almost 200%. Income from rearing poultry increased from US$ 51.33 to US$ 120.51 (134.8%), that from vegetables increased from US$ 31.06 to US$ 71.24 (129.4%) and that from aquaculture from US$ 34 to US$ 74.56 (119.3%). The improvement in agricultural earnings after involvement in the Farmer Field School has enabled the participating farmers to significantly improve their living standards.

6. Conclusion

There is great potential for increasing family incomes and creating security through engaging in aquaculture practices. However, there are several factors limiting its uptake. These are increasing vulnerability among poor farmers. The farmers are trying to be resilient with the resources that they have. Extension activities of the Government and International organizations and NGOs are helping them to be resilient to the vulnerabilities. The study has shown that aquaculture in waterlogged paddy lands and in the community based ponds are not only profitable but also can be economically viable in Noakhali.

Most of the fish produced in Noakhali go to the local market, except prawn. Some of the prawns go to the markets in the capital city, Dhaka and most to the processors in Chittagong and then frozen to the international market, mainly Europe and the United States. The aquaculture sector market is a private sector market. The Government sector is an actor only on the margins of seed supply, approximately only 2% of total seed supply and it has no role in the produce market. There are subsidies going to the processors of shrimp and prawn industries but there is very much doubt that whether these trickle down to farmers; and there are no subsidies for the limited external market for fish species from Bangladesh which mostly goes so far to the overseas Bangladeshi community (Demaine, H. Personal communication, 14 May, 2012).

Very little of the system could be controlled by the Government except quality control issues related to fish seed (registration and certification of hatcheries via new hatchery Act) and feed quality. The Government has role in extension mainly through donor projects. Better regulation and implementation of plans and strategies by the Government might help to improve returns of farmers and help farmers face climate change.

Again the credit system has a ‘missing middle’ in the sense that small farmers have some difficulties in accessing production credit except from the informal private sector. Bangladesh does not have an organization like Vietnam Bank for Agriculture and Rural Development (VBARD). The ‘missing middle’ refers to the fact that the poor can get funds from the

microcredit system and bigger commercial enterprises from the commercial banks, though some of these trickle down through the informal system.

More focus should be given on the shares of CBOs in future research and how these shares are contributing to farmers. It was beyond the capacity of the current study to investigate costs and benefits of all categories of aquaculture. The study had limited economic reasoning to provide essential information on the economic viability of the aquaculture activities. The mentioned costs and benefits of aquaculture were intended to show the development of farmers with the support from Government and extension authorities and how they are adopting the technology to develop their culture system and livelihood. The aquaculture activities are mostly small-scale in Noakhali and its contribution to total national aquaculture production should be studied. There are very few farms which are doing aquaculture in large scale. This current study finds that diversification in the farming system can build more resilience among the farmers and it can be a more than useful management practice in the rural settings like Noakhali.

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8. Appendices

Appendix 1. Interviews and meeting

Date	Informants
1 January, 2012	Senior Advisor Dr. Harvey Demaine of RFLDC, GoB-DANIDA
2 January, 2012	Former Monitoring and Evaluation Manager of RFLDC Mr. Kazi Gias Uddin
3 January, 2012	Meeting with other informants of RFLDC working at different levels in the different areas of Noakhali in Upakul Freshwater Prawn Hatchery

Note: I had regular personal communication with them through informal meeting, phone and emails on other dates also.

Appendix 2. Schedule of extensive field visits to the different kinds of aquaculture practice areas

Date	Activities
4 Januray, 2012	Visit to waterlogged paddy land areas of different sub-districts of Noakhali mainland and talking to the owners of paddy lands, farmers and CBOs involved with that aquaculture in those lands
5 January, 2012	Visit to community based ponds in the villages of the accreted land areas and talking to the farmers
6 January, 2012	Visit to the ponds of newly accreted land areas and talking to the farmers
7 January, 2012	Focus Group Discussion (FGD) in a CBO office with the farmers and the members of CBOs and Local Facilitators

Appendix 3. Area wise costs, returns and profit data of aquaculture in water logged paddy fields

Area Ha	Total Costs BDT/Ha	Income BDT/Ha	Profit BDT/Ha
6.07	19860	35059	15199
10.12	18731	39781	21050
10.12	16723	43571	26848
4.86	30710	52451	21741
18.22	17289	30174	12885
4.86	25233	60951	35718
10.12	20348	30642	10294
7.29	21479	37376	15897
3.24	24580	48590	24010
11.34	19135	43316	24181
6.88	16983	38631	21648
4.85	22982	46606	23624
4.04	20781	40007	19226
3.24	30267	68467	38200
4.86	14377	30421	16044
10.12	13284	28394	15110
4.86	23996	46822	22826
6.07	10985	21582	10597
4.86	15337	32252	16915
17	15659	29768	14109
4.85	14753	28909	14156
8.1	16200	28139	11939
6.48	21293	30341	9048
6.88	15363	40908	25545
7.29	13314	28158	14844
5.66	17970	39813	21843
7.29	31133	60694	29561
4.08	24977	84429	59452
4.04	24084	39679	15595

4.04	32830	48582	15752
4.05	27448	27239	-209
12.14	8852	21447	12595
7.69	25425	53856	28431
7.69	1590	35463	33873
3.44	19985	54518	34533
4.86	20750	42786	22036
6.07	15269	21342	6073
6.88	10738	24326	13588
3.64	22907	32531	9624
5.67	24250	41316	17066
4.86	29669	43807	14138
4.05	45802	61301	15499
4.05	17111	41830	24719
4.05	84402	149003	64601
10.53	28290	50863	22573
5.67	18358	36599	18241
10.12	21688	50408	28720
4.86	35993	63545	27552
4.86	29809	49014	19205
14.07	5572	16965	11393
4.86	26853	67816	40963
7.29	34812	70071	35259
7.29	20586	44202	23616
4.05	50551	93580	43029
13.77	22781	32336	9555
16.19	12998	39082	26084
16.6	22181	63112	40931
5.26	26962	18278	-8684
4.45	16948	34458	17510
14.17	10001	31613	21612
7.29	27672	47279	19607
7.08	16130	23331	7201

4.05	47965	40745	-7220
5.67	16266	25408	9142
4.05	29099	40579	11480
8.91	12198	18625	6427
4.86	16739	35122	18383
4.86	24650	70320	45670
12.15	19181	51727	32546
4.86	27634	52539	24905
4.05	39570	62551	22981
10.12	10152	20782	10630
5.67	16583	32523	15940
6.07	10180	31136	20956
4.04	13997	39495	25498
14.17	13162	23599	10437
9.71	21576	45710	24134
10.52	24017	59678	35661
12.14	24687	59487	34800
4.86	11673	24784	13111
4.86	17454	31444	13990
2.43	41049	76105	35056
2.43	33457	86913	53456
2.02	20186	25761	5575
14.98	17670	34863	17193
12.14	15512	27967	12455
12.14	18428	35592	17164
3.64	29148	92041	62893
3.24	35262	104563	69301
3.24	33765	95616	61851
4.86	22274	47427	25153
8.09	24876	48006	23130
2.02	90173	187831	97658
10.12	36126	51882	15756
8.09	40093	74937	34844

2.83	81152	175388	94236
6.07	58180	110279	52099
2.83	63428	148187	84759
6.07	46423	76630	30207
4.05	65454	116883	51429
10.12	41191	60085	18894
4.05	47096	88270	41174
4.05	38420	85357	46937
3.44	16754	36331	19577
3.44	22703	39477	16774
3.24	22901	38738	15837
3.44	16755	36331	19576

Appendix 4: Area wise costs, income and profit data of aquaculture in community based ponds

Area Acres	Costs BDT	Income BDT	Profit BDT
1.5	24326	70065	45739
2	42380	135325	92945
3	48508	129200	80692
2.5	35445	156950	121505
1.5	30080	78950	48870
2	37200	89700	52500
2.5	42200	110700	68500
2.5	38360	122320	83960
2	30030	95620	65590
2.5	42334	117650	75316
2	35700	92165	56465
1.5	30220	83775	53555
2.24	27443	38050	10607
1.4	25086	96725	71639
1.4	30857	86750	55893
1.4	31224	113060	81836
2.21	54666	95475	40809
2.07	45650	113725	68075
2.5	83492	106100	22608
2.2	73888	97700	23812
2.8	75000	135000	60000
3	75000	169400	94400
1.2	28931	91590	62659
0.8	30260	62550	32290
0.8	28450	67600	39150
2.8	36850	107725	70875
2.8	33590	107450	73860
1.2	37570	98050	60480
1.2	34475	151050	116575

0.8	36350	73010	36660
0.69	24252	52900	28648
0.69	23912	48450	24538
1	26280	67125	40845
0.85	27245	70900	43655
1	24820	65150	40330
0.85	29035	62075	33040
0.8	25195	63325	38130
2	23310	40250	16940
2	24656	41200	16544
1.5	22275	42675	20400
2	22610	59200	36590
2	23200	41600	18400
2	26870	35400	8530
2	26720	39600	12880
2	22650	50800	28150
2	22350	41400	19050
2	22930	52400	29470
2	56060	79450	23390
2	50180	21800	-28380
2	41180	22600	-18580

Appendix 5: Expenditure data in percentage of the community based ponds and in water logged paddy fields

Types of expenditure	Community based ponds	Water logged paddy fields
Dyke repair	11%	5%
Land lease		4%
Land tilling		9%
Lime and fertilizer	12%	2%
Carp fingerlings	42%	43%
Prawn PL	7%	5%
Tilapia fingerlings	3%	
Feed	19%	10%
Deweeding		4%
Others	6%	18%