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Integrated Assessment and Decision-Support Tool for Community-based Vulnerability and Adaptation to Storm Surges in Four Coastal Areas in Bangladesh

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Abstract

Bangladesh has been identified as one of the countries most vulnerable to climate change and rising sea-level. This is because it is located at the northern end of the funnel-shaped Bay of Bengal, and as a consequence it has experienced a number of severe storm surges in the last three decades. The inhabitants of the coastal region are very poor, and the surges have pushed them to a 'tipping-point'; that is, the point of desperation which is exacerbating the socio-economic threats to their existence. The study reported here aimed to explore the perceptions of coastal communities with regard to vulnerability and adaptation (V & A) strategies in four different areas of Bangladesh in order to reduce their vulnerability to future storm surges. After reviewing the impact assessment guidelines of the Intergovernmental Panel on Climate Change (IPCC), United States Country Studies Program (USCSP) and United Nations Environment Programme (UNEP), the researchers applied the Participatory Rapid Appraisal (PRA) method (a behavioural environmental decision-making tool) to survey 160 participants in four case-study areas, with 20 participants in two sessions in each case. The evaluation of V & A was implemented and prioritised in this study by a measuring scale, called the 'weighted matrix index'. This study not only considered the integrated assessment of V & A but it also classified the levels of vulnerability and adaptation in different categories. Additionally, it provides a comparative picture of the vulnerabilities for similar risks in different types of communities. The study emphasizes some key aspects: a. the composite nature of various levels of V & A issues; b. the constraints to adaptation implementation; c. how to overcome those constraints. These key aspects demonstrate and stress that adaptation policy needs to be implemented immediately in Bangladesh in order to

reduce and manage future vulnerability in the coastal region of Bangladesh under the potential climate change regimes.

Keywords

Bangladesh, Cyclones, Storms, Impact Guidelines, Vulnerability, Adaptation, PRA, Weighted Index, Adaptation Limits/Constraints, Climate Change.

Introduction

According to the Intergovernmental Panel on Climate Change (IPCC, 2014, 2007), United States Agency for International Development (USAID) (2007), and other coastal authorities in the Asia-Pacific region (Harvey, 2006; Warrick and Ahmad, 1996; Broadus, 1993), the coastal areas of Bangladesh face heightened risk from cyclones, storm surges, and coastal flooding as a result of continued global warming. Scientists have argued that all societies are fundamentally adaptive to vulnerabilities which they face repeatedly (Adger *et al.*, 2003). The coastal inhabitants of Bangladesh are highly adaptive (Younus *et al.*, 2012-13; Saroar and Routary, 2009), though due to the absence of adaptation planning, poor infrastructure, inadequate communication networks, poor transport modes, poverty, and a general lack of awareness of warning signals, the consequences of coastal flooding are serious and deadly for this region. The economic consequences of failed adaptation in response with flooding are large (Younus and Harvey, 2014). Bangladesh's low-lying coastal zone covers 47,201 km² and is occupied by 38 million people. The region is divided into 19 administrative districts encompassing 147 *upazilas*: of these, 48 *upazilas* are exposed to the coast and 99 *upazilas* lie in the coastal interior.

The GDP of Bangladesh in 2012 was 115.6 billion USD, and the GDP per capita was 597.49 USD (Trading Economics, 2014). Another study (Younus and Harvey, 2014; Younus, 2014) reported that the failed effect of adaptation (to crop, houses and plants) due to extreme flood in 1998 was large, i.e. US\$ 14 billion, which is nearly 75 percent of the agricultural sector's contribution to GDP. The potential damage bill from a 10 year return- period cyclone in a changing climate has been estimated at US\$ 2.44 billion, but a further US\$2.12 billion could be added for potential losses by the year 2050 (WB, 2010). Though there is no available data on estimates of the cost of 'reducing vulnerabilities' in Bangladesh, the above information indicate that the failed effects of adaptation due to extreme floods, as an example, and the potential damage bill of cyclones both are large. Due to the poor state of the economy (as per country's total GDP and the GDP per capita), the Government is unable to reduce the vulnerability of the coastal communities, although through long experience the inhabitants have developed wide knowledge of how to cope with these calamities through using local resources and inherited knowledge. But despite their ingenuity and experience these coping procedures are not enough to enable them to survive relentless assaults on their land and homes; hence the region's

vulnerability and adaptation (V & A) factors need to be identified. At the same time the limiting factors (that is, the barriers to adaptation) need to be better understood as do the methods for overcoming those barriers. So far, no studies have addressed these issues.

In this work the authors had two key objectives:

- (1) To categorize the common vulnerability and adaptation issues through a weighting index scale from four case-study areas in the context of recent storm surges caused by cyclones in order to understand various intensity levels of V & A in coastal region of Bangladesh.
- (2) To identify the integrated common urgent adaptation issues and the adaptation constraints/limits; to determine the factors for overcoming those constraints at the community level in the case study areas in order to ensure sustainable adaptations to cyclones and storms.

Younus et al. (2012-13) emphasized the importance of prioritising vulnerability and adaptation issues at the community level, and by addressing these urgent V & A issues the region's development and sustainability can be ensured. This paper focuses on the combined and common vulnerability and adaptation issues that exist in four coastal regions in Bangladesh. With regard to these integrated issues the authors argue that vulnerability and adaptation factors, identified as priorities by this research, need to be addressed immediately in order to reduce the vulnerability of the communities to future climate change regimes. Moreover, this paper focuses on the constraints to adaptations, and how to overcome those constraints: in short, how to get things done so that people can more effectively adapt to severe events. This study is a model for the future allocation of adaptation funds at the community-level in Bangladesh.

Methods

'Participatory Rapid Appraisal' (PRA) sessions have been conducted in four coastal zones in 2013. Four different communities were selected from the coastal districts of Bangladesh, and these represent four coastal zones from four Districts (Map 1). The four districts represent the scenario of the total coastal belt because they include the south western district (Khulna), south central districts (Pirojpur and Borguna) and the south eastern district (Cox's Bazar). It is noted that during the last 125 years from 1991 (cyclone Gorkey) 40 cyclones ravaged the coastal area; specifically, six cyclones struck the Bangladesh coast during 1970 to 2009. 300,000 people died due to cyclone 'Bhola' in 1971.

A 'Participatory Rural Appraisal (PRA)' method was adopted, having been applied successfully in a previous study by Younus and Harvey (Younus *et al.*, 2012-13; Younus and Harvey, 2013). The PRA method has been used widely in other studies

and has been shown to be methodologically sound for use in developing countries (Theis & Grady, 1991; Chambers, 2002). The PRA method is a participatory research method where participants could describe the local vulnerability and adaptation aspects/issues. These issues have then been weighted through a 1-20 weighting scale. In this session, one participant, for example, identified one

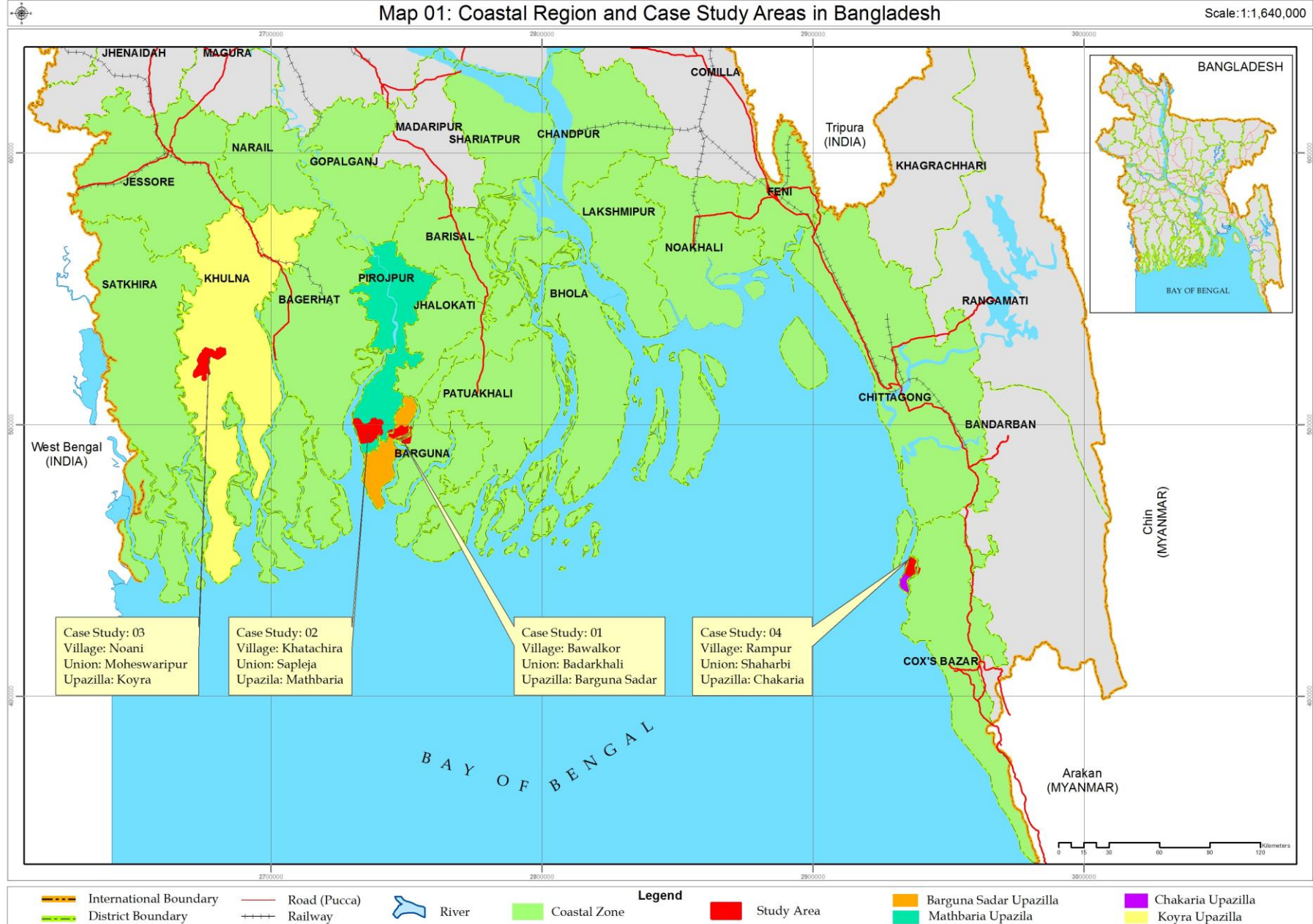
vulnerability issue; this issue has to be recognised and accepted by all the participants. This issue, when accepted, is weighted and agreed by all the participants. If any participant gives wrong information to the audience the other participants would refute it. The collective information was validated through this process.

The PRA method has several advantages and disadvantages. The advantages are: it provides substantial information within a short period of time; it can work effectively in illiterate societies and remote places where questionnaire survey is difficult to organise and time consuming; the information can easily be weighted, and intensity of vulnerability can easily be ranked; qualitative information can be transformed into quantitative data; it represents local knowledge, enables local people to make their own appraisal, analysis and plan; it is a bottom-up research approach which transforms local information to national policy information; it enables a consensus statement of the local people's opinion on the issue; it ensures local peoples' participation in the disaster management plan; it provides a 'basket of techniques' from which those most appropriate to the project context can be selected; it is cost effective. Two different PRA sessions were conducted for each *union* from four different districts. To assess vulnerability for this study, a weighted matrix index value (Baker & Rapaport, 2005; Ying & Liu, 1995; Glasson et al., 2005) was measured. V & A issues within each zone were identified based on the PRA which contained results of two cyclones. These two results were combined and an agreed weighted index value was generated.

Eight PRA sessions were conducted in four case study areas. Sixty eight vulnerability issues were identified, and participants were asked to come up with a number from 1-20, where 20 signifies highest vulnerability and 1 represents lowest vulnerability. It was also explained to them that the values are again ranked into four categories, very high (16-20), high (11-15), low (6-10) and very low (1-5). The participants discussed between themselves and agreed on one number for each vulnerability issue. Thus eight values were obtained for each of those issues. Composite indexes of those values were obtained, giving the final ranking for that particular issue. For example, on the issue of saline and sand deposition on agricultural land, three out of four rankings were high vulnerability and the remainder were low vulnerability. Subsequently this issue was ranked high according to majority consensus. This means saline and sand deposition was ranked as a "high vulnerability issue" for the whole case study area.

Map 01: Coastal Region and Case Study Areas in Bangladesh

Scale: 1:1,640,000



Adaptation issues were identified based on the respondents' perceptions, vulnerability experiences, needs and priorities based on pre-cyclone and post-cyclone scenarios. In accordance with the priority of needs, the adaptation assessment measurement scale was divided into four categories with equal interval i.e. 160-140: Urgent; 140-120: Intermediate; 120-100: Low; 100-80: Very Low. We excluded the issues with integrated weighted index values below 80, because of their very low frequency. Before the PRA sessions, pilot surveys were done for each study area and a semi structured questionnaire was formed which contained a checklist of vulnerability and adaptation issues. The issues of vulnerability (68) and adaptation (71) of the four case study areas (two PRA sessions in each case study area) were identified through these pilot surveys. Some case study areas had slightly higher numbers of issues than the issues mentioned in this paper but as these issues were of low weighted value according to the respondents, these have been omitted from the composite index.

The participants of PRA were chosen on the basis of "Judgement Sampling" which is one kind of non-probability sampling. Participants were selected who are considered to be most representative of the population as a whole. The men and women who took part in this study were recruited by personal contact. Information from recent major cyclones Sidr (in 2007) and Aila (in 2009) were obtained with reference to their effects on the case-study zones of Barguna, Pirojpur, and Khulna. Cyclone Aila did not strike Chittagong and so cyclone Gorkey (in 1991) and cyclone Sidr were taken as case-studies for that zone. Of the survey participants, 23 percent were farmers (both male and female) who owned their land and had extensive experience of farming; 26 percent of participants were fishers. The other half of the attendees comprised representatives of professional and community groups, and they included business people, service holders, community leaders, religious leaders, students, teachers, carpenters, day labourers, and rickshaw pullers. About 25 percent were female and almost 70 percent of the respondents were illiterate.

Climate-change impact assessment guidelines (IPCC: Carter *et al.*, 1994: USCSP: Benioff *et al.*, 1996: and UNEP & IES, 1996) were reviewed and seven steps/procedures were adopted. The steps are: step 1. Identification of V & A issues through PRA; 2. Cyclones and storm surges act as environmental barriers or constraints; 3. Adaptation options and limits were defined; steps 4. & 5: quantifying, classifying and identifying common V & A issues; 6. Developing a weighted value index; 7. The priorities and essentials of common V & A measures (including the limiting and overcoming factors for adaptation) are recommended in the light of climate change context.

The above adopted steps are mostly similar to other impact assessment guidelines but the manner of impact assessment of common vulnerability and adaptation issues in the coastal region has substantially differed from conventional (IPCC, USCSP and UNEP) guidelines. Firstly, in this study, unlike other assessment methods, the

identification of common vulnerability and adaptation issues was done through PRA followed by use of the weighting value index scale. Younus and Harvey (2013) discussed in detail the differences between the guidelines (IPCC, USCSP and UNEP) and micro-level bottom up assessment of V & A. Cyclones and storm surges have been considered here as environmental barriers and constraints; different levels of intensity of V & A (e.g. high, medium, low and very low) at case study level have been quantified and classified through the weighting value (WV) index. The levels were derived through local participants' consensus responses in a practical way. The evaluation of alternative adaptation strategies (how to overcome the barriers of current execution of adaptations) have also been indicated through this micro-level impact assessment in the present study – the alternative adaptation steps are shown in a different way which have not been prescribed in other guidelines. This study has shown a significant direction through which the local level climatic impact needs to be addressed. In addition, it shows how to identify common alternative adaptation options through local people's participation and consensus which may yield important findings of the local level's climatic shift. These local level findings could depict a range of interventions that are needed under the climate change regimes.

Results and discussion

Assessment of Vulnerability

Table 1 shows that the respondents in Cox's Bazar indicated 47 vulnerable issues which ranked as 'high' and which need urgent consideration for disaster management. Respondents in Barguna identified 42 high-vulnerability issues; respondents in Khulna identified 32 high-vulnerability issues, and the respondents in Pirojpur identified nine high-vulnerability issues for their area. This confirms that Cox's Bazar and Barguna were repeatedly struck by major cyclones (magnitude >6) whereas Pirojpur is located in a safer location than other coastal zones. Table 2 shows some common high vulnerability issues in four coastal districts. This also demonstrates the livelihood system of the area whereby most of the people directly or indirectly depend on agricultural production, fish-farming, and fishing. So the loss of primary occupation is one of the key threats from storm events.

Table 1. Number of Vulnerability Issues in Four Coastal Districts

Category of vulnerability	Barguna	Pirojpur	Khulna	Cox's Bazar
High vulnerability (HV) (WV: 16-20)	42	09	34	47
Medium vulnerability (MV) (WV: 11-15)	18	27	29	18
Low Vulnerability (LV) (WV: 6-10)	07	24	03	03
Very low vulnerability (VLV) (WV: 0-5)	01	08	02	00
Total No of Vulnerability Issues	68	68	68	68

Table 2. Common High-Vulnerability Issues in Four Coastal Districts

Primary occupation loss Pond-fish loss Culture fish-pond loss Agricultural input loss (seeds, pesticide, fertilizer) Labouring cost loss Land preparation for agricultural production loss Loss of working season (fishing/cultivation time) Loss of working efficiency
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Assessment of Adaptation of Four Coastal Communities

Using the PRA method, the survey by the authors identified adaptation issues in four different coastal zones: these issues were based on the participants' perceptions, experiences, needs, and priorities following various pre-cyclone and post-cyclone scenarios. In addition to the PRA participants, a number of older and more-educated local people were selected in order to gather more information about past disaster events and their impacts. About 71 adaptation issues were identified during the PRA session, these being summarised in Table 3.

Table 3. Number of Adaptation Issues in Four Coastal Districts

Category of Adaptation Issues	Integrated Weighted Value (WV) Index	No of adaptation issues in four coastal districts
Common Urgent Adaptation Issues (U)	160-140	14
Common Intermediate Adaptation Issues (I)	140-120	26
Common Low Adaptation Issues (L)	120-100	17
Common Very Low Adaptation Issues (VL)	100-80	14
Total No of Adaptation Issues		71

It can be seen (Table 3) that urgent adaptations require high priority. Of the many adaptation strategies 14 have been defined as being 'urgent'. Appendix A details the needs that arise after cyclone disasters. Food relief, supplies of safe drinking water, shelter construction-material, sanitation material, and the removal of uprooted trees were accorded urgent priority by all those who were surveyed. They also indicated the need for a proper damage-assessment system, for the prompt distribution of relief supplies, and for efficient recovery activities for the people most affected. The repair or reconstruction of roads, embankments, and communication system were also said to be urgent priorities. Particular mention was made of livelihood recovery-activities which can be done through easy access to low-interest loans from banks, governments, or NGOs. The participants also suggested the establishment of

disaster or climate funds at the local-government level (*Union Parishad*). The participants also reported that most of the time they could not understand the warning system which, it was said, needed to be reviewed.

The sale of land and trees after disasters was a common adaptation strategy in Barguna, Cox's Bazar, and Khulna. In these zones, the residents often move temporarily to other town and cities to make a living or to obtain loans, the money usually being used for fishing or for agricultural activities. This, too, is an adaptive strategy, and it must be remembered that some areas remain inundated for long periods, thus preventing farmers from making a living by resuming their usual agricultural activities. In such instances governments and aid agencies need to provide relief in the form of food and non-food item until the saline water subsides. Once the land is available again the farmers still need agricultural inputs (fertilizers, pesticide, seeds etc). In Cox's Bazar, immediate cash relief is preferred; in Khulna people sometimes choose to migrate from the area as an adaptation strategy because many are aware that increasing high tides, long-term inundation, salinity problems, and a lack of livelihood opportunities are on-going concerns. They also cited prohibitions against the conversion of agricultural land to shrimp farms as a constraint to the use of an adaptive measure for recovering from disasters. They also mentioned restricting the removal of trees and restricting the occupation of forest land as another urgent adaptive measure which may protect them from the severity of cyclone damage and a way of restoring biodiversity to the area. Another proposal was for the formation of village cooperatives; these could assist by strengthening local adaptations against future disasters, and would be useful in the early stages of recovery.

In regard to the construction of low-cost shelters, the elevation of house plinths using RCC (reinforced concrete column) columns is also an adaptive technique being adopted in Cox's Bazar and Khulna. In fishing communities in Khulna, Pirojpur, and Cox's Bazar the raising of the walls of ponds, and securing nets around ponds, were cited as urgent adaptive strategies. When considering the events in Barguna, Cox's Bazar and Khulna, the respondents focused on the different varieties of rice which could be used (such as HYV or saline-tolerant varieties). In Barguna and Pirojpur they emphasized the value of storm-warning practice drills which could be provided by local government agencies or by NGOs. Mock drills could be arranged in schools or colleges so that communities could become better prepared for the steps that should be taken during disasters and in the immediate aftermath of storms and floods.

Urgent Adaptations

Fourteen issues have been prioritized as 'urgent' adaptations as measured by integrated weighted index values above 140 (Appendix A).

Common Intermediate Adaptation Issues in Four Case Studies

According to the integrated weighted index values (120-140), 26 issues have been identified as 'common intermediate' adaptations (Appendix A).

Common Low-Adaptation Issues in Four Case Studies:

Issues with weighted index values of 100-120 were categorised as 'low' adaptation issues. Seventeen of the 71 issues have been categorised as being 'low' adaptations (Appendix A).

Common Very Low Adaptation Issues in Four Case Studies

Issues with weighted index value less than 100 were categorised as 'very low' adaptations. Fourteen issues have been allocated to this category (Appendix A).

Description of Common High Adaptation Issues, Constraints, and Recommendations

Thirteen common high adaptation techniques have been identified from the four case study areas which subsequently represent the coastal region of Bangladesh though each locality (e.g. agro-ecological zone or each coastal zone) holds diversified common vulnerability and adaptation techniques (Table 4). Some major aspects regarding the studied common adaptation issues have been investigated; these are: a. why adaptation is needed and what are the justification and benefits of these common adaptation techniques; b. what are the constraints or barriers of these adaptation implementations; c. how to overcome these constraints, along with some recommendations in order to improve sustainable adaptation in response with storm surges in coastal region of Bangladesh under the probable climate change regimes.

Conclusions and recommendations

This paper has focused on some recent aspects of community-based integrated vulnerability and adaptation issues in four case-study areas in coastal regions of Bangladesh. With population densities of about 750 per square kilometre, these districts are very poor and the economies marginal and vulnerable to weather-related events. The people may be poor but over time they have proved to be quite resourceful in the ways they have adapted to severe events. However, those events seem to be more frequent and more severe so that they capacity of people to adapt, recover, and readjust are being diminished. The survey reported here considered some of the issues which influence peoples' ability to adapt. Some key aspects of this survey method are as follows. Firstly, by using the PRA sessions with an integrated weighing method the common vulnerability and adaptation issues from four different coastal micro environments have been identified as common representative factors of coastal regions in Bangladesh.

Table 4. Common High Adaptation Issues, Constrains and Recommendations

Adaptation Techniques	Why needed /Justifications / Benefits	Adaptation implementation constraints	How to overcome these constraints; some recommendations
<p>1. Need relief in the form of food</p> <p>2. Need pure drinking water, water purification tablets, jerry cans</p>	<p>After severe storm surges, dry foods and pure drinking water are top priority relief items. During storm surges stoves become wet and all the water become saline, so it is an emergency issue to get pure drinking water. This zone depends on ponds and rain water for drinking and cooking purposes. Residents store rain water in bottles, jars, and drums. They purify the pond water with halotab tablets.</p> <p>Reserve ponds for pure drinking water are damaged in storm surges. Tube-wells are not effective sources of drinking water in this region because 1200-1500ft-deep wells are also unable to collect fresh drinking water. Moreover, due to lack of proper management, most of the tube-wells become unusable after storm surge. So, supplies of pure drinking water or halotabs can be helpful to meet the immediate challenges.</p>	<p>1. Inadequate funding and poor transportation networks are major constraints to the transporting of relief supplies to distressed people.</p> <p>2. Water is heavy and bulky so most relief agencies avoid transporting it from distant places.</p> <p>3. Everyone needs water after disaster period but the amount they receive is very limited.</p> <p>4. Storing rain water requires large containers which they cannot effort.</p> <p>5. Lack of information about flood and storm condition is also a barrier to relief work.</p> <p>6. Corruption among management, field staff, government and non-government staff, local representatives, Union Parishad members, Chairmen, and NGO workers are some major obstacles to effective relief work.</p>	<p>1. Maintaining reserve ponds for disaster periods, the boundaries to be built at such heights that flood-water cannot enter.</p> <p>2. More water purification tablets should be provided.</p> <p>3. Big containers (2000-3000 litres) may be used to store rainwater; they could be located beside cyclone shelters or near markets.</p> <p>4. Trollers (big fishing boat, locally made) may be used to carry water over waterways rather than roads. Local people could obtain pure drinking water at specified time at particular locations on river banks after disasters.</p>
<p>3. Need for temporary</p>	<p>Most of the houses in these four regions</p>	<p>1. Insufficient land and funding for</p>	<p>1. Efficient workers should be used</p>

shelter	<p>are katcha houses which are vulnerable to storm surges. To protect the people temporary shelters are needed. They also require security of life, valuable goods, livestock, and important papers. The katcha and semi packa houses were destroyed during cyclone Sidr. After Sidr many cyclone shelters were built in the area but still insufficient to meet their demand.</p> <p>The people were not aware of the use of warning systems prior to Sidr because they had not faced any major cyclones for many years. They encountered difficulties moving to shelters before Sidr struck as they were unaware of its approach. Insufficient shelters also increased the suffering of local people. Now they are more aware of the warning systems and they leave their katcha houses when alerted.</p>	<p>making shelters.</p> <p>2. Corruption among staff of NGOs and union parishads.3. Obstacles posed by third parties or agents between donors and victims. These inhibit the prompt and timely provision of all forms of assistance.</p> <p>4. Site selection for cyclone shelters is often influenced by local political leaders. They are biased and ultimately less vulnerable because people with good contacts with political leaders obtain better and less-vulnerable facilities.</p>	<p>for making houses.2. Equipment should be adequate and suited to recovery work and restorations.</p> <p>3. Selection of locations for cyclone shelters should be with the consent of local representatives; this will help preclude corruption.</p>
4. Need to maintain sluice gate.	Sluice gates are necessary to regulate the drainage of water. After a severe storm surge sluice gates need to be operated properly to maintain the water level, but most of them are not properly maintained. As a result rust is found.	Materials used in sluice gate are not appropriate and so rust and decay occur quickly. Technical knowledge about maintaining sluice gate is inadequate. Regular maintenance is also lacking.	The Water Development Board should strictly monitor the conditions of sluice gate. Directions and responsibilities for the management of sluice gates before, during, and after disasters must be clear and defined.
5. Easy access to bank/govt/NGO loans with low interest	To overcome acute conditions after storm surge people need immediate loans for recovery. They can obtain loans from local investors but at high interest. They need ready access to short-term or long-term	Banks are not providing loans to local people against any mortgaged property. Government and NGO-level cooperation is insufficient to meet demand. Financial constraints	No interest/ interest-free loans should be provided by different NGO/government/non government organizations.

	<p>loans at low interest (or without interest) from NGO's, banks, and government organizations. Such loans can play an important role in restoring occupations. Farmers and fishermen are able to use their loan in other sectors and it provides time to recover the losses from disasters.</p>	<p>are prominent in that case. Government is quite unable to support victims solely at that time. Funding shortages also apply to NGOs. After disasters some NGO's/INGO's providing assistance but it cannot help some people who are already in debt to different NGO's.</p> <p>It is a general practice for some people to obtain a loan from one NGO and using the instalments to repay another. It is a closed loop. This practice decreases the mental spirit of local people and discourages them from repaying banks from their own earnings. They may not be utilizing the loan money in their business and so economic stability is not achieved.</p>	<p>Knowledge of the proper use of loans should be strengthened among local people so that they can use the funds more productively. Cooperatives may be formed for disaster period from the income generated from loans.</p>
<p>6. Need to reconstruct roads</p>	<p>After cyclones Aila and Sidr many katcha and brick soling roads were damaged. Immediate relief couldn't arrive where it was needed because of poor roads and damaged infrastructure. Both internal and external markets are affected too. So roads must be repaired as soon as possible. Injured people cannot be taken to the hospitals because of damaged networks, and some areas remain isolated from the country.</p>	<p>Katcha, semi-paka, and paka roads are damaged by storm surges. Funding shortage is the main obstacle to repair. Everyone is busy with their own problems and cannot pay attention to road construction so the roads deteriorate even further.</p>	<p>Emergency response planning should establish priorities. Reconstruction of roads must be a high priority. Relief work will be enhanced if the road networks are maintained. A portion of relief funding should be applied to the repair of roads.</p>

7. Need to reconstruct sanitary facilities	Sanitary systems totally fail during extreme events. Slabs are often broken and latrines are washed out by water. Inundation of latrines is a serious problem, and they need immediate repair. Moreover, the effluent mixes with canals and ponds and thus pollutes open waterways. Water becomes unusable for drinking and cooking purposes. It can cause various diseases such as diarrhoea and typhoid.	People are often unaware of the dangerous effects of water pollution. The quality of sanitary latrines supplied by Union Parishad is very low and they are not located at suitable heights above flood levels. Little funding is devoted to constructing latrines so they are very vulnerable. Poverty is the main issue here.	Quality of ring slabs supplied by Union Parishad should be increased. Location and quality of construction of latrines are key issues for all coastal districts.
8. Allocate budget	Integrated planning is needed to reduce disaster risks in vulnerable coastal areas. All infrastructure items must take account of likely storms and surges. Construction of bridges, roads and sanitary latrines should be built in ways that they can survive disasters. It may take more funding to ensure that structures are disaster-resistant rather than having to replace items again after each event. So, governments should emphasize that there should be full integration between different departments when addressing disaster issues. Governments need to give special consideration to these areas and allocate budgets for the works based on each 'Annual Development Plan'.	<ol style="list-style-type: none"> 1. Lack of coordination among different sectors of government is the main problem. 2. Financial barriers are also responsible. 	Communication gaps between sectors should be minimized.
9. Need to assess damage and identify losses 10. Need to make the list of	Each disaster recovery-program involves damage assessment. If the assessment is conducted properly the areas of need can be identified and relief can be distributed	<ol style="list-style-type: none"> 1. Financial and technical barriers. 2. Tendency of people to prove themselves more vulnerable and more victims; this is a serious 	Experts and trustworthy people should be involved in assessments. Biases and nepotism involving relatives, families and friends should be avoided. People of one

priority relief.	where most needed.	<p>obstacle to accurate and fair assessment.</p> <p>3. Information collected and analyzed is not always correct, so victims most in need cannot be identified or located.</p> <p>4. Powerful communities obtain advantages while poor communities are inadequately identified or assessed.</p>	community may be assigned to do the assessment of another area, an approach which might help eliminate favouritism.
11. Need to train people about warning system	<p>Knowledge about warning systems is poor. Damage from Sidr was more severe than that of Aila because people were less aware of the warning system and so remained at home rather going to the cyclone shelter. But at time of Aila their response was different. They followed the warning and were able to reduce deaths, injuries and damage.</p>	<p>Local people are reluctant to learn about warning systems. In some places people reported having been misguided by false warning systems on previous occasions and so they ceased heeding the alarms.</p>	<p>Social awareness builds-up programs and may be provided to local people to encourage them to follow warning system. Text books for students at all levels should contain information about warning system so that new generations can play a role in disseminating information about cyclone warnings. Local religious leaders may provide accurate information and can play a great role in ensuring that people are better informed about warning system.</p>
12. Need to establish disaster/climate fund in the Union Parishad	<p>It is essential to establish a disaster fund in the Union Parishad for future events. Union Parishads may work at pre-disaster, during disasters, and after disasters. If they are active prior to events then damage will be reduced. Roads, trees, bridges, link-roads, and access to cyclone centres may be</p>	<p>1. Unavailability of funds.</p> <p>2.Lack of coordination in decision making</p>	<p>Proper monitoring is a prerequisite for establishment of such a fund.</p> <p>Local people should be involved to protect against corruption of UP members.</p>

	<p>maintained by community funds. Warning systems and evacuating people after disasters is also a duty of Union Parishads. So, if the Union Parishad works throughout the year it will be a benefit to the community when a severe event occurs. They will collect funds from NGOs, INGOs, or from governments so that they are prepared for any future emergencies.</p>		
<p>13. Need to ensure effective distribution of relief goods</p> <p>14. Need to recovery activities to all of the affected areas</p>	<p>It is important to distribute relief items and recovery activities properly otherwise some people will benefit while others are deprived.</p>	<p>Damage to transportation systems makes it very difficult for citizens to reach other communities and to move around. Relief teams might distribute aid to the people with better transportation facilities, failing to provide for those in remote inaccessible districts.</p>	<p>Transportation networks must be repaired as a top priority. There must be integration between all agencies responsible for distributing relief.</p>

The vulnerability factors have been divided into four categories: high, medium, low and very low, and the adaptation procedures have been described as urgent, medium, low, and very low. Secondly, by addressing the urgent adaptation issues, the main research gaps (that is, the constraints to adaptations at the community level, how to overcome those constraints, and some recommendations) have been explored systematically: the details are summarised in Table 4. These recommendations will help to ensure sustainable adaptations in response to future weather events under probable climate change regimes and sea level rise in the coastal regions of Bangladesh.

To reduce community vulnerability and to assist sustainable adaptations to these natural hazards, international donor agencies and developed countries, together with the Bangladeshi Government, need to pay more attention to local infrastructure development and improving other facilities (e.g. communication facilities, local transport modes, sluice gates, embankments, and multi-purpose cyclone shelters). Another priority is the installation of modern storm/surge warning technology and the education of the people in its use. It is important, too, that governments strengthen the work of local *union parishads* (for example, their work in relief distribution, monitoring, and evacuation). It would also be beneficial to train workers in *union* agricultural offices in order to improve local cropping patterns and reducing logging of saline water. Another improvement to aid adaptations would be easy access to funds which could be used to rebuild houses, re-establish farms and fisheries, and construct/repair ring-slabs latrines. Funds are also required for improving communication between local UPs and other local Government agencies, for helping to form cooperatives among the local communities, and for facilitating unbiased VGF lists through the UP or the community-based adaptation committee (CBAC) (Younus & Harvey, 2013; Younus *et al.*, 2012-13). The lists are needed for prioritizing rapid-response relief and for establishing and providing disaster/climate funding at the local UP or CBAC. To meet these many needs the Government must urgently develop effective adaptation policies in anticipation of climate change and sea-level rise, because in the future the main focus will be on strengthening local UPs and their connections with CBAC in order to reduce environmental, economic, and human damage from cyclones and storms in coastal region in Bangladesh.

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Appendix A: Common Adaptation Issues in Four Case Studies and ranking

No.	Common Urgent Adaptation Issues in Four Case Studies (Integrated WI Value 160-140)	Integrated WI Value (Total 160)
1	Need to calculate the damage	160
2	Need to ensure effective distribution of recovery activities to all of the affected area	158
3	Need to ensure effective distribution of relief goods to the all of the affected area	157
4	Need to identify actual looser to make the list of priority relief	153
5	Need to train people about warning system	153
6	Need relief of immediate food (puffed rice, flattered rice, molasses) for survival	152
7	Need to maintain sluice gate	147
8	Need to reconstruction of sanitary latrines	147
9	Need to give emphasis and allocate budget for the development work for climate vulnerable area in the Annual Development Plan (ADP) by Government	147
10	Need pure drinking water, water purification tablet, jerry cane	146
11	Need to reconstruction of road	145
12	Need to establish disaster/climate fund in the Union Parishad for the next time disaster that they can use it for early recovery stage.	144
13	Easy access to bank/government/NGO's loans with low interest	142
14	Need for immediate relief facilities (by the army)	141

No.	Common Low-Adaptation Issues in Four Case Studies (Integrated WI Value 120-100)	Integrated WI Value (Total 160)
1	Need to raise the boundary of ponds	119
2	Need to put net around the boundary of ponds in order to prevent fish being carried away by flood water	117
3	Need of immediate cash for survival after disaster	116
4	Selling land	116
5	Need loan for next seasons/ transition period's cropping, agricultural inputs, laboring, land preparation, watering without interest for 3 years or with very low interest	115
6	Need of loans for immediate foods	114
7	Need to store immediate food item & non-food item in the Union Parishad for the next time disaster that they can use it for early recovery stage.	113
8	Burial of dead bodies/animals	112
9	Need of immediate fuel/moveable stove	111

10	Need to train people through technical education	111
11	Need medicine/ health care	107
12	Need of temporary shelter construction material (Bamboo, rope, Plastic sheet)	105
13	Need of cash for work activities	105
14	Changing cropping pattern (time)	103
15	Need to recover the loss of students during and post disaster period	103
16	Need of cyclone shelter which should be multi-purpose (schools, drying wet crops)	101
17	Need to relief from the interest of loan for 1 year after the disaster	100

No.	Common Very Low Adaptation Issues in Four Case Studies (Integrated WI Value below 100)	Integrated WI Value (Total 160)
1	To move temporarily to other northern part/Faridpur/Gopalganj for paddy harvesting work.	99
2	Change of occupation	98
3	Need for alternative source of drinking, cooking water (i.e.Rain water harvesting, PSF)	98
4	Need to grow seedlings on flood free high land immediately	96
5	Need to establish easy communication	94
6	Need of small boat for transportation	93
7	Need to reconstruction of embankment which Height, Width, Riverside, Country side should be increased 5 feet, 6 feet, 10 feet, 30 feet, 12 feet more respectively.	93
8	Need to stop cutting mangrove forest	86
9	Need of loans for seedlings from professional lenders/wealthy persons/rich relatives/local land lords/banks/NGOs	85
10	Need to stop converting agriculture land to shrimp farming	85
11	Need to establish technical/vocational school	82
12	Selling personal belonging	81
13	Shifting house from outside of embankment to inside the embankment	81
14	Need permanent migrate to better place	80