Journal of Aquaculture Research & Development

Hasan and Bhowmik, J Aquac Res Development 2016, 7:9
DOI: 10.4172/2155-9546.1000449

Research Article Open Access

Impact of Climate Change on the Socio-Economics of Aquaculture in the District of Noakhali, Bangladesh

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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 used extensive field visits, interviews with the key informants of regional fisheries and livestock development component (RFLDC) and farmers, personal communications, questionnaire survey and focus group discussion as the main procedures to collect data and information. 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 Danish international development agency (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.

Keywords: Aquaculture; Climate change; RFLDC; DANIDA; CBO; Noakhali

Introduction

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 [1].

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 [2]. 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 [3].

Climate change will affect socio-economic sectors which include water resources, agriculture, aquaculture, fisheries, human settlements, ecological systems and human health [2,4]. The ecological systems which support aquaculture are already known to be sensitive to climate variability [5]. There is very limited work done on climate change and the effects of climate change on aquaculture production. Therefore, it is urgent need to improved management and better aquaculture practices to minimize the loss of aquaculture production.

Materials and Methods

Extensive field visits, interviews and personal communications were used to survey the dominating categories of aquaculture in Noakhali. People who worked for RFLDC at different levels gave the information about how the technologies were being extended to the

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***Received** August 03, 2016; **Accepted** September 23, 2016; **Published** September 26, 2016

Citation: Hasan MM, Bhowmik S (2016) Impact of Climate Change on the Socio-Economics of Aquaculture in the District of Noakhali, Bangladesh. J Aquac Res Development 7: 449. doi: 10.4172/2155-9546.1000449

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. Questionnaire was used during the interviews.

Results

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. 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.

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. 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'.

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.

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).

Union parishad (UP)

Union Parishad is 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.

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.

Table 1: List of FFS objectives.

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.

Table 2: The role of CBOs.

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

Table 3: Various services of CBO associations.

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

Table 4: Characteristics of different categories of aquaculture practices.

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

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

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.

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 especially 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. In 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 mixes 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. 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.

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. 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); poaching and poisoning. 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.

Production in community based ponds and waterlogged paddy lands

Community based ponds and waterlogged paddy lands were 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 50 community based ponds and 107 waterlogged paddy lands in 2011 were calculated in which extension services were provided (Tables 5 and 6). The data

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

Table 6: Possible problems related to climate change on aquaculture in Noakhali.

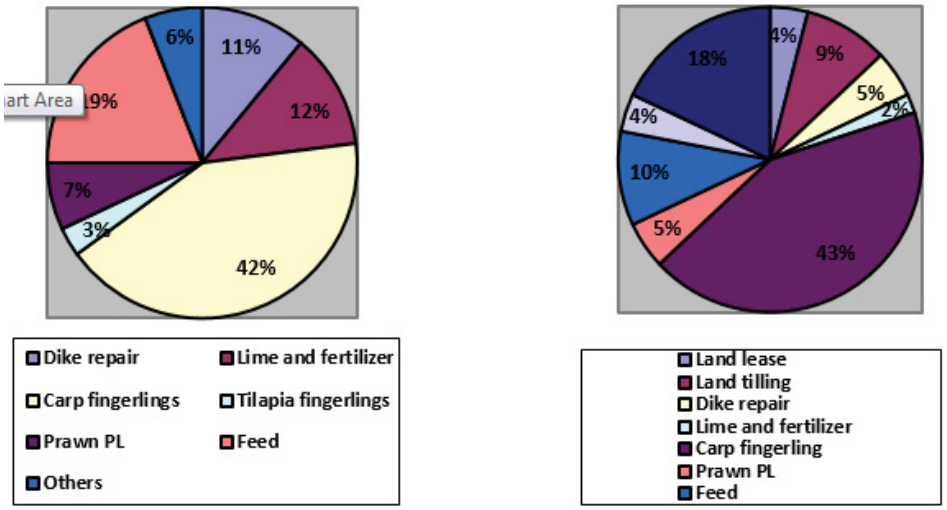

Figure 1: Pie diagram of average expenditures in community based ponds (left) and water logged paddy lands (right).

were collected from RFLDC office. In Figure 1 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 provide average expenditures in the water logged paddy fields in the wet season. This study predicts that increased incidence of extreme events due to climate change to be exacerbating the adverse effects on aquaculture operations and increase damage and disruption to coastal and riparian homes, services and infrastructure.

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. 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. 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.

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 7.

Discussion

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% [6]. However, the best

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

Table 7: Shocks, trends and seasonality faced by farmers in Noakhali.

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 observed 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 [2].

Benefit-Cost ratio

Benefit-cost ratio 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 5). The findings showed that the community based ponds recovering US$ 2.28 per USD 1 of investment and water logged paddy fields generate returns of USD 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 [7]. The benefit-cost ratio 1.82 proved catfish farms as viable enterprises in the study of Emokaro et al., [8]. 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. Earlier there were not much aquaculture practices in the waterlogged paddy lands and Das and Hossain, suggested that Government intervention could introduce aquaculture in these water logged paddy lands to improve farmers' livelihoods and food security [9]. 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.

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 [10]. Adrika et al., 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 [11]. 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, also had similar observation like the current study that production systems and livelihoods were in risk of being affected by climate change [12].

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., 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; and

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 [13]. 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, that climate change and coastal development are closely linked and cannot 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; and

6. Harmonization.

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

1) More care in handling fish, selective breeding and genetic improvements towards temperature tolerance can adapt to the problem of rise in temperature;

2) Regular monitoring can reduce the physiological stress on the farmed stock and thus can help in reducing farmed stock mortality;

3) Introduction of salt tolerant species mix; specially in the ponds of newly accreted lands;

4) 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;

5) 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; and

6) 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.

Conclusion

Although 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.

Acknowledgment

Authors would like to acknowledge Dr. Harvey Demaine and Mr. Kazi Giasuddin for providing valuable information regarding aquaculture farmers in the area, and Noakhali Science and Technology University for providing scopes and opportunities for research. Dr. Arne Eide is acknowledged since the first author has learned a lot from him to do research.

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