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Participatory Action Research on Climate Risk Management, Bangladesh

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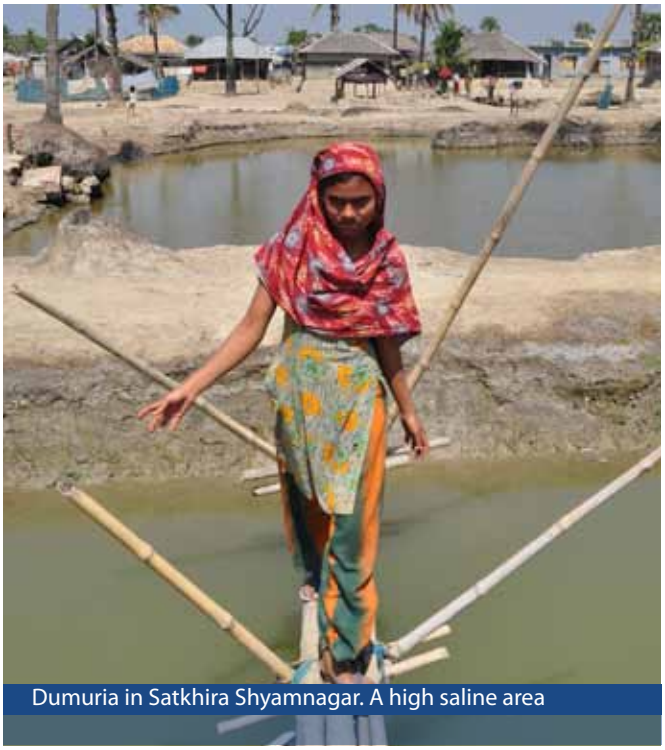

Dumuria in Satkhira Shyamnagar. A high saline area

Executive Summary

The rural populations of southern Bangladesh are some of the most vulnerable communities in the world to the future impacts of climate change. They are particularly at risk from floods, waterlogged soils, and increasing salinity of both land and water. The objective of this project was to analyze the vulnerability of people in four villages that are experiencing different levels of soil salinity. The study evaluated the strengths and weaknesses of current coping strategies and assessed the potential of an index-based insurance scheme, designed diversification and better information products to improve adaptive capacity.

Participatory research appraisal was carried out in rural communities with local stakeholders in the districts of Jhalokati, Bagerhat, Khulna and Satkhira. The village in Jhalokati is not yet affected by salinity, the village in Bagerhat is marginally affected, whereas the villages in Khulna and Satkhira are exposed to relatively high levels of salinity in both the soil and the water.

The methods used included risk prioritization matrices, semi-structured interviews and focus group discussions. The analyses were gender differentiated. The results allowed for an assessment of risks, exposure, adaptive capacity and the perceived needs of people in these communities. The study provides a baseline for future interventions and recommends activities for the CG's Climate Change, Agriculture and Food Security program for 2012 and beyond.

Jagannathpur village in Jhalokati is a non-saline area where the major production systems are rice paddies, vegetable gardens, livestock and poultry. The main risk identified by people in this village is flooding, followed by cyclones and storm 'surge', and seasonal dry spells, all of which have been increasing over the last ten to twenty years. The most important needs expressed by people were for better water management and the development of flood resistant and short-duration rice varieties.

Gabgachia village in Bagerhat is a medium saline area where people make a living from aquaculture and agriculture. Salinity has been progressively increasing, causing a decline in tree coverage and vegetable productivity, and it constitutes the main risk for people, affecting food production and health. Other risks expressed were floods and cyclones, which were reported to have become more frequent, unpredictable and severe. People identified their primary needs as strategies to improve food security, and access to freshwater.

Harikhali village in Khulna and Dumuria village in Satkhira are highly saline areas where shrimp farming is the main activity. Salinity was the dominant issue identified by people in these villages. Saline water intrusion, either directly or indirectly due to shrimp farming, affects soil conditions causing a reduction in agricultural productivity, and contaminates water supplies leading to a shortage of freshwater. Shrimp farming is therefore a source of conflict between large shrimp farmers and land owners with small or medium sized plots.

In Dumuria, located close to the Sundarbans, people have become much more dependent on resources extracted from the forest, risking attacks by tigers or local criminal gangs. Other risks reported include cyclones, heavy and irregular rain, and floods. People discussed changes taking place in the last ten to twenty years, including progressive increases in salinity, fewer freshwater fishes, less rice production, a perceived shift from six to three seasons each year, water level rises, increased temperature, and very erratic rainfall. To cope with these challenges they are seeking more consistent access to freshwater and greater diversity in their livelihoods, improved vegetable production and more variety, as well as the possibility of reducing the level of salinity.

Based on the results of the field visits, recommendations are presented to address the key concerns which vary depending on the level of soil salinity. In Jagannathpur village, Jhalokati district, where salinity is not an issue, the concerns to be addressed are related to the prevention and management of flood waters. Flood resistant rice and crops with short growing seasons are desired. In Gabgachia village, Bagerhat district, the moderately saline soils raises the need for both flood and saline resistant rice varieties, along with techniques for improving freshwater management for both drinking and vegetable cultivation.

In the two villages with high levels of salinity, Harikhali village, Khulna district and Dumuria village, Satkhira district, recommendations focus on possible methods to reduce the salt levels and/or on coping strategies that would serve to improve villagers' livelihoods. Saline intrusion onto the land will not cease until current management practices by large scale shrimp farmers changes. This is unlikely unless there is agreement between all parties, particularly the shrimp farmers and the government, that an alternative course of action is more beneficial. Strategies to reduce the impact of high soil salinity that can be employed and investigated further include the use of ring agriculture and/or hanging vegetables, the development of larger scale systems for rainwater harvesting and freshwater conservation, a study on the use of *Moringa oleifera* as an aid to water purification, the use of a greater variety of different horticultural techniques and a broad range of vegetables that allow production across the whole year, promotion of livelihood opportunities around fruit trees and palm trees, turmeric, and alternative livestock options such as Chinese ducks and pigeons.

The potential benefits from new or alternative insurance products and micro-credit arrangements need to be communicated both to the product suppliers and the consumers.

Four intervention programs have been analyzed, prioritized, and presented for consideration. Two programs are examples of designed diversification whereas the other two were analyzed to explore the impacts of different types of integrated farming systems. In decreasing order of priority the suggested interventions are: integrated paddy and prawn/freshwater shrimps/carp production followed by vegetable production, rainwater harvesting, and lastly, integrated shrimp and paddy production.

Women drawing a map of their village during PRA activities in Paikgacha

1. Introduction

The combination of low-lying deltaic geography, very high population density and extreme poverty make Bangladesh one of the world's most vulnerable countries to climate change. The current, and projected, impacts of climate change can be classified into three types:

(i) ***Changes in climate trends across spatial and temporal scales, including increased duration and intensity of monsoon rains in some areas, as well as increased irregularity of precipitation in others, alongside increasing average temperatures.*** In Bangladesh, the monsoon rains are estimated to intensify by 20 to 30 % due to climate change and the average maximum and minimum temperatures during the monsoon period to show a rise of 0.5°C and 0.3°C respectively per decade (MoEF, 2009).

(ii) *"Slow onset changes", for example sea level rise associated with the melting of polar* ***ice caps and Himalayan glaciers.*** The World Bank estimated sea level rises of 10 cm by 2020, 25 cm by 2050, and 100 cm by 2100 putting 2 %, 4 %, and 17.5 % respectively of the country's land mass below sea level (World Bank, 2000). The Intergovernmental Panel on Climate Change (IPCC) calculated sea level rise at 66 cm by 2100 under 'business as usual' conditions, with a range of uncertainty of 13 to 110 cm (Parry et al., 2007).

(iii) ***Hazard-related impacts, including increased frequency and intensity of cyclones and storms exacerbated by the above issues.*** In Bangladesh, peak cyclone intensity is projected to increase by 5 to 10 % because of climate change (MoEF, 2009).

Each of these issues has serious implications for rural populations and worsens existing vulnerability to flooding, waterlogging and salinity of land and water. The overlying project objective is to develop tools to improve monitoring and management of these changes through the development of a network of participatory pilot demonstrations, which will engage rural communities and other local stakeholders in four selected locations. The project sought to identify, develop and evaluate promising risk management interventions. A participatory action research approach was used to capture the risks, adaptive capacity, exposure and sensitivity of men and women, as well as to evaluate their interest in developing an adequate and efficient implementation plan. The implementation process and key partners were identified on the basis of results from a preliminary participatory rural appraisal (PRA) designed to identify the most suitable interventions.

The report presents a brief summary of the PRA methods used, followed by a section on the results of the information gathered. This includes an assessment of current risks, historical changes and exposure assessments for each village, together with an analysis of their current adaptive capacity. It continues with an evaluation of the suitability and community reaction to three proposed strategies—an index-based insurance scheme, designed diversification, and better information products. Based on this feedback, the most promising strategies to improve adaptive capacity were developed for each village. The report concludes with recommendations for future activities to enhance livelihood resilience.

2. Methodology

The information presented in this report is drawn from 137 formal interviews with male and female heads of households, supplemented with additional comments from another 137 family members, neighbors, and representatives of men's and women's groups. The participants were drawn from four villages located in southern districts of Bangladesh. The methodology followed is explained below.

2.1 Site selection

Four villages were selected, based on their different levels of vulnerability to salinity and natural disasters (Figure 1):

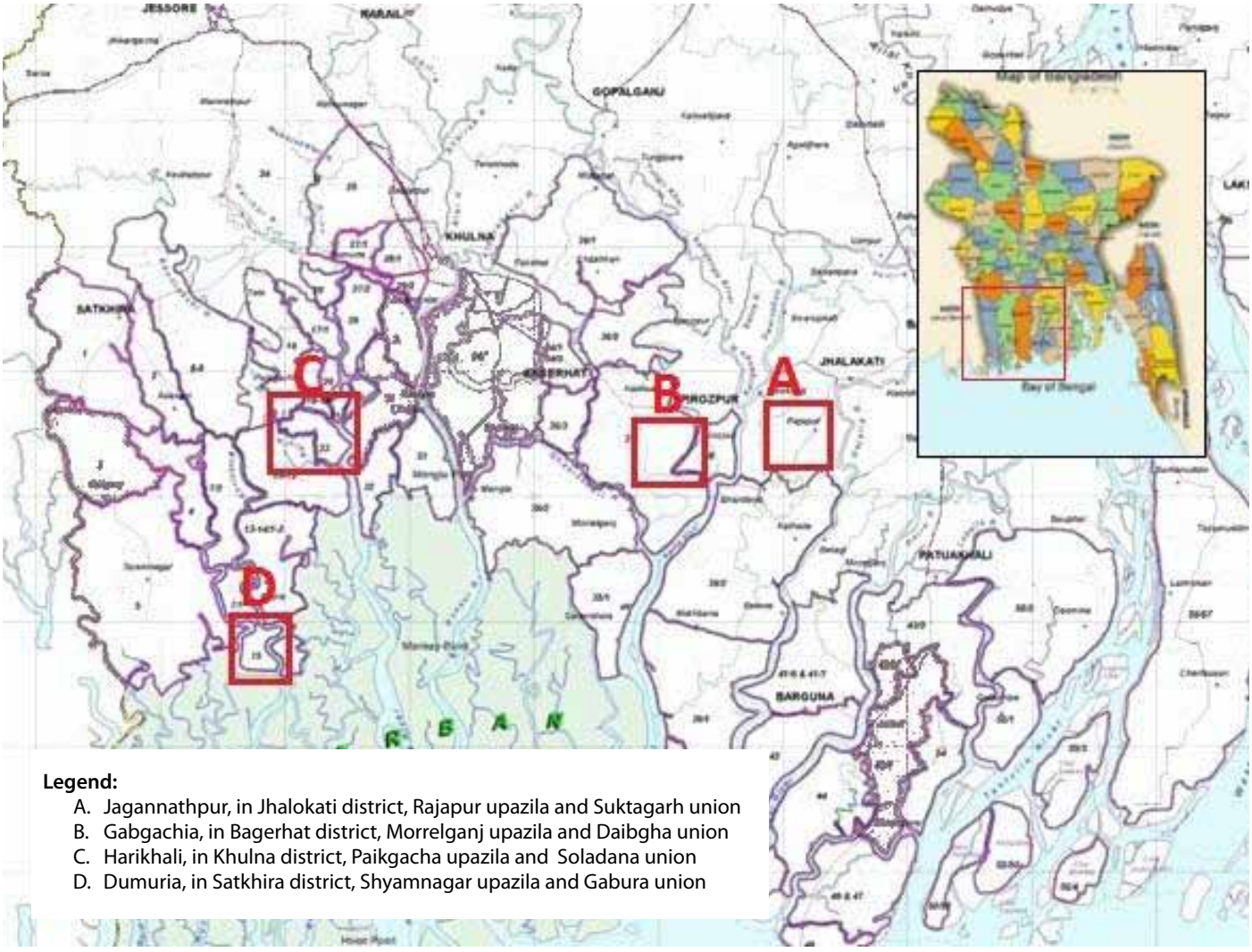

Figure 1. Map of the selected sites.

2.2 Participatory research activities

The research activities consisted of participatory rural appraisal (PRA), focus group discussions, semi-structured group and family interviews. They were designed to:

(i) Analyze the risk management process, from the identification by women and men in farming communities of the risks they are facing and the access they have to existing climate and weather information, to the risk management strategies they have developed and the constraints they face;

(ii) Capture the communities' perspectives on priority gaps and opportunities for improving management of climate-related risk by exploring with them the need for a more efficient climate risk management strategy and analyzing their self-identified options;

(iii) Gauge their interest in developing pre-selected strategies such as 'designed diversification', index-based financial risk transfer, and adaptive management in response to advance information.

Three well-established techniques were used.

2.3 Research techniques

Agricultural calendars: These calendars provide a visual representation of farming activities throughout the year. They can be used as a means of quantifying farmers' perceptions of environmental variability and risks across each month.

Risk prioritization matrices: The vulnerability of a community to climate change depends on an assessment of the risk and the adaptive capacity of the farmers. The magnitude of the risk factor is based on the severity and the frequency of each hazard. Once the climate events were identified, a risk prioritization matrix was used to understand the communities' perceptions of the severity and frequency of various types of hazards. The matrix was then prepared with the risks in rank order and adaptive capacity prioritized on the basis of the most important risks. The participants were asked to mark the severity and the frequency of each hazard, and scores were given by multiplying the marks for each one.

Semi-structured interviews: These were employed to (i) identify all the changes in agriculture and aquaculture practices developed by men and women in farming communities in the last 10 years; (ii) evaluate current accessible climate and weather information products and delivery mechanisms for smallholder

decision-making; (iii) identify gaps in existing information products and services, and determine the demands for new information and mechanisms for information delivery that could inform local decision-making.

A set of standard questions were prepared; however they were used flexibly to spark discussions in the following thematic areas:

On changes of practice:

- What changes of practice in agriculture or aquaculture have been observed by men and women in the last 5 to 10 years?
- What triggers farmers to develop new adaptation strategies and make changes to the usual agricultural calendar?
- Upon what experiences do they base their adaptations?
- How do farmers communicate and share information on agricultural innovations?

On climate information products:

- What are the ingredients/needs for good climate risk awareness?
- What tools and mechanisms do farmers currently access that help them predict climate events? Examples: early warning systems, weather forecasts?
- What are the gaps that need to be prioritized for an improved risk management strategy?

The semi-structured interviews were also used to propose new suggestions and explore the levels of interest, feasibility and possible constraints for implementing them.

2.4 Options raised for discussion

The options and strategies brought for consideration were mentioned only at the last stage of the participatory research in order not to influence the interviewees and to provide them the opportunity to express and develop their own ideas. Considering agriculture and aquaculture are two sectors with significant exposure to climate change, the assumption was that climate risk management should include three types of strategies:

1. Adaptation technologies and strategies, such as designed diversification of livelihoods and activities to decrease vulnerability to climate variability;
2. Development of policies, social safety nets and market-based interventions to transfer risks from the most vulnerable segment of the population;
3. Development and use of climate information products and knowledge in strategic planning to anticipate climate risks.

Based on these assumptions, the project aimed to assess peoples' interest in the following three strategies (CCAFS, 2011):

2.4.1 Designed diversification

One well-established risk management strategy is to reduce dependence on single income-generating activities or resources. Diversification of livelihood activities reduces overall risk as the second or third activity can compensate if the primary activity fares poorly. Similarly, diversification spreads the impact of human activities and eases pressure on the natural resource base. Where current livelihood portfolios appeared inconsistent with farmers' goals and risk tolerance, we sought to understand why and how constraints to improved livelihood diversification might be alleviated. For example, at the field level diversifying into cultivars with different phenologies or degrees of tolerance to environmental stress offers the potential to reduce production risk for a given crop. At the farm level, we considered how the mix of production enterprises influenced income and food security risk and balanced competing demands for limited resources. In many rural communities, non-farm income sources were an important component of livelihood strategies and were considered as well.

Diversifying rural economies at the community level might confer risk reduction benefits on individual households where existing community risk-sharing mechanisms are well developed. Considerable attention was devoted to developing and testing analytical tools to design and target improved livelihood diversification strategies. Work in this area provided a framework for evaluating proposed new agricultural enterprises and component technologies from the standpoint of household-level livelihood risk and resilience.

To be most efficient, diversification must take into account not only the resources used but also the yearly calendar of activities. The livelihood income streams must not be strongly correlated in time to ensure revenue generation all year round. Rural communities are generally quite good at adapting their livelihood strategies to their environments. However, research and well-informed outside interventions can add value where livelihood strategies are sub-optimal because: (a) an external change has been too rapid to adapt to through trial-and-error; (b) environmental, social or policy changes have undermined traditional livelihood strategies; or (c) emerging livelihood opportunities lack adequate technical support or market development (CCAFS, 2011).

2.4.2 Index-based financial risk transfer

Recent innovations have prompted a resurgence of interest in managing risk for smallholder agriculture through insurance. Index insurance is an adaptation of the traditional insurance system to cover agricultural losses due to meteorological risks. Payouts are based on independently verified departures from a pre-defined value of the index, for example, rainfall below a minimum level, temperature above a maximum level, or variation from a predetermined number of hours of sunshine. This system overcomes problems of moral hazard and asymmetry of information, a common problem if yields are used as the basis for triggering payments, and negates the need for farm visits to verify losses. By avoiding the main obstacles that make traditional crop insurance unfeasible in most of the developing world a new set of opportunities is created.

Index insurance does not protect against all risks; hence, it should be regarded as a strategic component of a multifaceted approach to managing risk, rather than a comprehensive solution to agricultural risk. Index insurance is one of a broad range of risk management strategies that may be used in climate adaptation and development efforts, and may complement new technologies, production inputs and alternative financial structures for access to credit. The question under research here is to assess how 'index-based financial risk transfer products' can be best targeted and implemented to reduce vulnerability to climate shocks and alleviate climate-related constraints to improving rural livelihoods.

Several steps are required before an index insurance scheme is implemented. The feasibility will be evaluated based on its suitability, demand, laws and policies, and the capacity and willingness of financial service providers. Any implementation must be preceded by institutional scoping and engagement on the financial services supply side, and engagement and empowerment of the rural communities on the demand side. Experience demonstrates the value of training to build capacity within the providers and to foster understanding and demand on the part of farmers. Implementation will involve participation of both providers and users in the design of insurance contracts. Pilot implementation will be a laboratory for research on index design, contract design, targeting, communication and impact (CCAFS, 2011).

2.4.3 Adaptive management in response to advance information

Interactions between the atmosphere and the oceans provide the basis for forecasting future climate conditions. Improved modeling, providing forecasts over different time frames would allow farmers to prepare more effectively. Over the longer term for example, changing crop varieties or farming techniques to adapt to climate change, over the medium term for optimizing planting and harvesting periods, and in the short term, implementing

adaptive strategies for sudden and unexpected weather changes or events.

Research with smallholder farmers in developing countries has shown that there is considerable interest in the use of weather information. However, it has also brought to light widespread communication failures, and a mismatch between smallholder farmers' needs and the scale, content, format and accuracy of available information products and services. This has limited the widespread use of seasonal forecasts. As an early warning system for cyclones has already been well developed in Bangladesh, constraints related to communication can be overcome relatively easily (CCAFS, 2011).

2.5 Participants, gender and equity

The impacts of climate change do not affect men and women equally. Hence the actual and perceived climate-related risks differ between genders. In light of this, the participatory research was designed to pay particular attention to understanding and overcoming gender and social inequities in the impacts of climate-related risk, particularly risk management interventions and the institutional and information services that support them. Gender differentiation was captured by conducting separate male and female group interviews, as well as family group interviews, for each participatory research activity. For the female groups, both the researcher and the translator were female. However, the availability of female participants varied considerably from one village to the next (Table 1). In Bagerhat for example, the total number of interviewees was reduced as several important markets took place during the research week. The numbers presented below only include the key participants, but as friends and neighbors joined the conversations the actual number present was double.

This research thus aimed to determine which combination of livelihood diversification, innovation and risk transfer offers the best prospects for building resilience and reducing long-term climate vulnerability in rural communities.

Table 1. Number of key participants from each village.

	Jhalokati	Bagerhat	Khulna	Satkhira	Total
Female participants	11	9	28	16	64
Male participants	23	12	21	17	73
Total	34	21	49	33	**137**

3. VULNERABILITY AND NEEDS ASSESSMENT

3.1 Jagannathpur village, Suktagarh union, Rajapur upazila, Jhalokati district

3.1.1 The study site and livelihood activities

The village of Jagannathpur is in the central south of Bangladesh, situated in the district of Jhalokati (Figure 1). Development has not occurred uniformly throughout the village. The southern part has paved roads and electricity, although not to all houses. The northern and eastern parts have only muddy roads and no electricity.

The villagers, predominantly Muslim, are engaged in a variety of livelihood activities. Approximately two thirds are involved in agricultural occupations and one third in the timber business, petty trade and money lending. Agriculture includes rice cultivation, vegetable crops, betel nut and coconut sales, livestock and poultry, and white fish farming. Since Jagannathpur is not affected by salinity, there is no shrimp farming. Livelihood activities are diversified across the year within each family to provide a monthly income all year round.

Paddy: Around eighty percent of the villagers grow rice, employing several different varieties: Aman, Aus, Boro IRRI and Boro BR 8 (BRRI rice 8, developed by the Bangladesh Rice Research Institute). Aman and Aus are local varieties; Boro is a winter rice, Boro IRRI being a high yielding variety (HYV) developed by the International Rice Research Institute (IRRI). Boro IRRI production per unit area is more than double that of Aus production and higher than Aman, but its cultivation is limited due to water crises and the fact that it requires more input and labor.

Aman is grown from May-June to November and harvested in December and January. One variety of Boro IRRI is grown from January to May and harvested in June, and another variety is grown from April to July, harvested in August and September. Aman production is around 400 kg/bigha and Boro IRRI production around 500 kg/bigha, hence one crop of each variety can result in production of 900-1000 kg of rice each year. This yield varies depending on the level of pest infection and the quantity of chemical inputs used. In the northern part of the village Aman is frequently damaged due to late and extended flooding in September through to October.

Families use two distinct systems to lease land from landowners:

- At a price of 7 000 to 8 000 BDT per year per bigha (1 bigha = 0.66 acres)
- By giving to the owner 400 kg of rice per bigha

A landless family rents, on average, 2 to 3 bigha of land.

Vegetable crops: Vegetables are cultivated year round but with higher yields in winter. Common examples include: dal, mosori, kashari, sesame seeds, water melon, rock melon, sweet gourds, sweet potatoes, tomatoes, bringels, cucumber, and cabbage. The men grow winter crops from October to February and summer crops from February to June. About 25 % of the crop is for family consumption and the remainder is sold.

A family in Jhalokhati who rear pigeons (see under the rooftop). A quite lucrative and not so common livelihood activity in the village

Livestock and aquaculture: In addition to the 70 % of villagers that keep poultry, 60 % of households have cows. They usually take a loan of 10,000 BDT to buy the cow and reimburse 300 BDT each week for 46 weeks. Some families have pigeons. Pigeons are easy to breed and do not need much input, except for residual food in July-August and October-November. A pair of pigeons can be sold for 120 BDT one month after hatching, and are consequently quite profitable. Around 2 to 3 % of the local population is involved in white fish farming and related activities.

Timber: The timber business is only possible during the dry season, so the wood cutters find alternative occupations during the rainy season. They usually work as day laborers or in agricultural work (land preparation and de-weeding from June to September), and on the maintenance of roads.

Gender patterns: Women work within the home for most of the time. They take care of the house, the children, and they cook the meals. In August and September women undertake specific activities such as stitching and embroidery to make warmer clothing (katha).They also grow vegetables within the homestead in winter. A few women own poultry and ducks but this is not common because it requires feeding outside the home and potentially exposes them to diseases. Almost all women are members of microcredit programs but face difficulties in repaying their loans.

The calendar: January and February are the best months of the year, because they come just after the harvesting period. After that, there is a quiet period from March to May when few employment options are available except for mud cutting, and it is a period when many people stay at home because of the risk of cyclones. April to June is the time to prepare seedbeds for Aman, Aus and some of the Boro crops, and to harvest the other Boro varieties, but the interviewees mentioned that many people are sick during this period after the first rainfalls of the year. Consequently, there is enough work, but the labor force is weak. July–August is a period of low income for most people, because of floods limiting their activities. From June to September/October fishing is popular, mainly for domestic consumption. October and November are quiet months again with few employment opportunities.

Food intake: Food is purchased mainly from the market. As a result, food is lacking when employment is limited. During the low period from March to May, people can still rely on the rice harvested and stored in December and January and they also have vegetables. October to November is more difficult, the Boro and Aus harvests are often limited due to water (either insufficient or excessive), and vegetables are not yet ready so people frequently have to go without breakfast during that period. Potatoes are the most popular vegetable as they are cheap to buy along with green papaya and cucumber during winter. Daal (boiled lentils) and meat are too expensive for the poorest families to obtain. Fish can be stocked and cultivated in ponds from June to October, and local fishes (small size) can be caught in open water bodies until January to be sold or consumed, although only in very small quantities.

Fuel and freshwater collection: During the rainy season women use small branches from trees, roots and bark for fuel. During the dry season, leaves and trees are used for the most part. Those who have cows can collect and store cow dung in holes in the ground. When dry it can be used as a fertilizer for plants and vegetables for five months of the year, and for burning for the remaining seven. There are a few tube wells providing clean fresh drinking water.

Table 2. Agricultural calendar, Jagannathpur village.

Activities	Gender distrib	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Rice crops													
Aman	M	harvest					seedbed		transpl.			mature	
climate impacts		rain: PI					floods				rain: no PI		rain: PI
Boro	M				seedbed	transpl		mature					
Boro	M	seedbed	transpl			harv	harv						
climate impacts							variation of water level						
Aus	M												
Vegetables													
Winter crops	M												
homestead vegetables	W					only bean (negligeable)							
Farming activities													
Fish (open water + ponds)	M												
Livestock	M&W			chicken pox						diarrhea			
Fodder collection	M&W	shortage						fodder crisis, use stored f.			fodder storage		shortage
Betel nuts	M		sell dry					planting	p	p, h	p, h	h	h, s
Labor													
Fishing	M												
Agricultural work	M	h						prep	plant	plant			h
Mud cutting	M												
Wood	M												
Petty trade	M												
Road maintainance	M												
Embroidery and stitching	W												
Fuel collection													
Leaves, branches, coconut, betel nut	M&W												
Cowdung cakes	W	preparation					use						
Wood													

3.1.2 Risk assessment

The IPCC defines risk as a function of the probability and consequences of an event. To measure risk, people were asked to evaluate the frequency and intensity of each hazard. However, this assessment is based on frequency and intensity at a certain point in time and does not necessarily capture the notion of long-term changes in frequency and intensity. The notion of changes over time is included in a later section.

During interviews, the frequency and intensity of four risk factors—cyclones and surge, rain, flood, and droughts—were assessed on a scale of 1 to 5 and the average figures from female and family groups combined to provide a guide to the relative level of risk each factor is perceived to hold.

Flooding, which occurs almost every year and may occur three to four times in a single year, was judged the factor offering the highest risk. Floods cause damage to the rice crop and loss of fish cultures from ponds. Aman crops are very sensitive to the quantity of water they receive. Rain in October and November kills parasites' eggs and reduces pest infection, but rain in late November or December destroys the rice flowers, and can be responsible for the loss of up to 65 % of the harvest. The other risks in decreasing order of importance were rain, cyclones and droughts.

Small cyclones are frequent, but less damaging than Sidr and Aila which hit the village in 2007 and 2009 respectively. Damage from Sidr was more visible as the strong winds destroyed everything, but damage caused by Aila was actually worse because the water stayed for a very long time and caused an increase in salinity. There are droughts almost every year, usually in March and April; they strike with variable intensity causing shortages of freshwater.

The calendar in Table 3 shows the impacts of climatic hazards on people's livelihood activities.

Table 3. Impacts of climate hazards on livelihood activities, Jagannathpur village.

Activities	Gender distrib	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Climate events													
Floods (frequency)							2	↗ 3	↗ 5	↗ 5	↗ 5	3	3
Heavy rains (f)		1						5	5	4	3	3	
Cyclones and surge (f)						5	↗ 5	5			↗ 3	↗ 3	
drought (f)				3	5	5	5	3	3	3			
Rice crops													
Aman	M	harvest					seedbed		transpl.			mature	
climate impacts		rain: PI					floods				rain: no PI		rain: PI
Boro	M				seedbed	transpl		mature					
Boro	M	seedbed	transpl			harv	harv						
climate impacts							variation of water level						
Aus	M												
Vegetables													
Winter crops	M												
homestead vegetables	W					only bean (negligeable)							
Farming activities													
Fish (open water + ponds)	M												
Livestock	M&W			chicken pox						diarrhea			
Fodder collection	M&W	shortage						fodder crisis, use stored f.			fodder storage		shortage
Betel nuts	M		sell dry					planting	p	p, h	p, h	h	h, s
Labor													
Fishing	M												
Agricultural work	M	h						prep	plant	plant			h
Mud cutting	M												
Wood	M												
Petty trade	M												
Road maintainance	M												
Embroidery and stitching	W												
Fuel collection													
Leaves, branches, coconut, betel nut	M&W												
Cowdung cakes	W	preparation					use						
Wood													
Problem faced													
Water Shortage													
Food scarcity											skip breakfast		
Human diseases						rain							
Pest infection													
Lack of work and income						sick		low income			no work		
Best period													
Fish + crops available													

Shrimp ghers in Dumuria (Satkhira, Shyamnagar). The village is located in high saline area, where vegetation and fresh water are rare

3.1.3 Identification of changes

Cyclones: Both men and women have noticed an increase in the intensity of cyclones, but they had different perceptions regarding the period when they occur. There are two cyclone periods each year, in October–November and May–June. Men were under the impression that the cyclones have been increasing in May–June; this is the period when they are preparing land for Aman. Women felt that the cyclones have been increasing in October–November; this is the time they usually work on maintenance of houses after the flood period. After discussion, they agreed that the major cyclones used to occur in May–June, but that this has progressively shifted to October–November.

Water: Observations on water were mixed. People had observed more rainfall than usual this year, but had not experienced any flooding or waterlogging, unlike previous years.

Temperature: Summer was hotter than usual this year, causing deflowering of betel nut trees. Cold days were irregular and foggy days more frequent.

Nutrition: Day by day, the nutritional quality of food has been deteriorating. People cite, as an example, the fact that they don't get the quality or quantity of milk that they received before.

General changes: House quality has been improved in the southern part of the village: larger sizes, raised platforms, roofs made of corrugated iron instead of golpatha and access to electricity. At the community level, the bamboo bridges have been replaced by concrete bridges; some of the muddy roads have been paved. Mobility and communication have been improved over the last few years.

3.1.4 Exposure and sensitivity

The perceptions of men and women on the vulnerability of their assets and activities varied considerably because of the gender division of labor. Vegetables and livestock, the main female activities, were mentioned by them as the most vulnerable, whereas ponds and winter crops are managed by men and are the most vulnerable assets and activities according to them.

3.1.5 Assessment of adaptive capacity and needs

The villagers currently adopt a variety of different strategies when faced with environmental challenges such as flooding, cyclones, and droughts. These are given in Table 4. The needs they expressed to help them overcome these challenges in the future are mostly related to infrastructure development. To combat rain and flooding the villagers need the old canals to be re-excavated and new sluice gates and embankments constructed. However, this does raise a conflict of interests in some cases as people have already built houses on these sites. Flood-resistant rice varieties are an option. They have been tested in the past but were eaten by fishes. The villagers would be better prepared for cyclones if there were more shelters and the roads were improved. Re-excavation of the canals would also be beneficial to overcome drought conditions as they could be used as a source of irrigation water.

A family in front of their raised house (mud plinth) in Paikgacha, high saline area of Satkhira district

Table 4. Existing strategies, Jagannathpur village.

	Current strategies
Floods/rains	**Livestock** • Cattle are moved to higher ground and fed with straw • Raised platforms used for cowsheds • Patrols to prevent livestock from being stolen • Poultry: kept inside houses when possible **Agriculture** • Buy and replant germinated seeds if first seeds have been flooded; only during the first month • Vegetables: maximum two replanting times • Planting vegetables and placing seedbeds on higher ground • Hard surfaces to dry rice **Fish** • Nets for normal flooding Housing and cooking • Elevated houses (plinths) • Cooking on elevated platforms General arrangements • Canals for drainage and irrigation • Bamboo bridges for accessibility • Men replace women to fetch water when it becomes too difficult • Elevated latrines to avoid spread of diseases
Cyclones	**Livestock** • Use of stored straw to feed cows • Move the animals to elevated platforms or land • Keep cattle in house when possible **Agriculture** • Hard surfaces to dry rice • Crops are not the priority, the priority is to save lives Fish • Fishing ponds protected with nets and barriers Housing and cooking • Houses built on higher ground • Fix additional pillars to the house to prevent it from collapsing • As a fuel for cooking, use dried leaves and cow dung; collected and used from October to December and dried from December to March **General arrangements** • There is no cyclone shelter within 2 to 3 km. Even if one was available there is no guarantee they would go; they might stay to protect their home
Droughts	**Agriculture** • Canals used for irrigation • If soil is too dry, supplementary water is given from jars; women go at night and men during the day; this needs to be done twice a day from March to May

3.1.6 Opportunities for improved adaptive capacity
Pre-selected strategies

Designed diversification: The interviewees in the village of Jagannathpur were interested in designed diversification, especially for the most difficult months of the year, October and November. Design diversification could be used to develop betel nut sales. The men would have two strategies:

- Buy during October with a loan (5000 pieces for 5000 BDT) and sell immediately for 6000 BDT.
- Buy in October and dry, then sell during February/March or July/August for 20 000 BDT.

If they take a 1000 BDT loan, they will have to reimburse 225 BDT per week for 46 weeks. Here the problem is the lack of flexibility in the credit system.

People are more interested in ring agriculture than hanging vegetables because they believe it can be done on a larger scale and would therefore be more profitable.

Index-based financial risk transfer: People are broadly interested in the concept but do not know how it would work. To what extent would they be reimbursed? What kind of assets would be covered? What kind of hazards would be taken into account? The more skeptical were ready to invest 1/20 of the maximum reimbursement they would get, the most generous 1/5, the majority 1/10.

Adaptive management in response to advance information: The early warning system for cyclones is quite impressive. Information is transmitted from TV, radio and the upazila disaster committee several days in advance, and relatives spread the word to those who have no TV. Nature also provides signals to those who recognize them: cattle make unusual noises and groups of birds start to fly off. These signs alert the men working in the field who may fail to receive the information early enough if the warning time is too short.

Although the early warning system for cyclones is good, there is no reliable forecast for less extreme events such as rains that lead to flooding. Some people do have local knowledge and can predict potential flooding events from weather signs such as large black clouds and south-easterly winds ten days after a new moon, but these are usually only very short term forecasts. Ideally, five days' advance notice would allow people to prepare dry food, store clean water, set up nets, and search for safer places for their livestock.

3.1.7 Strategies selected
The foremost needs expressed concern flooding: people are asking for more sluice gates, higher embankments, and flood resistant or short duration rice varieties. People also experience water shortages in March–April, as well as food scarcity and lack of work in October–November.

Designed diversification strategies could help improve the water and food shortage crisis through:

- More flexible loans and credits schemes
- New techniques for growing vegetables (hanging vegetables and ring agriculture)
- Water management technologies (water purifying and rainwater harvesting systems)
- Promotion of fruit trees
- Integrated farming systems

Weather information products and index-based insurance could help to reduce the risks related to flooding by providing early warnings and safety nets.

The villagers were lukewarm towards the idea of developing cooperatives or self help groups. They are not opposed to the concept but were a little bit reluctant because of their lack of knowledge about the mechanisms. The people living here would be interested in receiving training and external help to better understand the advantages and disadvantages, and means to ensure equity among the group.

3.2 Gabgachia village, Daibgha union, Morrelganj upazila, Bagerhat district

3.2.1 The study site and livelihood activities
Bagerhat district is located directly to the east of Khulna district in southern Bangladesh (Figure 1). Gabgachia village, which is predominantly Muslim, is easily accessible from Khulna, the third largest city in Bangladesh, in about an hour and a half to two hours. The village is located in a medium saline area and people make their living from a variety of livelihood activities that include farming rice, vegetables, fruits, fisheries, and livestock. Men work in agriculture, aquaculture, day labor and small businesses (grocery shops). Other NGOs (BRAC and Muslim Aid) have previously worked in the village. People complained that only the richest received benefits from these earlier interventions.

Shrimp culture: According to interviewees, people involved in shrimp farming represent 10 % of the village: 5 % are large landowners and 5 % work in the shrimp farms. The north-western part of the village has been transformed into ghers. Some small producers also grow shrimps because their ponds have been affected by higher salinity, but they would prefer to grow rice, which would also be beneficial for cattle, poultry and fuel collection. They don't think mono-cropping is "a good thing".

Prawn culture: Prawns are grown in the main pond until November (Table 5) when the mature individuals are sold. Non mature prawns are gender separated and grown in small ponds for a further year as there is competition for food between the sexes. Prawns can be sold at higher prices than shrimps but cost more to produce.

Farmers also grow white fish. The fry are added to ponds in May and June; the cycles are two to three years. The ghers are fed by rainwater from canals, but their poor condition often leads to water contamination.

Women rear livestock and chickens, engage in agricultural labor during the harvest season (November to January), and grow vegetables during the winter. They sell milk from February to June and get half a kilogram per day per cow. The cows graze freely from January-February to May, but have to be tethered during the harvest period in December-January to prevent them from damaging the crops. During the rainy season people usually have to buy agricultural residuals to feed them.

Vegetables: Vegetables are grown on the dikes of ghers over two different periods:

1. Winter vegetables (October-November to February): cauliflower, spinach, onion, tomato, cabbage.
2. Summer vegetables (August to November): cucumber, sweet gourd, bitter gourd.

A widow explained to us that she consumes half her produce and sells the other half to pay for the education of children.

Some people also grow turmeric from June to March. This crop does not need much labor or inputs and so is cheap to cultivate; the returns are four to five times higher than the investment. Further, turmeric is not affected by heavy rainfall and can survive immersion for up to 10 days; however cultivation is limited by the fact that it usually requires higher land. Following an initiative by BRAC, six or seven families from the village have started to grow maize for the fish food industry.

Dumuria in Satkhira Shyamnagar, a high saline area

Several people find work in the Chittagong garment industry in order to increase their standard of living and they frequently send money back home to their families.

Water and fuel: Women avoid the use of tube wells as the ground water is contaminated by iron. They prefer to use pond water purified through the sand filter installed by BRAC a few years ago and rainwater collection (at very small scale level) using jars during the rainy season.

For fuel, they use cow dung cakes during the post-rainy season as well as branches, trees and leaves collected in the homestead or from the neighborhood. This is not always sufficient and sometimes has to be supplemented with fuel purchased from the market.

3.2.2 Risk assessment

People prioritized their problems as: (1) salinity; (2) floods; (3) cyclones.

Salinity: One of their principal difficulties is that seedbed preparation in January for Boro IRRI rice is badly affected by salinity. Seven canals bring water to the village and the fields, but most of them are saline. Two of them have been enclosed with embankments and the infiltration of saline water has stopped. People would be willing to do the same with the other canals, with the help of a third party. Saline tolerant varieties (such as IRRI 47) have been tried but the salinity level was too high. Five years ago BRAC provided tube wells which are still being used to supply drinking water. Irrigation with tube well water has not been tried but the villagers thought that it could be an option.

The vegetables grown within homesteads are also being damaged by high levels of salinity. Some households are growing gourds and beans on raised platforms and this has been a success. They have also tried to grow vegetables in earthen pots but the pots are too small and they used saline soil so the results were poor and inconclusive.

Floods: Flooding is made worse by one canal that has silted up and needs to be re-excavated. There is a sluice gate but it is poorly managed by the Bangladesh Water Development Board (BWDB). During floods, the roads and some courtyards are regularly under water. Prawns and white fish escape and vegetable crops are lost. As the village is located in a natural depression it does not drain well and the land becomes waterlogged.

Cyclones: Cyclones affect the harvest of Boro rice and vegetables, destroy betel nut trees and palm trees. They are also responsible of the loss of white fish and prawns from fish farms.

Table 5. Agricultural calendar, Gabgachia village.

Activities	Gender distrib	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Seasons													
Before		Winter		Summer				Rainy		pre-winter 1		pre-winter 2	
Now		Winter			summer		Rainy					summ.	winter
Climate events													
Salinity													
Floods													
Heavy rains													
Cyclones and surge													
Rice crops													
Aman	M	h						sb prep	plant	plant		flower	mature
problems faced								heavy rain					
Boro	M			flow	mature	harvest						sb prep	plant
problems faced				salinity		cyclone							
Aus	M					plant	pl/fl	fl/mat	mat/har	harvest			
problems faced									rain				
Shrimps	M		pond pr	fries	fries	feeding			harvest	harvest			
problems faced									virus				
Prawns	M					pr+fries	feeding					harvest	
problems faced												cycl/flood	
White fish	M					fries	fries						
problems faced												cycl/flood	
gher vegetables (1)	M	harvest									plant	plant	
gher vegetables (2)	M								plant			harvest	
problems faced									rain			cycl/flood	flood
homestead fruits	W				flower						mature		
						mature							flower
fruit orchards	M	irrigat°	harvest							flow	fertilize	chemicals	
poultry and livestock	W			NB						NB			
problems faced				disease									
Cattle and milk selling		NB	NB/WF	wild feeding (WF)			extra food needed						
Milk selling			milk selling										
betel nuts	M	harvest			flowers to fruits						harvest		
palm fruit	MW		flower	collect juice 3x/day						ripe			
problems faced						cyclone							
sugar cane	MW											harvest	plant
problems faced		pest											
turmeric	W			harvest			plant	plant					
problems faced												floods	
fuel	MW				dry wood								
manure	MW			buy CwDg				buy CwDg					
Problem faced													
Pest infection													

Women showing us their fishing nets in Khulna Paikgacha

3.2.3 Identification of changes

Salinity: The perception, as reported by the majority of people, is that salinity is increasing in soil, water and air, causing the disappearance of trees and vegetables. Only trees and plants that are resistant to low levels of salinity can continue to grow: betel nuts, coconuts, mehagani, rain tree, sofeda fruit, palm, dates, and some mango trees. Betel nut and coconut trees do not grow where they used to in the past. Other varieties that have been tried, but failed, include the lychee, khatal, jackfruit and pineapple. People reported that they had better vegetable production in the past, and that the tree coverage is now considerably reduced. Some people attribute the raised levels of salinity to the increased connectivity of rivers. Sometimes there is a shortage of freshwater, a situation that did not occur previously.

Floods: Nowadays, due both to rain and the influence of the tide, the land floods three to four times a year; and as the water fails to drain away it sits and stagnates. The rains this year (2011) were particularly bad. Aman rice was delayed by one month because of the floods and they lost the whole harvest of homestead vegetables. They estimate rice production to be approximately 1mon/bigha instead of 20. Floods have always occurred but used to happen during the night and disappear by the next day. Now the duration and geographical extent have increased and the water remains for several days. This may be because the width and depth of canals have decreased due to the construction of polders and embankments, and because of the higher number of housing units.

Cyclones: Interviewees perceive an increase in the duration and severity of cyclones and thunderstorms, but a decrease in the mortality rate, attributed to better housing conditions and the presence of shelters. Cyclone awareness has increased, "now people even know the names of the cyclones!", and people understand the importance of investing in better housing units. Cyclone shelters have been built, and some schools have been strengthened to be used as shelters. Moreover, the development of a good early warning system now saves lives. Trust in early warning systems has increased since cyclone Sidr, and people are now less reluctant to go to the shelters.

Rain: The interviewees reported that, in their opinion, rain has become more intense, lasts for a longer period, and is more unpredictable. Ten to twenty years ago the rain used to be continuous, but shorter and smoother. The exceptional amount of rainfall this year had the advantage of decreasing salinity and improving the production of coconuts, while decreasing the productivity of rice and shrimps because of flooding of crops and ponds. One small producer said he lost 100,000 shrimps due to the rainfall. The women believe that the unexpectedly heavy rainfall contributed to the increase in the number of people who contracted fevers this year.

Temperature: The villagers recalled that people used to feel cold at some time of the year in the past, but this does not happen anymore and they have to use the fan all year round.

3.2.4 Exposure and sensitivity

A comparison of the six primary hazards (salinity, pests, flooding, waterlogging, cyclones temperature), and the risk to their assets is shown in Table 6. The perception of men and women regarding the impacts of these six hazards is almost the same. The hazard with the greatest impact is flooding; the second and third are waterlogging and cyclones (reversed for men and women), followed by salinity, temperature and pest infection.

The ten assets that are most exposed were ranked: winter vegetables, water, sugar cane, homestead vegetables, poultry, rice, cattle, fish, and betel nuts.

Table 6. Most vulnerable assets, Gabgachia village.

	Salinity		Pest infection		Floods		Water logging		Cyclones		Temperature		Total	Vulnerability rank
Frequency 1 < 5	5		5		4		3		2		4			
	W	M	W	M	W	M	W	M	W	M	W	M		
Vulnerability of activities and assets														
Aman	3		3		4		4		3		0		**64**	**8**
IRRI / Boro	5		4		5		5		5		-3		**78**	**6**
Shrimps	-4		5		3		2		2		2		**35**	**17**
Prawns	2		2		3		2		3		2		**52**	**12**
White fish	4		1		5		2		4		2		**62**	**9**
Cattle	3		2		3		4		3		3		**67**	**7**
Poultry	0		5		5		4		3		4		**79**	**5**
winter veg	5		2		5		5		5		3		**92**	**1**
home veg	3		3		5		4		5		2		**80**	**4**
betel nut	5		0		3		0		4		4		**61**	**10**
coconut	2		2		1		0		1		2		**34**	**18**
palm	0		2		0		0		0		3		**22**	**20**
sugar cane	4		4		5		3		0.5		4		**86**	**3**
Labor	0		0		4		5		4		2		**47**	**14**
Cooking fuel	4	0	0		5		4		0		0		**42**	**16**
Water	5		0		5		5		5		5		**90**	**2**
Health	4	2	0		4	2	4	3	2		3		**53.5**	**11**
Education	2		0		4	2	4	2	3	2	3		**48**	**13**
Houses	3		0		4	3	3	3	4		0		**46**	**15**
Communication	0		0		4	2	3	2	2	4	0		**25.5**	**19**
total	50	44	35		77	70	63	59	58.5	59.5	41			
rank W	**4**		**6**		**1**		**2**		**3**		**5**			
rank M	**4**		**6**		**1**		**3**		**2**		**5**			

Notes for table: With reference to the column 'cyclones', for the section from shrimps to poultry, the marks include cyclone and storm surge and must therefore be decreased for cases when cyclone is not accompanied by surge. Some hazrads may have a negative effect in the short term but positive effects in the long term. in those cases, an average mark has been used:

- For sugar cane, the mark is 5 during cyclone but -4 after for an average of 0.5.
- For cooking fuel, the mark is 5 during cyclone and -5 after (because people can use parts of collapsed houses for fuel).

3.2.5 Assessment of adaptive capacity and needs

Salinity: People believe that the best strategy to reduce the level of soil salinity is through re-excavation of the seven canals. The canals are currently poorly connected to two rivers: Doratana which is less saline, and Kocha which is non saline. The re-excavation of the canals and improved connections to the rivers would thus increase the inflow of freshwater. However, they do not want to take any action by themselves because of time constraints and cost. They are expecting a "food for work programme" from a third party.

Concerning land use, the interviewees expressed their wish to go for saline tolerant rice instead of shrimps, because they do not believe shrimp farming can be a sustainable option. They expressed a need for tractors to enhance the mixing the different soil layers before planting, and to break the saline layer.

Floods: The usual response to floods is to move to more elevated houses and platforms. Floods can last for a week or a month. If the floods persist people suffer from hunger. This is because there is no mechanism for storing dry food. During 2011 there were two flooding events and villagers had no opportunities for work, and therefore no income to buy food. In order to survive the only option was to miss one meal each day. Women suffer disproportionately from this strategy as they tend to save food for their husbands and children. Standing water also leads to contamination of the drinking water supply which results in an increase in gastro-intestinal infections (usually characterized by diarrhea) and skin diseases.

The farmers try to prevent their fish escaping during floods by protecting their ghers with nets. Vegetables are grown on higher land when possible, but they often lose the harvest. They would only be interested in ring agriculture if the rings were provided to them.

Cyclones: When a cyclone hits, the poorest people take shelter in their neighbors' houses. One female respondent lives in a house

made of banana leaves and has to evacuate to her neighbor's house for shelter during each cyclone. Her house is destroyed each time but she does not have the resources to rebuild with different materials.

Water scarcity: Access to freshwater is irregular. Salinity is a permanent problem affecting the water supply, but both too much rain (flooding) and too little rain (drought conditions) occur regularly to disrupt supplies. The women stated their need for larger reservoirs for rainwater collection. The men, however, are reluctant to invest in this infrastructure and believe that collecting groundwater is a better option. At the present time people are using a pond-sand filter. Some use plastic sheets to collect rainwater but they are costly and frequently stolen. The need for irrigation facilities in the dry season was expressed.

Houses: Housing units are built on raised platforms to stay clear of flood waters. They are surrounded by canals to prevent the animals from escaping and to help water drainage. However, people are experiencing saline water floods six months of the year. This did not happen in the past. These canals often have increased salinity which negatively affects homestead vegetable production. When asked why they were still keeping the canals despite the salinity, respondents explained that digging the canals allows the raising of platforms for houses, and ensures that plants have sufficient water when needed. They can also store rainwater for a while, so it is "better than nothing". They believe that the canals should be re-excavated and embankments should be built but they are not willing to take the first step; they would like the government or a third party to act.

Some houses are built so that their courtyards have sunlight throughout the day. Courtyards are used for several purposes including post harvest processing of paddy, e.g., sun drying. To ensure daylong sunlight, trees are planted only along the north-west and south-west aspects of the homestead boundary, providing maximum protection from cyclonic winds that blow from the north-west during May and June.

Integrated pest management
Some farmers have received training on integrated pest management (IPM). They use some of the IPM techniques on a small scale for Aman rice. For Boro (local) and Boro IRRI, they do not believe in IPM.

Conservation techniques: The women shared that due to lack of conservation techniques, not enough food is stored for times of crisis.

3.2.6 Opportunities for improved adaptive capacity

Suggested strategies
Designed diversification: The interviewees were interested in diversifying their livelihoods. Ring and hanging vegetables can be developed to improve nutritional status. Fruits and culture of turmeric can be added for supplementary income. Palm fruit is complementary to other strategies as it is very profitable, but only for a few months of the year (February to April).

Index-based financial risk transfer: Interviewees are interested in the idea of index-based insurance; however they don't fully understand how it works and what it includes in reality. They would be prepared to pay up to 10 % of the losses covered as the premium.

Adaptive management in response to advance information: Forecasts and early warning systems are good for cyclones but could be improved for rains and floods. Seven days would be the ideal advance warning period to give enough time to prepare for the hazard.

3.2.7 Strategies selected
The main risks highlighted were related to floods, cyclones, and waterlogging while the most exposed assets were winter vegetables, water, sugar cane, homestead vegetables, poultry, rice, cattle, fish, and betel nuts (Table 6). To address these risks, the following strategies have been selected.

Water management: The main problem for drinking water is from flooding, which prevents people from using the pond sand filter and forces them to drink flood water. Consequently, a system to purify water such as the use of *Moringa oleifera*, and rainwater harvesting systems would be of great interest and benefit.

Flood and saline resistant rice varieties: For floods and salinity adaptation strategies, people expressed great interest in flood and saline resistant rice varieties, putting it high on their adaptation priority list.

Female entrepreneurship: Women strongly expressed their willingness to develop female entrepreneurship and they have a desire to create small businesses. To do so, they would like a third party to help them to start. They want individual businesses but are not willing to take the risk to invest in them.

They mentioned the creation of nurseries to grow different kinds of trees, from fruit trees to timber for furniture. One of the poorest women of the village told us she has a small piece of land which she dreams of developing as a nursery. She identified the different steps needed: (i) elevate the land to prevent floods, (ii) buy seeds and earthen pots, after which she believes she can become independent.

A respondent named Asma mentioned her willingness to start a chicken farm. Her neighbor is already involved in this business with the help of a business man. He gives her chickens and food, she takes care of them until they grow bigger and then she sells them for a higher price. She just has to reimburse the initial cost to the businessman and can keep the profits for herself. He also pays for medicine in cases of pest infection. Her only risk is that if a chicken dies, she has to pay for it.

The possibility of creating cooperative female groups to develop similar businesses was discussed but met with a generally negative response. The women believed that personal interests were too predominant and this would make it impossible to achieve common goals. Some women were strongly resistant to the idea of new initiatives because of the perceived risk. Lack of money to initiate new strategies was also cited as a reason. However, they would be more motivated if a third party would be prepared to start a scheme for them. They referred to the initiative by BRAC that led to the pond sand filter which they are still using regularly.

Training: People mentioned that they would be interested in receiving training on: (1) fish, (2) chicken farming and pest management, and (3) rice.

Freshwater shrimps: This is another possible option, but it is not the highest priority.

3.3 Harikhali village, Soladana union, Paikgacha upazila, Khulna district

3.3.1 The study site and livelihood activities
Harikhali village is located about two and a half hours drive south-west of the city of Khulna (Figure 1). Frequent floods often make road conditions extremely poor. There are equal numbers of Hindus and Muslims living here. Men and women promote gender empowerment, attributing it to good education and awareness. For men the main income generating activities are leasing land, shrimp farming, small trading, day labor (mainly in large shrimp farms), and sometimes migration to urban centers for four to five months to find alternative jobs (e.g., in the rickshaw, brickfields, or garment industries). For women the main

jobs, in addition to household activities, are dike repairing and jobs related to shrimp farming; the women also work for road contractors.

Shrimp farming is a major activity in the village. Except for a few large local landlords, 80 % to 90 % of the large gher owners are 'outsiders' who have migrated here for the shrimp industry. A third of the landholders with small and medium-sized plots have leased their land (willingly or forcefully) to these outsiders for the last two to three decades, through renewable contracts of 3 to 7 years. For at least the last 10 to 15 years, villagers have been facing the progressive disappearance of vegetation because of increased salinity in the soil and water. This degradation has caused increasing food scarcity and has convinced more and more owners of these small and medium-sized plots to reclaim their land in order to stop the ingress of saline water and try to grow rice again. This is creating a conflict of interests with the shrimp farmers.

Livelihoods and income generating activities vary throughout the year (Table 7). Nearly half of the families in this village do not own land suitable for cultivation; in reality some families have even built their houses on government owned khas land. In the remaining paddies, people grow BR 19, BR 23, BR 30, BR 47 rice and, on a limited scale, a local variety called Ashfal. Productivity is around 10 mon/bigha (i.e. 30 mon/acre) whereas standard production is from 20 to 30 mon/bigha. Some people also catch wild fish and fry, such as khorsula fry in October, Paisa (fish) in November and December, Bagda fry from March to May and Golda fry from June to August. They can catch 20 to 100 fry twice a day during low tide.

Today, water and food scarcity are both important issues for the village. The groundwater is affected by iron and arsenic, and surface water is saline. The women collect rainwater during the rainy season through small-scale harvesting systems, and a tube well system during the dry season. The poorer section of the village experiences hunger mostly in September and October when there are no job opportunities and no food production. According to a BCAS baseline survey in this village, 58 % of the population experiences hunger during some part of the year (BCAS, 2011).

Jagannathpur is located in a non saline area

Table 7. Agricultural calendar for Harikhali village.

Activities	Gender distribution	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Fish-related activities													
Preparating + cleaning farms	W												
Entering saline water	M												
Bagda (shrimps) fries	M												
Feeding shrimps	W20, M80												
Shrimps catching	W40, M60												
Selling to brokers	M												
Prawns + white fishes	M												
Catching + selling p.+w.f.	M												
Crop-related activities													
Cleaning and preparing land (barricades) : now	W30 M70												
Before													
Spreading fertilizer	M												
Spreading seeds: now	M												
Spreading seeds: before	M												
Transplantation	M												
Cleaning land (removing weed) + spreading fertilizer	W												
Cutting paddies	M												
Non rice crops													
Vegetables in rings													
Vegetables in soil: now	W80 M20												
Vegetables in soil: before													
Livestock-related activities													
Harvesting and storage of agricultural residuals	M & W												
Preparation of cowdung cakes	W												
Fodder availability	M & W	Minimum availability				der water. Use of agr. resid				Maximum availability			
Other													
Fuelwood			esidual from harves			stored cowdung cak			casionnally b		trees, leaves		
Best time of the year		ice and fish available											
Hunger period													
Migration period													
Brick field work	M & W												

3.3.2 Risk assessment

Cyclones: The village is prone to regular cyclones of variable intensity. In 2007, cyclone Aila had dramatic consequences causing the destruction of houses, loss of crops and livestock, and long-term flooding. people view it as an exceptionally strong cyclone, but they face smaller cyclones and storm surges almost every year. Sidr, although considered a national disaster, was not very harmful in this area.

Floods: Floods in Harikhali occur 2 to 5 times a year, for 2 to 7 days, and cause severe problems in mobility and livelihood earning activities. The localized, short duration floods are often caused by excessive rainwater trapped behind dikes synchronized with cyclonic surges or high tides.

Salinity: Increased salinity in Harikhali is caused both by the overtopping of polders during high tides or storm surges, and by the management of sluice gates in favor of shrimp farmers to allow more saline water to enter their farms.

The interviewees (disaggregated by gender and family groups) ranked these risks based on marks given for the frequency and severity of the impacts. Risk perceptions are influenced by the adaptive capacity of the family, their poverty status and their level of exposure to the activities.

The highest perceived risk is from salinity, followed by rain and floods. These are progressive or recurrent phenomena for which the consequences are less violent than a large cyclone but have a considerable impact on daily life. The more destructive cyclones do not happen every year and to be caught by one is considered more as bad luck than as a normal recurrent event, which explains the fourth position. Droughts and elevated temperatures are not very common and have limited impact.

3.3.3 Identification of changes

In order to evaluate the villagers' vulnerability to climate change, the concept of change over time was included. Changes of all kind were identified with the groups of men, women, and families (Table 8).

Table 8. Observed changes in Harikhali village.

Switch from six to three seasons	There has been a change in the usual pattern of seasons. The previous six seasons a year has become only three: winter, summer and the rainy season.
Increase in water level in the river	The water level of the Shipsha river has been increasing yearly by about 1 foot (30 cm) bringing it almost to the same level as the top of the embankment; people fear that the water will breach the top next year if nothing is done.
Decrease of freshwater fishes	The quantity of freshwater fish caught is decreasing; this is attributed to salinization and climate change, and partly to poor catching techniques causing the loss of too many juveniles.
Decrease of rice production	People have noticed an overall decrease in rice yields, even though the cropping period remains the same. They attribute this to saline water, excessive rain, freshwater shortages and decrease in soil fertility.
Increase of temperature	Higher temperatures, especially in the summer and rainy seasons, are believed to be responsible for an increased spread of shrimp disease.
Irregular rains	Rain has been less regular for the last three years. People complain that they are not able to predict when rain is coming.
Increase of salinity	Salinity is increasing in soil and water, in severity and duration. In canals and ponds, people are experiencing loss of tilapia. Vegetation cover is decreasing, such as the number of date trees. Occupations based on the dates, such as extracting juice or syrup to make sweets, have been lost. Buildings are collapsing as salinity is attacking the plaster. Freshwater is becoming scarcer, there are increasing health problems due to salinity, and a greater distance to walk to fetch freshwater.

People are convinced that solving the salinity problem will reduce all of their problems. As one villager put it: "*Water has become a poison. Before, the farms were successful and we could sell the excess products. Since ten years ago, we have become dependent on buying due to the salinity.*"

When asked about the degree of severity of the salinity problem, people compared the current situation to how things would be without the salinity problem. Examples of their perceptions included:

- If there was no salinity, the family could have agricultural crops, which would allow them to collect agricultural residuals to use for fuel.
- With food from agricultural crops, children would have a better nutritional intake.
- If there was no salinity, the family could keep goats and cows, sell some in times of need and save money for education.

The calendar overleaf (Table 9) shows the timing of weather related events through the year, and the perceived change of seasons over time. The data for cyclones is difficult to analyze as some people took into consideration small annual events, which are frequent and not severe, while others only considered serious cyclones such as Sidr and Aila, which are much more damaging but less frequent. As a cyclone of this magnitude has not occurred in the last two years, people considered that the situation is getting better, as shown in the table.

Table 9. Climate change trends over the years, Harikhali village.

	Hazards	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Seasons													
Now (3)		winter	summer				rainy season					winter	
Before (6)		winter	spring		summer		rainy season		autumn		late autumn		winter
2011 Numbers indicating risk	Rain	0	0	0	0	2	5	5	4	3	0	0	0
	Floods	0	0	0	0	0	3	3	2	1	0	0	0
	Cyclones	0	0	0	0	3	3	0	2	3	0	0	0
	Surge	0	0	0	0	0	3	3	4	4	3	0	0
	Drought	2	2	3	3	0	0	0	0	0	0	0	0
	Salinity	0	2	4	5	5	4	2	2	1	0	0	0
	Temperature	0	0	4	5	4	2	2	2	3	0	0	0
Direction of the trend	Rain					↑	↑	↑	↑	↑			
	Floods						↑	↑	↑	↑			
	Cyclones					↓	↓		↓	↓			
	Surge						↓	↓	↓	↓			
	Drought		↑	↑	↑								
	Salinity			↑	↑	↑	↑	↑	↑				
	Temperature			↑	↑	↑	↑	↑	↑				

Note: The numbers shown indicate the degree of risk the environmental condition presents at that time of the year from 0 as no risk to 5, the most significant risk. The second half of the table shows peoples' perceptions of long-term changes observed for each condition.

3.3.4 Exposure and sensitivity

The various livelihood activities and assets each have different degrees of risk exposure to significant changes in climatic conditions. As a result of the gender-differentiated division of labor, women and men do not have the same sensitivity to climate change. The perceptions of men and women about the exposure or vulnerability of assets and activities was collected during the PRA activities. Exposure alone is difficult to assess because people usually take into account the adaptation strategies available and their own sensitivity when ranking assets and activities, leading to an assessment of vulnerability more than an assessment of exposure.

The most vulnerable assets and activities identified by men and women are rice crops, vegetables, ghers and livestock, and houses.

3.3.5 Assessment of adaptive capacity and needs

As in the previous example, villagers adopt a variety of strategies when faced with environmental challenges (Table 10). The four conditions causing the greatest risk are (i) increasing salinity, (ii) rain and floods, (iii) cyclones, and (iv) drought. They expressed their needs as follows.

To combat increasing salinity there should be an end to shrimp farming, improved access to freshwater through water filters and rainwater collection systems, further trials on saline tolerant rice varieties, training, and new strategies for their livestock. To meet the challenges posed by rain and flooding the villagers suggested better drainage and more elevated roads, and the use of flood resistant rice varieties, though this was less important than saline tolerant varieties. More cyclone shelters with cooking facilities and separate toilets, and reconstruction of embankments would lessen the impact of cyclones.

Table 10. Strategies to combat environmental hazards, Harikhali village

	Current adaptation strategies
Salinity	• Reduction in use of income for food, especially for women • Migration to cities, 2-6 months/year (for both men and women) • Trials of rice varieties claiming to be saline tolerant (currently unsuccessful) • Replacement of organic fertilizer by chemicals • Rainwater collection at small scale level (but regular use of saline water as well, which leads to skin diseases and hair loss)
Floods, heavy rain, waterlogging	• Take shelter in more resistant infrastructure (school, concrete houses, cyclone shelters) • Sometimes receive early warning for heavy rain, but not frequently • Secure their assets by moving them to higher ground • Secure cows by taking them onto elevated embankments (done by older men) • Women cook, take care of children and secure assets simultaneously • Add 4-foot plinths on each house
Cyclones	• Early warning systems (radio, local chairmen, mosque leaders) • Consumption of dry food during cyclones • There is one cyclone shelter and one disaster management committee for ten • villages, created by Caritas and the government. Caritas have also trained people in disaster management.
Droughts	• "Hand fan" to refresh children • Staying inside the house

3.3.6 Opportunities for improved adaptive capacity

Pre-selected strategies
Designed diversification: As in the village of Jagannathpur, the interviewees were interested in the idea of designed diversification, especially for fuel generating activities from August to November when they usually have to purchase fuel, and for food and income generating activities in October and November. These are the two most difficult months of the year due to lack of work and food. To cover the hunger period (October—November), they suggested developing better food drying and conservation methods. A CCAFS baseline survey carried out by BCAS concluded that livelihood diversification is currently limited in Harikhali (BCAS, 2011).

Index-based financial risk transfer: The interviewees were not interested in index based insurance at all. They did not trust any insurance system, and did not have any initial investment capacity.

Adaptive management in response to advance information: The early warning system for cyclones is working really well, and the interviewees did not see any possible improvement. The alert is broadcast via TV, radio, and also by the local union parishad and mosque leaders moving around with loudspeakers. There is no gender inequality in access to information. When women get the news there is no social barrier preventing them from going to cyclone shelters by themselves if their husband is not at home.

However, having a better weather forecasting system for potential flooding events would be beneficial. It would allow them to prepare their crops and livestock accordingly. However they have little faith that a forecasting system for heavy rain is possible and therefore do not give the strategy much credit.

Initially, the highest priority needs declared by the interviewees were for an improvement in access to freshwater and the development of alternative activities to decrease their vulnerability. After discussing a wide variety of strategies, the men and women prioritized their needs as shown in Table 11.

Table 11. Prioritization of needs, Harikhali village.

Needs	Priority
Freshwater collection, saline water filtration	1
Designed diversification (especially for October and November)	1
Reinforcement of embankments, mangrove plantation	2
More cyclone shelters	3
Promote and return to organic fertilizers	4
Adaptive strategies for livestock feeding	5
Training (capacity building) in the use of new varieties and techniques in agriculture, aquaculture and livestock farming	6
Weather information products	6
Index-based insurance	Little interest

3.3.7 Strategies selected

Freshwater shrimps: The cultivation of shrimps in saline water is responsible for the progressive saline contamination of the surrounding environment, endangering traditional livelihood activities. However, the activity remains much more popular than prawn culture in freshwater because of the competitive advantages of shrimps over prawns: higher selling price, shorter maturation period, better survival rate, less inputs and less labor required. Although shrimps are more sensitive to viruses than prawns, they remain more profitable.

WorldFish is currently carrying out trials on shrimp and prawns at different levels of salinity through the Ghers Project. Developing freshwater shrimps would encourage shrimp farmers not to bring saline water into their ghers.

Water management technologies: Different technologies can be developed to improve access to freshwater, from rainwater harvesting systems to water purifying systems. The tree *Moringa oleifera*, also known as drumstick in English or sajna in Bangla is common in the southern districts of Bangladesh. Its crushed seeds contain a high-capacity flocculating agent that might be used for water purification; further research on this subject would be beneficial.

Designed diversification: Designed diversification in Harikhali can include several different strategies.

Promoting vegetables in October-November
Greater diversity and higher productivity in vegetable production can be achieved in Harikhali village, and the wider Paikgacha upazila, by combining different techniques such as traditional seedbeds, hanging vegetables and agriculture in rings, and using different varieties of vegetables. Each technique is has its own advantages, and when used in conjunction could increase both food production and diversity throughout the year.

Promoting the use of fruit trees
Four types of palm tree are readily available in the region: date palms (*Phoenix sylvestris*), coconuts (*Cocos nucifera*), betel nut (*Areca catechu*) and one just called palm tree (*Borassus flabellifer*). All four species have economic value. People noted palm trees and betel nut trees as being particularly profitable. Betel nuts are harvested from September-October to December and can be sold either at that time to cover the most difficult months, or at a higher price in February and March after being dried. Palm juice can be collected from March to May and sold at a very high price. These two activities are still under-exploited in Harikhali and could be developed, although it is important to keep in mind that the exploitation of this resource must be done in a sustainable way and with a long-term perspective.

More flexible loans and credit: Almost all the households are members of microcredit programs, which all operate in the same way: people have to pay back in 46 weeks, starting the week after taking the loan. The duration period for pay back is not flexible. Providing flexibility, for example either starting reimbursement later or reimbursing the whole loan at one time, would help people to invest in other livelihood activities.

3.4 Dumuria village, Gabura union, Shyamnagar upazila, Satkhira district

3.4.1The study site and livelihood activities

Dumuria village (not to be confused with Dumuria upazila in Khulna district), is located in an island of Gabura union. It is separated from the mainland by the Khel Patua river and is accessible by boat (10 minutes) from the nearest rural growth center, Nil Dumur. Nil Dumur is about 10 minutes drive from Munshiganj by motorbike. The Sundarbans start on the other side of the Khel Patua river that separates Gabura union from Nil Dumur (Figure 1).

Gabura union, which comprises six villages, is home to roughly 6 000 families. About 113 of these families live in Dumuria village which covers an estimated area of 2 km^2. This village is less densely populated than the national average. The majority of the population is Muslim. Two NGOs (GGS and CCDB) are currently working on house building and road construction in the village.

Similar to Harikhali, the soil in the village of Dumuria is highly saline. About 80 % to 100 % percent of the villagers depend on resources from Sundarbans for their livelihood. Although they collect various timber and non-timber forest products, their livelihood is centered on catching fish in the bays, rivers and canals.

Fishing: In 80 % of the families, at least one member regularly visits Sundarbans and its adjoining bays to catch fish and crab. Fishing occurs year-round, with increased activity from December to March and a quieter period from September to December. Only three persons per boat can travel at one time. Mostly country boats (small paddle boats of various designs) or boats with engines are used. Each boat is equipped with fishing gear, nets, food, water, essential medicines and an ice box. Before going into the Sundarbans the fisherman are supposed to pay a fee to the local forest department office for a 3 to 14 day entry permit. However, only about half of the people actually ask for this permission and they usually stay for a longer period than technically allowed.

Extraction of non-timber forest products: In addition to fishing, villagers collect honey, wax, fuel wood, and other non-timber forest products such as golpatha (used as roofing material). Their dependency on the forest is highest during the winter (December to March) and lowest during the post-rainy season (September to December).

Villagers form 9-member groups and enter the forest during April-May to collect the honey and wax. They may spend up to a month inside the forest; a trader provides an advance of around 90 thousand BDT to support their families during their absence. They collect honey in plastic drums and get 6 to 7 thousand BDT from the trader for every mon (40 kg) of honey collected. The golpatha extractors also obtain advance money from golpatha traders and work for a month inside the forest.

Timber: Unlike fish, honey or golpatha collection, there is a ban on the extraction of timber from the Sundarbans. Those entering usually pay 6000 BDT per boat for six days to get permission to collect fish and crabs, but then cut wood illegally. Despite people continuing to cut wood, interviewees did mention noticing an increase in some varieties since the ban has been established. They usually stay for up to two months, in January and February. They tend to use big country boats which have the capacity to stockpile 600-700 mon of Goran trees, and can fill the boat twice during that period of time. These people work as paid laborers for influential timber merchants who 'manage' the forest department when a worker is caught by the forest guards.

Livestock and poultry: People do not have cows. Some of them have chickens, goats and Chinese ducks. Chinese ducks are the only ones which don't eat fish fry, only algae, and thus are allowed to forage in ghers without being killed by the gher owners.

Shrimp and fish: As agriculture is very difficult due to the excessive salinity in the soil and water, people who own land have gradually switched to shrimp farming in the dry season. Shrimp farming is the second most important activity after resource collection in Sundarbans. The large gher owners (farm size 30 bigha or above) usually carry out commercial shrimp culture throughout the year. They prepare their ghers in December and January and grow shrimps and white fish from February to May. Harvesting begins in April. Every month they release new fry and harvest until November. They start harvesting when 40 pieces weigh 1 kg. Then they also grow prawns and white fish during May to December when salinity decreases due to rainfall.

For various reasons most prefer to grow shrimps (bagda), even though they can sell prawns (golda) at higher prices. First, the harvest cycle is shorter for shrimps, potentially allowing several rounds of harvest. Second, shrimps require less external inputs. Finally, the water in most low-lying areas/agricultural fields is too saline for good prawn production.

Men, women and even children collect shrimp fry from tidal rivers using traditional nets. Men can go twice a day around low tide, whereas women only visit in the morning because the evening low tide is too late to allow them to go out alone. The catch is very variable. Catching wild shrimp fry is very popular as they can be readily turned into cash. These small daily catches make up the only source of income for a large number of housewives.

Work carried out principally by women: During the dry season, almost all women within the age range 20-50 carry out reconstruction work through NGO-operated rehabilitation programs for cyclone Aila victims. They are employed in mud cutting activities to stabilize the dikes and build raised earthen platforms where the disaster victim families erect their housing units. Some of the women provide casual labor to shrimp farms, others grow vegetables. For example one female interviewee has her own vegetable garden on elevated land. She lives alone and produces beans, sweet gourds, cucumbers, lady's fingers (okra), potatoes, and pumpkins. She uses pond water to irrigate, and does not use any fertilizer. She plants in May and harvests from July to December, depending on the varieties, and also plants winter vegetables during the post-monsoon period. She uses the vegetables for her own consumption and sells any extra. If she does not consume any of her produce, she has the opportunity to earn 150 BDT per week. This year, major floods from the heavy rainfall seem to have had a positive impact on her vegetable production since it decreased the salinity level both in the soil and in the water bodies used as sources of irrigation.

Expenses: The families' major expenses are for fuel wood (approximately 125 BDT for 10 days), food (200 BDT per day for 7 persons), sometimes water, and sometimes health treatment. For health treatment they mainly ask local doctors and use traditional remedies (such as leaves) to heal skin complaints.

Typical food regime: The usual meal is composed of rice, small tilapias, potatoes, papaya, green bananas, and pulses. It is not possible to buy other fruit due to their high prices. The average family can only afford meat once every two to five months.

Power structures and conflict of interests: There is an outspoken conflict of interest between the owners of large ghers that grow shrimp and the smaller land owners that prefer to grow rice. We were not able to talk to the most successful shrimp farmers, as they mostly live in cities, so the information here is derived from the local farming community and the small scale shrimp farmers. We thus collected a one-sided point of view, although it includes 90 % of the village community.

The interviewees accuse the shrimp gher owners of controlling the sluice gates to manipulate the flow of water in the canals for their own benefit, while it contaminates their land with saline water making it unsuitable for growing rice and animal fodder. Many of the smaller land owners have had to switch from rice to shrimp because of the contamination to their land. Unfortunately, they do not have strong negotiating power as they are all individual farmers and are not organized into a group.

Apart from this conflict, people also mentioned political discrimination. The women in the study groups explained that some members of the village are favored by the elected representatives who give preferential treatment to those whom they believe had voted for them. There is a belief that it is always the same people who receive aid from NGOs and this creates mistrust.

3.4.2 Risk assessment

The two primary issues of concern identified were the crisis surrounding lack of clean freshwater due to increasing salinity, and the risk of being attacked in the Sundarbans. Although highly vulnerable to cyclones, people placed more emphasis on the problems associated with salinity.

Dangers faced in Sundarbans: Collecting resources in Sundarbans carries considerable risk. The two main dangers are attacks by tiger and capture by bandits. The Sundarbans, which is a UNESCO World Heritage Site, is home to over 250 Royal Bengal tigers

(*Panthera tigris tigris*) that have protected status. Attacks on people are regular though humans are not a primary food source, more an opportunistic supplement. However, attacks have been increasing since cyclone Sidr in 2007. This may be due to a reduction in the tiger's natural prey forcing them to move closer to areas of human habitation and increasing the chances of unintended encounters. Families of tiger victims are entitled to receive compensation from the Government of Bangladesh under provisions included in the Wildlife Preservation Act, 2010. However, widows often struggle financially to support their family and suffer psychologically as the husband's family often blames the wife when anything inauspicious occurs.

Villagers entering the Sundarbans also face the risk of encountering criminal gangs. If caught they are left with no choice but to pay 5 to 6 thousand BDT to avoid being held hostage. If they fail to pay, which happens frequently, the kidnappers ask for 25 thousand BDT from their families. Usually the fishers form groups of several boats to avoid the risk of being kidnapped while fishing.

Water crisis: People face difficulties in year-round access to fresh drinking water because of salinity. Consequently, they drink fresh-water from community ponds, but as water quality is poor they suffer from stomach and intestinal sickness.

Rice and vegetables: A very small proportion of the villagers currently have land that grows rice. In the winter season the presence of paddy is nearly absent. In a 'good' year, without the misfortune of a significant natural catastrophe, they grow Aman rice during the rainy season. This year (2011) however, as all the seedlings have been damaged by the floods in July, most of the farmers are buying seedlings to replant. Despite the salinity in soil and water, some sporadic attempts to cultivate winter vegetables, mostly for household or domestic consumption, have been observed. The key obstacle to vegetable cultivation is the lack of freshwater for irrigation. This year, due to unusually heavy rainfall, the level of salinity of surface water bodies, small ponds and ditches was relatively low and people were able to use the water to irrigate their vegetable gardens.

Salinity and health: It is believed that drinking the saline water is causing skin complaints such as wounds and darkening of the skin. This causes social problems as men ask for a higher dowry from a girl's family if she suffers from a skin disease.

Fuel shortages: Whereas other areas of the country can use agricultural residues and cow dung, or plant leaves from homestead forestry, in this village cooking fuel is nearly absent. The reason for this is the very limited scope of agriculture, livestock rearing or home-based forestry due to the salinity in the soil and water. Most of the families rely heavily on fuel wood collected from Sundarbans forest, even though the extraction of timber from Sundarbans is prohibited.

Cyclones: Located in the extreme south of Shyamnagar upazila, next to the river, Gabura union is highly vulnerable to cyclones. People recall three recent major environmental events as catastrophes. The first was Sidr in 2007, after which the land was unusable for a whole year. The second was Aila, in 2009, which left the whole area under water for more than two years, and the third was the unusual floods of July-August 2011.

Cyclone Alia caused long-term saline waterlogging that has contaminated the ground water and the soil. There is no sweet water anymore. The recovery process in ongoing with numerous NGOs working in the area. Many people have had to take out loans from microcredit providers. Loan repayment arrangements are the same in almost every case: for every 1000 BDT one has to pay back a total of 1125 BDT in 46 equal weekly payments, starting from the week following the beginning of the loan. There is no flexibility regarding the terms of the repayment.

3.4.3 Identification of changes

Shrimp culture and salinization of water and soil: An interviewee told us that he started shrimp cultivation in 1980, a change followed by many other farmers in the village, some because it was thought to be very profitable while others were forced to switch to shrimp farming because of saline intrusion into their land. The salinity was naturally present in the dry season, but the biggest shrimp farmers started to bring saline water into their ghers during the monsoon and post-monsoon season to increase their production. Looking at the prospects for a saline water market, these few influential larger gher owners secured permission to manipulate the sluice gate for drawing saline water from the river. Today, they are successfully trading saline water using both natural and constructed canals; they supply saline water to parties who are in need of saline water for their ghers. It is stated, by the farmers, that in one season a single saline water trader can supply saline water to 30 thousand bigha (i.e. 15 thousand acres) of land. If he charges 300 BDT per bigha per season/year this is a huge business for a single person (reaching 9 million BDT a year).

In or around the year 1990, farmers started noticing the impact of increased salinity on their vegetables, fruits and crops. Before this date they were growing local Boro rice and Patnai, had many goats and cows, and sweet water ponds with local fishes in such high quantity that they could dry and preserve the catch. However, now only a few saline resistant species remain: palm trees, date trees, and coconuts. They are trying to replant some species but without confidence. They don't have livestock anymore because of the disappearance of grazing areas, paddy fields have been replaced by ghers, road have been damaged by salinity, vegetable production and access to freshwater have decreased.

Rice cultivation: A farmer explained that until 1988, when floods and cyclonic surges became more severe, they used to cultivate rice regularly. The main varieties of rice grown were Gethidhan (short duration), Patnaidhan (very thin variety), and Vorandhan (very thick variety). Aman production was still good (15 mon/bigha). From this time onwards they have been growing rice more occasionally. Today the farmers cultivate BR 11, BR 22 and BR 30 during the Aman season, but the flowering stage is affected by salinity in late September to October and results in poor yields.

Fuel wood: In the past, rice residuals and cow dung cake were popular choices for fuel. With the development of shrimp farming these items are no longer available and people rely mostly on wood from Sundarbans. Fuel wood is purchased at 125 BDT/mon and 1 mon lasts for ten days.

Division of labor by gender: Women used to be involved in rice-related activities (cleaning land, de-weeding and transplantation). When the paddies were changed into ghers women were employed in gher cleaning and preparation. However, many ghers were destroyed or damaged by cyclone Aila and the gher owners lost money. Now they don't invest as much in gher cleaning and preparation and the women have fewer employment opportunities. They are hired as mud cutters by many NGOs who give priority to women (e.g., Shushilon, Caritas, Concern Worldwide). They also collect fish fry from the river. However, even though they have changed their occupations because of Aila and the increased level of salinity, they are still able to earn the same amount of money whether they are working in paddy fields, ghers or as mud cutters—50 BDT for a half day (from 6 am to 1 pm).

Other changes: Interviewees noted that October temperatures were elevated and that there was an overall increase in water levels.

3.4.4 Exposure and sensitivity

The men and the women evaluated the vulnerability of their assets and activities (Tables 12 and 13). The most damaging hazards are, in order, cyclones, floods, heavy rains, salinity and high temperature. It appears that people prioritize the

violence, suddenness and unpredictability of the cyclone and weather hazards rather than the slow but progressively increasing environmental damage that characterizes salinity or rise in temperature. However, in contrast, when interrogated about the risks they prioritized those related to salinity, which affect all aspects of their daily life and livelihood activities over the longer term.

The assets and livelihood activities considered most vulnerable by men and women are (i) fish, (ii) health (because of skin diseases), (iii) roads, houses and cooking activities (lack of fuel), (iv) need for migration, (v) vegetation and plants in general; then rice, cows, vegetables, and poultry.

Table 12. Most vulnerable activities and assets, Dumuria village (female group).

	Salinity	Floods	Cyclones	Heavy rain	High temperature	Total	Vulnerability rank
Frequency 1 < 5	5	1	3	4	1		
Vulnerability of activities							
Fish	5	5	5	5	5	**70**	**1**
Shrimps	-5	5	5	5	5	**20**	**15**
Aman (BR 49, 21, 22, 23)	3	5	4	4	3	**51**	**6**
Homestead vegetables	3	4	4	4	3	**50**	**7**
Palm	3	0	3	0	0	**24**	**13**
Coconut	3	0	3	0	0	**24**	**13**
Date	3	0	3	0	0	**24**	**13**
Mud cutter	-2	3	3	4	2	**20**	**15**
House / road maintenance	-2	4	3	4	2	**21**	**14**
Sundarbans	0	3	5	4	2	**36**	**10**
Fish and crab collection	0	4	5	4	2	**37**	**9**
Migration	5	3	4	4	2	**58**	**4**
Boat men	0	4	4	3	2	**30**	**12**
Chicken, goats, ducks	3	3	3	3	0	**39**	**8**
Cows	5	5	3	3	0	**51**	**6**
Cooking	5	4	5	5	1	**65**	**3**
Fuel	0	4	3	4	-5	**24**	**13**
Vulnerability of assets							
Houses	5	5	5	5	0	**65**	**3**
Plants	5	5	5	3	0	**57**	**5**
Roads	5	5	5	5	0	**65**	**3**
Drinking water	5	5	5	5	3	**68**	**2**
Health	5	4	2	3	3	**35**	**11**
Total	54	80	87	77	30		
Rank	**4**	**2**	**1**	**3**	**5**		

Table 13. Most vulnerable activities and assets, Dumuria village (male group).

Occurrence 1 = low frequency 5 = high frequency	Salinity	Rainfall/Waterlogging	Cyclone/Storm surge	Intensity * Occurrence	Ranking
	5	**5**	**3**		
Vulnerability of activities and assets					
Aman (limited cultivation)	High salinity affects growing to flowering stage (5)	Waterlogging frequently damages seedbed or transplanted fields (3)	Cyclone/storm surges damage mature and ready-to-harvest fields (3)	**49**	2
Fish culture in ghers	0	Heavy rainfall in Jul-Sept leads to lower salinity in ghers and causes poor harvest (3)	Cyclone and storm surges with abnormal height severely damage productivity (5)	**30**	6
Winter season vegetables	High salinity affects planting and growth of most winter vegetables during Nov-Feb (3)	Even occasional and light rainfall help planting and growth of most winter vegetables during Nov-Dec (-3)	Cyclone and storm surges inundate newly planted vegetable fields during Oct-Nov causing total loss (5)	**15**	8
Summer season vegetables	High salinity affects planting of most summer vegetables during Apr-May (4)	Even occasional and light rainfall helps growth of most summer vegetables during Jun-July (-5)	Cyclone and storm surges inundate newly planted vegetable fields during May-Jun causing total loss (5)	**10**	9
Fish catch/fishing	0	0	Fisher groups lose many income earning days due to very bad weather during May-June and Oct-Nov (3)	**9**	10
Crab catch	0	0	0	**0**	
Collection of fuel wood	0	0	Fuel wood collection is reduced to a minimum in May-June and Oct-Nov due to very bad weather (3)	**9**	10
Collection of *Golpatha*	0	0	0	**0**	
Collection of honey	0	0	Honey collection from April to June is affected by strong winds in May and June (3)	**9**	10
Cattle/goats	High salinity degrades the pasture land during dry season and creates shortage of fodder (3)	Waterlogged ground from heavy rainfall during Aug-Sept damages pastures and restricts mobility of animals (3)	Cyclone and storm surges with abnormal height may wash away livestock during May-June and Oct-Nov (5)	**45**	3
Poultry/ducks (swans)	0	Ground waterlogged due to heavy rain during Aug-Sept makes poultry rearing difficult (3)	Cyclone and storm surges with abnormal height wash away poultry during May-June and Oct-Nov (5)	**30**	6
Wage labor	Due to higher salinity, demand for labor for crop agriculture is now reduced (5)	0	Following the cyclonic events localized demand for labor increases for reconstruction and rebuilding activities (-3)	**16**	7
Small business/petty trade	0	0	5	**15**	8

Occurrence 1 = low frequency 5 = high frequency	Salinity	Rainfall/Waterlogging	Cyclone/Storm surge	Intensity * Occurrence	Ranking
	5	**5**	**3**		
Vulnerability of activities and assets					
Water for drinking and domestic use	The freshwater crisis is chronic year round due to salinity (5)	Only during the wet season (monsoon and post-monsoon) is freshwater relatively easy to harvest or fetch from community managed ponds (-2)	There is an acute freshwater crisis during and immediately after a cyclone (5)	**30**	6
Communication (market/bazaar, school/health facilities)	0	5	5	**40**	4
Housing and settlements	Salinity severely affects building materials used for the plinth, floor and roof (3)	2	Houses constructed of mud and other weak materials collapse during cyclones due to the action of wind, rain and storm surges (4)	**37**	5
Homestead garden/forestry	3	-5	3	**-1**	
Public health and sanitation	Water-borne diseases, e.g., skin infections due to use of highly saline water (3)	Water-borne diseases, e.g., diarrhea, skin infections due to use of contaminated water and unhygienic sanitation practices (5)	Water-borne diseases, e.g., diarrhea, skin infections due to use of contaminated water and unhygienic sanitation practices (5)	**55**	1
Total	170	45	183		
Rank	**2**	**3**	**1**		

3.4.5 Assessment of adaptive capacity and needs

The adaptation strategies currently employed to combat the challenges posed by excess salinity, rainfall and waterlogged soils, cyclones and storm surges are shown in Table 14, along with a brief summary of the villagers' specific needs to address them.

Adaptive strategy to deal with the freshwater crisis: People have rudimentary arrangements on the roofs of their dwelling units to harvest rainwater during the rainy season. To collect and store rainwater they use plastic drums, buckets and large earthen jars with a capacity of 50 to 200 liters. The same plastic drums are also used to carry freshwater while going fishing in the bay or Sundarbans area. One family can last six months with 1000 liters of water and they can keep water for one year without having health problems. A few families received plastic drums as aid relief in the aftermath of cyclone Aila and can now store 200-500 liters of water each season, but this is only sufficient for two to three months. Only a few families have containers large enough to catch sufficient water during the rainy season.

During the dry season people drink water from a large, community-managed pond, where bathing is forbidden, until it becomes too salty. At this point women will collect water from Nil Dumur. The NGOs Caritas, Shushilon and others have carried out water distribution projects.

Apart from this pond, almost every family has its own small pond. Water from this small family/relative's/neighbor's pond is used for cooking, utensil cleaning and bathing. However, water from these ponds is not really suitable for drinking purposes and is a source of dysentery and diarrhea. People usually fail to boil their water because of fuel shortages and because it increases the concentration of salt.

Table 14. Adaptation strategies and needs, Dumuria village.

	Salinity	Rainfall/Waterlogging	Cyclone/Storm surge
Current adaptation strategies	Use highly saline land for shrimp farming Other land parcels are used for Aman, although yields are low Homestead land is used for seasonal vegetables keeping provision for manual irrigation and draining of excessive water Harvest rainwater from individual houses and fetch water from community managed freshwater pond Seasonal migration to find employment Rear geese/swans which do not eat fish and have better market price, instead of the usual ducks	Rainwater harvesting Delay planting of Aman rice in lowlands to avoid immediate short-duration inundation Raise houses (2 to 3 feet; cost 70 000 to 80 000 BDT) Try to build terraces for homestead vegetable gardens to regulate rainwater Store/preserve agricultural residuals and similar fodder to feed cattle and goats during wet season Use country boats for mobility (e.g., going to school, market place, health clinic, etc.) Construct latrines on elevated round to avoid discomfort and health hazards Buy portable cooking stoves made of mud or corrugated iron in case of house flooding Storage of fuel wood in elevated locations	Take shelter on BWDB embankment or in cyclone shelter during emergency, or in small canals if in Sundarbans Adjust resource extraction from Sundarbans and its adjoining bay area depending on weather conditions Women and children maintain their own calendar to take advantage of the low-tide catch of wild fry Try to repair and rebuild housing units during dry season to ensure maximum protection against normal cyclonic/windy conditions Try to ensure safekeeping of cattle during extremely bad weather conditions
Specific needs	Maintenance of sluice gates and canals to stop intrusion of saline water from the river systems Excavation and regular maintenance of natural creeks and canals to store and preserve rainwater Improve rainwater harvesting systems	Maintenance of sluice gates and canals to ensure smooth draining of excess water from the embanked settlement back to the tidal river system Improve rainwater harvesting systems	Maintenance of BWDB embankments along Khel Patua and Kobadak river-system to protect settlement from higher storm surges and cyclones Construction of cyclone shelter within the village Construction and maintenance of access roads to emergency establishment, e.g. cyclone shelter, BWDB embankment, bazaar, health clinic

Gender differentiated opinion of village needs: Women cited the need to increase access to fresh drinking water as their top priority. To achieve this objective they want to dig more ponds and acquire new and larger water containers for rainwater harvesting and storage. Their next priority is the construction and improvement of embankments and roads, as well as the need to find health treatment for water related diseases (diarrhea, dysentery, skin diseases) and to build more weather resistant houses. They pointed out that there are only 4 shelters for 15 villages in Gabura union, and access was difficult; they would like to have one shelter in their village. Finally, women expressed their enthusiasm for the promotion of female entrepreneurship; an NGO named LEDARS (Local Environment Development and Agricultural Research Society) is currently providing support in this field. They complained that women get lower wages than men for similar jobs.

The men, on the other hand, prioritized needs related to reducing salinity, without which they consider no livelihood problem can be solved. They recommended alternative management arrangements for the sluice gates, and an end to leasing of government canals to shrimp farmers as first steps. Other needs include repair and maintenance of roads, capture of the gangs in the Sundarbans, and more cyclone shelters.

3.4.6 Opportunities for improved adaptive capacity

Pre-selected strategies

Designed diversification: Designed diversification in this village can include female entrepreneurship. Women repeatedly stated their interest in developing more vegetable cultivation. LEDARS is working with a small number of people on homestead gardening. The group also shared ideas on developing and improving poultry farms and nurseries. The group dynamics is such that they are comfortable discussing initiatives with each other and will consider organizing themselves into a women's group or cooperative. However, there is a lack of trust and a degree of self interest present. A third party would be needed to help explain and establish the rules and the mechanisms. Social barriers and mobility constraints are not a problem in this village.

Index-based financial risk transfer: The entry permit to the Sundarbans provides a form of life insurance. For a yearly sum of 100 BDT the family of a tiger victim will receive 25,000 BDT.

Villagers would be interested in an extension of this form of insurance to cover houses, rice cultivation, and fishing. They would be prepared to restart their rice business if they knew that the risks were covered by insurance. For the premium, the more skeptical villagers were only ready to invest 1/20 of the reimbursement they might get back from the insurance, the most generous 1/5, the majority 1/10. However, there is no capital available to pay the premium in advance.

Adaptive management in response to advance information: The village already receives advance warning about cyclones and potentially heavy rains through the TV and radio. Local knowledge of environmental signs such as high temperature, clouds and wind direction also provide indications of impending weather changes. However, cyclone Aila arrived so suddenly that they didn't have any advance warning. After Aila, NGOs provided loudspeakers and radios.

They suggested improving the system by using flags, so that men in the fields could have a visual warning. The NGO Christian Commission for Development in Bangladesh (CCDB) has already set up some signboards to raise awareness about a flag system, but they would like the government to implement it. People consider that a five day forecast would be ideal for floods and rain to allow them to prepare nets, protect livestock and adapt their agricultural schedule as needed.

Improving the system does not necessarily mean that people will go to shelters more often. When the women are aware that a cyclone is coming, they usually prefer to stay at home. The rationale behind this decision is based on effort, economics and acceptance. Distance to the shelter is one of the major factors (although there are 96 in Shyamnagar upazila, there are only 4 in Gabura union); the second is the need to preserve possessions if at all possible, and third is a fatalistic attitude and acceptance of the 'will of God'. When the men hear that a cyclone is coming while they are still in the village preparing to go out to Sundarbans, some of them will postpone their departure but others will venture out anyway.

3.4.7 Strategies selected

Food and income: To increase production and decrease the need to buy food, people have started hanging vegetables and homestead gardening. This needs sweet water, for which rainwater harvesting systems could be profitable. Rearing chickens, but also Chinese ducks, which are bigger than normal ducks and can be managed in houses, could be an additional livelihood option for some families. However, people cannot afford to start new enterprises by themselves as they currently use all of their income to buy food. There is an interest in developing integrated farming systems with fish, livestock and vegetables, as well as small businesses.

Water management: As in the other villages, water management is also a critical issue here. The occurrence of health problems due to the consumption of unsafe water shows that the development of rainwater harvesting systems and purification systems would be of great interest. A study of the suitability of *Moringa* and its resilience to salinity would also be beneficial in this area.

Freshwater shrimps: It is still an option to persuade shrimp farmers to reduce the influx of salinity without a substantial change to their activities. This might be possible if LEDARS cooperates in a campaign to convince the government to stop leasing canals to shrimp farmers.

More flexible loans and credit: Again, the lack of flexibility in microcredit arrangements affects everybody in the village. Developing a more flexible system could help diversify livelihood activities and promote female entrepreneurship. The creation of a women's group or cooperative could be linked to the development of a different system of microcredit.

Index-based insurance: If possible, some kind of extension of the current insurance system used to cover the risk of death from tigers to other areas of their livelihood would constitute a useful safety net and help ensure the continuity of any new activities developed.

Table 15. Summary of the most pertinent results from the village assessments.

	Major livelihood activities	Main risks in order of priority	Changes seen over time	Primary needs to combat threats
Jagannathpur village, Jhalokati district	Paddy, vegetables, livestock and poultry; a little aquaculture	Floods > rain > cyclones and surge > droughts; (No salinity)	Increased intensity and frequency of cyclones, increase of rainfall and floods, increase of temperature, deterioration of quality of nutrition	Water management, flood resistant rice, short duration vegetable varieties
Gabgachia village, Bagerhat district	Agriculture and aquaculture	Salinity > floods > cyclones	Increase in salinity, decrease in tree coverage, decrease in vegetable productivity, increase in the intensity and frequency of floods, increase in severity and duration of cyclones, increase in duration and unpredictability of rainfall, increase in temperature	Flood and saline resistant rice varieties, re-excavation of canals, rainwater harvesting system, improved vegetable-growing techniques and varieties, food conservation techniques, training in new or alternative techniques
Harikhali village, Khulna district	Shrimp farming; existing conflict between shrimp farmers and rice cultivators	Salinity > rain > flood > cyclones and surge > droughts and high temperature	Sea level rise, decrease in rice production and freshwater fishes, increase of salinity, temperature and irregularity of rain, shift from six to three seasons	Improved access to freshwater, designed diversification, reinforcement of embankments, cyclone shelters, organic fertilizers, livestock feeding, training and weather information products
Dumuria village, Satkhira district	Shrimp farming and collecting resources from the Sundarbans	Salinity > cyclones > tiger and kidnapper attacks in the Sundarbans	Increase in salinity, increase in temperature, water level rise, disappearance of rice and grazing areas, decrease in production of vegetables, decrease in number of fish varieties	Decrease in the salinity of soil, solve the water and food crisis, raised houses, health treatment, female entrepreneurship, cyclone shelters

4. RECOMMENDATIONS

A summary of the key results from the interviews held in the four villages is given in Table 15, and forms the basis for the following recommendations and the proposed activities.

4.1 Addressing the salinity issue

In all three of the areas where the soils are saline, from moderately saline upwards, this issue was deemed the most pressing by the interviewees in each village. Where the land is moderately saline but shrimp farming has not become the de facto norm the desire is to grow saline tolerant rice varieties. Where the land has become highly saline, the preference expressed by the smaller land owners, who have had to switch from paddy to shrimp and by the landless day laborers, is for a return to paddy cultivation through measures undertaken to reduce the salinity. This would allow the smaller land owners to produce animal fodder and fuel material, and improve the production of vegetables. The landless would have more employment opportunities as paddy cultivation is more labor intensive than shrimp farming.

However, vested interests are opposed to this change. The large-scale shrimp farmers, often powerful and influential outsiders, make significant profits from shrimp culture and have no motivation to change their business model. Only new incentives from government might prevent them from continuing to bring in saline water.

In those areas where salinity is an issue, the problem could be addressed at three levels: adaptations by the poorest group of villagers, changes introduced by government, and changes adopted by the shrimp farmers themselves.

Poorest people

Vegetable production: the production of vegetables is very limited because of the salinity level in the soil and lack of suitable land. People have to buy vegetables from the markets and can only afford the cheapest ones. The diversity of food consumed is reduced and the overall nutritional value achieved is diminished. This is especially detrimental for the children.

To compensate, the use of ring agriculture and/or hanging vegetables should increase the quantity of vegetables produced. Bag agriculture does not appear to be a suitable option because jute bags fail to retain sufficient water, and the government is trying to reduce the use of plastic bags. The local organization, Initiative for Right View (IRV) based in Khulna, has organized training on hanging vegetables in the Jessore region; a partnership could be considered. The Asian Vegetable Research and Development Center (AVRDC), now known as World Vegetable Center, is interested in forming a partnership for the development of saline resistant vegetables.

Scarcity of water: increased salinity means that freshwater becomes a scarce resource. To cope with this situation, women collect rainwater as best they can during the rainy season. During the dry season, if freshwater is available in the area, women will walk several kilometers with jars to collect it. Improved control over water resources is fundamental to decreasing their vulnerability to climate change.

Two strategies can be promoted to improve the situation. The first would be to develop a larger scale system for rainwater harvesting and water conservation, allowing storage of drinking water for the dry season. Another strategy, more experimental, would be to study the use of *Moringa oleifera*, which grows in southern Bangladesh, and whose seeds have natural coagulant properties. The organization 'Practical Action' has developed expertise in rainwater harvesting systems and is working in Satkhira district. They have already engaged in partnerships with WorldFish in the past and are ready to do so again.

Government

The government leases canals to shrimp farmers who use them to bring saline water to their ponds to grow shrimp. Management of the sluice gates by the government is weak. The shrimp farmers usually have their own sluice gates or control the government sluice gates, allowing the entry of saline water into their ponds when desired. However, saline water leaks beyond the pond edge. By joining with a strong network of other organizations, pressure could be put on the government to reduce or even cease leasing the canals and to adopt a management protocol for the sluice gates that was more beneficial to a wider group of people. The organization LEDARS is already campaigning on this issue.

Shrimp farmers

Shrimp farmers are influential people who will never switch to another activity unless it is as profitable for them. However, if the government strengthened the management of sluice gates and ended the practice of leasing canals to them, they would have fewer opportunities to bring saline water to their ponds. Water would be saline for only a few months during the dry season (peak salinity in January–February) but at a lower level. Options for the development of freshwater shrimps could then be promoted.

4.2 Livelihood designed diversification

Designed diversification includes several different strategies that aim to help people to utilize a wider variety of resources and undertake a broader range of activities. This improves their overall resilience to the anticipated impacts of climate change and helps them to be better prepared for the unexpected.

Production of vegetables all year round: Using a variety of different horticultural techniques and a broad range of vegetables, small scale homestead units can ensure production year round, providing at least a minimal quantity of food or income on a more regular and consistent basis. For example, winter vegetables can include the following: Sal shak, mustard oil, broccoli, beans, cucumber, pumpkin, sweet gourd, bitter gourd, spinach, dal, mosori, kashari, chili, sesame seeds, water melon, rock melon, sweet potato, tomato, eggplant and cabbage; and summer vegetables can include pumpkin, data shak, kocho, poisak, lady's fingers and gurt.

The techniques used may include traditional seedbeds, hanging vegetables and agriculture in rings. A variety of techniques must be employed as the different vegetable crops each grow optimally under their own unique set of conditions.

- Ring vegetables: short rooted vegetables such as pumpkins
- Hanging vegetables: gourds and leafy types of vegetables
- Use of rain shelters during the wet season for production of high value crops such as chili peppers and tomatoes
- Use of flowering plants in cropping areas to decrease pests
- Use of irrigation systems such as collection and storage of flood water, or low-cost drip irrigation.

The vegetable crops grown need to be selected on the basis of their suitability to the environmental conditions, resilience to flooding, drought and/or salinity. Some further research may be required to optimize the varieties cultivated or to breed new strains. For example:

- Flood tolerant vegetables such as Indian spinach and kangkong
- Underutilized vegetables such as jute mallow (*Cochorus ditorius* or pacha) tolerant to floods, high rainfall, temperature and brief drought episodes, but not saline tolerant
- Saline or medium saline tolerant vegetables such as potatoes, pumpkin, beet, asparagus, spinach, purslane, cowpea, garlic, turnip greens, artichokes, melons, cucumbers, broccoli, and squash
- Quick and profitable vegetables such as amaranth (eaten as a type of red spinach).

Increase the potential benefits from fruit trees and turmeric: Some fruit trees can give yields that provide high income over a short period. Betel nuts are harvested from September- October to December and can be sold either at that time to cover the most difficult months or at a higher price in February and March after being dried. Palm juice can be collected from March to May and sold at a very high price. Turmeric is grown from June to March. It is cheap (no input required), easy, and highly profitable as the returns are 4 to 5 times higher than the investment. It is quite resistant to climate events.

Promote alternative animal rearing: Some of the families interviewed are rearing Chinese ducks, swans or geese. These birds don't eat the fish and prawn fry and thus do not constitute a threat to gher owners who leave them alone (unlike other ducks which are killed). Some additional research could be done to assess whether Chinese ducks have a positive impact on rice cultivation, as their feces constitute a natural fertilizer and their paddling movement ventilates the water.

Rearing pigeons also appears to be a potential livelihood activity. They do not require purchased feed as they can eat any left-over food, though extra feeding may be required during the rainy season. The birds are productive for at least five years and breed year round so there is the potential for regular income. This would be particularly useful in the difficult months of September and October. One breeding pair will produce from 12 to 15 young each year.

Integrated farming systems: Integrated farming systems are becoming more and more widespread. Improving livelihoods by combining rice culture and aquaculture in the same pond can be developed where the gap still exists. Villagers in Jagannathpur requested training on these farming systems.

Female entrepreneurship: Women expressed their willingness and desire to develop their entrepreneurial skills and create small businesses such as poultry farms and nurseries. For the most part they do not have the initial investment and are not willing to take the risk involved with launching a new business. They expect some third party to help them in the early stages.

Cooperatives/Self help groups: People from all villages were reluctant to form groups or cooperatives because they did not fully understand how they could work and how to share the benefits in an equitable way. In addition, they are not willing to put in any initial investment. However, villagers in Gabgachia (Bagerhat) and Dumuria (Satkhira) expressed their interest in training so that they could better understand the opportunities and constraints.

4.3 Insurance system

People showed some interest towards insurance systems that included, in addition to agricultural losses, other dimensions of their lives such as house damage. They were not really clear about how this might work or which meteorological hazards could be taken into account. Interest in this strategy depended on which hazards were considered and which assets or activities could be reimbursed after adverse events.

4.4 Improved microcredit systems

Across all villages almost every family is a member of a microcredit program, but they are all limited by the lack of flexibility in the terms and conditions applying to the loan. Apart from the high interest rates, they have to reimburse in 46 weeks, starting the week after the day they take out the loan. For long-term investments, they don't have money to start reimbursing one week after having taken out the loan. For short term investments, they may generate the necessary returns quickly but are not allowed to reimburse the whole loan at one time, instead having to keep paying every week for the total 46 weeks. Keeping money for so long is almost impossible. Having more flexibility in microcredit loans would make investment in diversified livelihood strategies much easier.

5. STRATEGIES AND INTERVENTIONS

The participatory research activities completed in the four villages gave a clear appreciation of villagers' vulnerability to climate change, and the tools available for them to cope. Based on this analysis, several strategies were designed to improve their resilience to climate change. The outlines of these programs are presented for consideration; each one focuses on the needs expressed by the local communities and has been analyzed by a prioritization and evaluation tool.

5.1 A prioritization and evaluation tool

A Microsoft Excel tool has been developed to evaluate and compare different possible interventions. Based on the issues raised by the village communities during the participatory research assessment, four issues and four programs have been evaluated with the tool to facilitate prioritization. The overall objective of the tool is to provide a critical view of each potential intervention in order to highlight areas for improvement.

The tool has four inter-related but dynamic components which evaluate the issues or programs from four perspectives: Environment, Economics, Social, and Management. While the management perspective is global (evaluates the whole project) and is the same for all four candidate issues/programs, the other three perspectives, which give an indication of overall sustainability, differ from one issue/program to another.

A list of criteria and sub-criteria has been established for each perspective. The Management criteria have been drawn from *Compas Qualite* (URD, 2011), a tool prepared by the Groupe Urgence Réhabilitation Développement (URD) for assessing the quality of development projects. The criteria and sub-criteria for the other three perspectives have been identified based on the standpoint of sustainable development.

5.2 Issues

Based on the results of the participatory research the following four issues were analyzed using the prioritization tool:

A. Access to flexible microcredit
B. An end to the deliberate entry of saline water into areas where rice cultivation is the key source of livelihood
C. Provision of index based insurance
D. Use of *Moringa* for water purification

Results from the policy prioritization model

- From an environmental point of view the highest priority was given to robust interventions to stop the deliberate entry of saline water onto prime agricultural land, followed by research on the potential role of *Moringa* to purify turbid water, flexible micro-credit and lastly, index based insurance.
- From an economic point of view the highest priority was given to flexible micro-credit, followed by robust measures to stop deliberate ingress of saline water onto prime agricultural land, index-based insurance, and lastly research exploring the potential role of *Moringa* to purify water with high turbidity.
- From a social point of view the highest priority was given to robust measures to stop deliberate entry of saline water to prime agricultural land, followed by flexible microcredit, index-based insurance, and lastly research exploring the potential role of *Moringa* to purify water with high turbidity.

Overall, the ranking of interventions would be: robust measures to stop deliberate entry of saline water onto prime agricultural land, followed by flexible microcredit, index-based insurance and finally research to explore the potential role of *Moringa* to purify water with high turbidity.

5.3 Program candidates

Four programs of activities were also analyzed using the tool. The first two programs are examples of designed diversification whereas the other two were analyzed to explore the impacts of different types of integrated farming systems.

A. Program related to rainwater harvesting
B. Program related to vegetable production
C. Program related to integrated paddy and prawn/freshwater shrimps/carp production
D. Program related to integrated shrimp and paddy production.

Result from the program prioritization model

- From an environmental point of view, the highest priority was given to a rainwater harvesting program, followed by integrated paddy and prawn/freshwater shrimps/carp production, vegetable production, and lastly integrated shrimp and paddy production.
- From an economic point of view, the highest priority was given to integrated paddy and prawn/freshwater shrimps/carp production, followed by shrimp and paddy production, vegetable production, and lastly rainwater harvesting.
- From a social point of view, the highest priority was given to integrated paddy and prawn/freshwater shrimps/carp production, followed by rainwater harvesting, shrimp and paddy production and finally vegetable production.

Overall, in descending order of priority the suggested interventions are: integrated paddy and prawn/freshwater shrimps/carp production followed by vegetable production, rainwater harvesting, and lastly, integrated shrimp and paddy production.

A proposed outline for these four projects is given in Table 16 along with suggested sites, a time frame and suitable organizations that might be interested in forming partnerships.

Table 16. Possible programs to improve resilience.

Program	Project	Piloting Areas	Time Frame	Possible Partner
Integrated rice and prawn/freshwater shrimps/carp production for income and nutrition	Integrated rice and prawn/freshwater shrimps/carp production in freshwater zone	CCAFS benchmark sites in Jhalokati	2012-2013	To be decided
	Integrated rice and prawn/freshwater shrimps/carp production in saline zone	CCAFS benchmark sites in Bagerhat (low saline) and trials in Khulna and Satkhira during rainy season	2012-2014	To be decided
Vegetable production for income and nutrition (designed diversification)	Hanging vegetable gardens	4 villages	2012-2013	Initiative for Right View in Khulna
	Ring vegetable gardens	Saline affected villages in Bagerhat, Khulna and Satkhira	2012-2013	LEDARS in Shyamnagar
	Low-water demand vegetable gardens	High saline CCAFS benchmark sites in Shyamnagar	2012-2013	AVRDC Shyamnagar
Integrated shrimp and rice production for income and nutrition	Integrated shrimp and rice production in medium saline zones	Moderately saline CCAFS benchmark sites in Morrelganj	2012-2014	To be decided
		High saline CCAFS benchmark sites in Shyamnagar and Paikgacha	2013-2015 (assuming more saline tolerant rice will be available by then)	To be decided

The first program aims to reduce levels of soil salinity by developing trials on freshwater shrimps with the large scale shrimp farmers, as well as introducing or improving prawn culture combined with rice culture in locations where the level of salinity allows it, reducing risk by diversifying sources of income.

The second aims to decrease the food crisis by 'designed diversification' of vegetable cultivation, introducing new techniques and/or new vegetable varieties adapted to the different ranges of salinity found in different locations. This program could be developed in partnership with three NGOs: Initiative for Right View (IRV), a local NGO based in Khulna which has developed expertise in hanging vegetables; with LEDARS (a local NGO from Shyamnagar) which is already implementing ring agriculture and promoting homestead gardening; and with AVRDC which is developing new varieties adapted to local environmental conditions, and better post-harvest and conservation techniques. Designed diversification of vegetable cultivation can be combined with the promotion of alternative livestock such as pigeons and Chinese ducks, as well as the use of fruit trees and short term profitable crops such as turmeric.

The objective of the third strategy is to improve accessibility to freshwater by promoting better rainwater harvesting systems, and by studying the potential for water purification by *Moringa oleifera*. Practical Action has expertise in rainwater harvesting technologies. A partner should be found to explore the potential of *Moringa oleifera*.

The fourth and final project would promote integrated shrimp and rice production in medium to high saline areas. This project is dependent on suitable saline resistant rice varieties and ranked as the lowest priority of the four.

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Abbreviations and Acronyms

AVRDC	Asian Vegetable Research and Development Center (now known as World Vegetable Center)
BRAC	Bangladesh Rural Advancement Committee
BWDB	Bangladesh Water Development Board
BRRI	Bangladesh Rice Research Institute
CCAFS	Climate Change, Agriculture and Food Security
CCDB	Christian Commission for Development in Bangladesh
HYV	high yielding variety
IRRI	International Rice Research Institute
IRV	Initiative for Right View
LEDARS	Local Environment Development and Agricultural Research Society
MoEF	Ministry of Environment and Forests
NGO	non-governmental organization
IPCC	Intergovernmental Panel on Climate Change
PRA	participatory rural appraisal
SCD	scored causal diagrams
URD	Groupe Urgence Réhabilitation Développement

Definitions/Glossary

Aman	Rice crop transplanted during the monsoon and harvested during November/December
Adaptive capacity	Ability or potential of a system to respond successfully to climate variability and change, which includes adjustments in both behavior and in resources and technologies
Bagda	Shrimp produced in saline water
BDT	The currency of Bangladesh, the Taka; US$1 is approximately 75 BDT (Oct. 2011)
Bigha	Traditional or local unit of land area measurement; size varies but equivalent to either 0.33 acres or sometimes 0.66 acres
Boro	Rice crop transplanted in January–February and harvested in May
Char	Low-lying river island
Exposure	Nature and degree to which a system is exposed to significant climatic variations
Golda	Prawn produced in freshwater
Gher	Shrimp production farm; normally larger but more shallow than large pond
Katha	Traditional blanket; prepared by women from used clothing
Khas land	Government owned land; usually in the form of marsh, canal, forest patch
Mohajon	Trader who pays in advance for people to extract various non-timber forest and marine products for him
Mon	Local unit of weight, equivalent to 40 kilograms
Sensitivity	Degree to which a system is affected, either adversely or beneficially, [directly or indirectly] by climate-related stimuli
Vulnerability	Degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes; vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity

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