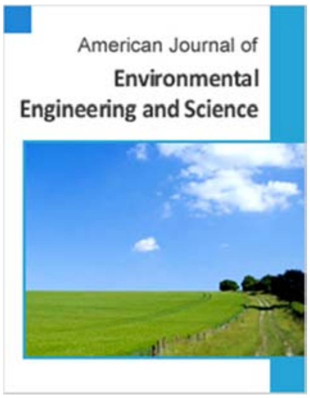
American Journal of Environmental Engineering and Science
2017; 4(1): 1-7
http://www.aascit.org/journal/ajees
ISSN: 2381-1153 (Print); ISSN: 2381-1161 (Online)

American Association for Science and Technology



Climate Change Induced Multi Hazards Disaster Risk Assessment in Southern Coastal Belt of Bangladesh

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Citation

Md. Sagirul Islam Majumder, Irteja Hasan, Shibaji Mandal, Mohammad Kabirul Islam, Md. Mustafizur Rahman, Nazmul Huq Hawlader, Israt Sultana. Climate Change Induced Multi Hazards Disaster Risk Assessment in Southern Coastal Belt of Bangladesh. *American Journal of Environmental Engineering and Science.* Vol. 4, No. 1, 2017, pp. 1-7.

Keywords

Disaster,
Risk Assessment,
Hazards,
Vulnerability,
Bangladesh

Received: January 12, 2017
Accepted: February 23, 2017
Published: June 3, 2017

Abstract

The coastal regions of Bangladesh are disaster prone due to its geographical location. Climate induced natural disasters like severe cyclone, shocking tidal surges, severe floods, underhanded river erosion, excessive rainfall, overwhelming salinity intrusion, sea level rise etc. are occurring more frequently in greater intensities along with prominent human activities. Disaster risk assessment is a key tool in natural disaster management and accurate risk assessment allows for realistic evaluation of such types of risk in a community is likely facing or to be faced in near future. The study was conducted in Amtali Pourashava Under Barguna district which is one of the lower administrative units of low lying deltaic coastal region of Bangladesh. The study mainly concentrates on the disaster risk assessment, impact of disaster in aspects of socio economic conditions in the study area. This study identified nine types of hazards which are particularly important for the study area. The results found that Amtali Pourashava is highly exposed to cyclone risks due to its different driver factors. People's response is insufficient in terms of climate resiliency and in some cases absent because of poor knowledge, absently skill, lack of adaptation technology, and lack of financial instrumental support. Such information is energetic to develop optimal intervention measures that will build resilience and reduce vulnerability. Climate smart adaptation practices should be focused on the climate education, pathways of sustainable livelihoods, climate resilient housing, and climate compatible health support for the most affected people.

1. Introduction

There is a consensus that over the coming decades, anthropogenic climate change induced natural disasters will cause histrionic changes in the biophysical systems that will distress human settlements, ecosystem services, water resources and food production in Bangladesh; all of which are closely linked to human livelihoods [12], [13], [17], [19], [24]. These changes are likely to have widespread effects for individuals, communities, regions and nations. In particular, poor, natural resource-dependent rural households will bear a disproportionate burden of the adverse impacts [2], [3], [5]. The number of people affected by disasters has increased significantly over the last 30 years. Sea level rise, floods, and tropical cyclone/storms surges accounted for approximately 100 thousand fatalities and US $250 billion of damage in 2005 [9], [22] and for 80% of life-threatening natural hazards worldwide [4].

Disaster Risk Assessment is such kind process which can help the community to reduce probability of harmful consequences, or expected loss (of lives, people injured, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable/capable conditions [6], [14]. Various risks assessment equations have been developed around the whole world. Wisner et al. (2004: 49) described the disaster risk equation using two elements, namely hazard and vulnerability. However, the Wisner et al. (2004) risk equation does not consider the community capacities to deal with different hazards. The UNISDR (2002) risk equation included the community capacities in the equation. This study used the UNISDR (2002) equation for getting the result of disaster risk assessment.

Table 1. *Disaster Risk Assessment Equations.*

R = H x V Where R = risk; H = hazard; V = vulnerability.	*Wisner et al. (2004)* Risk Assessment Equation
R = H x V / C Where R = risk; H = hazard; V = vulnerability; C = capacity.	*UNISDR (2002)* Risk Assessment Equation

The coastal communities of Amtali Pourashava has already been facing several climate change effects such as increasing cyclones, flood frequency probabilities, erosion, inundation, salt water intrusion and tidal surges etc. [1], [10], [16], [18], [21], [23]. This Study mainly concentrates on climate change induced multi-hazards disaster risk assessment in southern coastal belt of Bangladesh. Attempts have been made to disaster risk assessment that considered both quantitative and qualitative aspects of hazards, vulnerability and capacity factors. The methodology which is used here for risk assessment can also be applied to other any natural or anthropogenic disasters. The results which is found for this study are expected to provide a useful reference for decision and sustainable development for the coastal local community.

2. Selection of the Study Area

Amtali Pourashava lies with the Amtali Upazila within the Barguna District of Bangladesh. It is situated closely on the left bank of Buriswar River. It is geographically located between longitudes 90°00' and 90°23' east and latitudes 21°51' and 22°18' north. The study area is a Class-B Pourashava with an area is 8.96 km^2 and it consists of 15 Mahallas with 9 wards. Water bodies such as rivers, ponds, ditches and khals cover a substantial part of Amtali Pourashava. The study are lies about 38 kms from the sea coast and other important rivers in the area are Rupsa-Passur to the west a highly saline river that connects Gorai-Modhumati through Halifax-cut at Bardia, Atharobanka and Ghasiakhali, Bishkhali, Buriswar and Lohalia/Galachipa to the east. As it is coastal region of Bangladesh, different types of climate change induced natural and anthropogenic disaster hit in the study area. That's why nine words of Amtali Pourashava were selected for conducting the research.

3. Methodology

This study was followed purposive sampling method in order to assess the disaster risk in the study area. This sampling technique was selected in order to confirm that data and information were attained from well-informed and knowledgeable participants. The participants interviewed were disaster manager who had more than 10 years of experience in Disaster management sectors and University professors from Faculty of Disaster Management, Patuakhali Science and Technology University, Bangladesh. The middle aged local communities (60) were also included for conducting the research. They were interviewed in order to find out the extent and impact of climate change induced disaster risks in the study area. Maximum local communities are fluent in Bangla. Thus the interview session with local communities was carried out into Bangla and these were translated in English. Disaster risk assessment score sheets were circulated via email, and also distribution to the professors for getting the results. A risk assessment score sheet was used to capture collected data. Hazard assessment was determined through scoring some criteria such as geographical limits historical and geological records, likely impact of disasters etc. and overall rank of the identified risks (scale: from not likely to occur = 0 to extreme =1). The scores were added and then divided by six to give the hazard score. Similarly, Vulnerability and capacity assessment were also determined through the scoring of each different criteria. Risk equation calculation was used to get the final risk value for each hazards and prioritized them based on descending order. Qualitative data sets on elements the influence the climate change induced disasters were collected. People perception were also collected for quantitative data sets using interview method and questionnaire methods. Secondary data were collected from different journals, reports and websites which are available in the public domain. The collection of secondary data before visits was intended to reduce time needed from communities.

Table 2. *Characteristics Profile of the Respondents.*

Variables	Sub-variables	Respondents	
		Frequency	Percentage
Age	Young(21-35)	10	17
	Middle(36-50)	20	32
	Old(>50)	30	50
Sex	Male	35	57
	Female	25	43
Level of Education	Illiterate	15	25
	Primary	20	32
	Secondary	15	25
	Tertiary	10	18
Occupation	Agriculture	20	32
	Fisheries	15	25
	Day labors	15	25
	Others	10	18
Farm Size	Landless	20	32
	Marginal	15	25
	Small	15	25
	Medium	10	18
	Total	60	100

4. Results and Discussions

4.1. Socio-Demographic Characteristics

Human temperament is the most complex and interesting phenomenon. There are many consistent and integral powers that characterize distinct and take an essential part in influencing the development of human behaviour. These comprise the individual's, economic, social and psychological characteristics. The information regarding the selected characteristics of the rural socio demographic peoples features is presented in Table-2. Socio-demographic status is needed for knowing vulnerability condition resulting from various climatic problems with its future disaster impact assessment.

4.2. Hazard Assessment

Before the risk could be determined, it was essential to first conduct a detailed hazard, vulnerability and capacity assessment as required in the risk assessment equations. The assessment of climate change induced hazards is an integral part and it is the first steps of disaster risk assessment process. Hazards comes to disaster when they harm people and damage property beyond the ability of the community to manage. Nine types of major hazards (Table-3) identified at Amtali Pourashava include river erosion, cyclone/storm surges, saline water intrusion, sea level rise, earthquake, flood, excessive rainfall, hailstorm and water crisis [15]. These type of hazards have the potential to negatively affect the coastal sustainability and productivity in the study area. If these type hazards are not properly prevented or managed, it would be a great problem in near future. The hazard assessment results suggests that there is high probability for cyclone/storm surges (0.83) to occur in the coastal area. The community established disaster histories generally represent only the last few years but expert members founds cyclones from as early as 1965 and 1970 respectively. After that in the year of 1988, 1991, 1997 and 2007 respectively devastating cyclone occurred in the study location. After adding the all score of each hazard, the results clearly expressed that the management needs to develop plans and strategies to prevent the occurrence of these hazards.

Table 3. *Community Hazard Assessment Index.*

Hazards	Geographical limits	Historical and geological records	Access information	Likely impact of disasters	Likely physical nature of possible disasters	Probabilities for credible disasters scenarios	Total Value of hazards (H)
River bank erosion	0.75	0.50	0.50	0.25	0.50	0.25	0.46
Cyclone/ Storm Surges	1.00	0.75	0.75	1.00	0.75	0.75	0.83
Saline water intrusion	0.75	0.25	0.25	0.25	0.25	0.25	0.33
Sea level rise	0.50	0.00	0.00	0.25	0.25	0.50	0.25
Earthquake	0.25	0.00	0.00	0.00	0.25	0.25	0.13
Flood	0.50	0.25	0.25	0.25	0.50	0.50	0.38
Excessive rainfall	0.50	0.75	0.75	0.50	0.75	0.75	0.67
Thunderstorm	0.50	0.50	0.50	0.25	0.50	0.25	0.42
Water crisis	0.25	0.00	0.25	0.25	0.25	0.00	0.17

4.3. Vulnerability Assessment

The second stage in the risk assessment process is to estimate the potential loss of life and damage as a consequences of different kinds of disasters and to calculate the vulnerability score for the study area. This type of assessment will make broad reflection about vulnerability and the adverse impacts of different climate induced hazards. There are two types vulnerable groups of people in the study area such as living Pyra River side area (landless) and other who live outside the Pyra River. The people who are living nearside the river consistently suffers greater than who living outside the river. Human condition / gender, physical vulnerability, functional, economic, environmental, administrative are the basic criteria for analyzing the vulnerability in the study area. As the communities have faced adequate capacity to cope with destructive impact of natural calamities, their losses is getting higher day by day. The study found that the local communities are highly vulnerable to the damaging effects of hazards such as

Cyclone/Storm Surges> Excessive rainfall> Thunderstorm> Flood> River bank erosion> Water crisis> Saline water intrusion> Sea level rise> Earthquake

The previous estimated damage loss is the basic evidence analyzing the vulnerability and the Table-4 shows that the human loss occurred in that area mainly for the cyclone and storm surge. Cyclone disaster occurs more frequently and with greater intensity and severe damage than any other natural disaster on that location. They have virtually no existing systems that can be said they are protected from cyclone or others natural disasters. The local experts mentioned that economic and environmental damages by tropical cyclone generally higher considered to others hazards. Cyclone also causes highly damage of environmental settings in the study area. Other remarkable hazards which is affected is river bank erosion and for the people who live nearside the river of Pyra mostly damaged houses, infrastructure and agricultural crops. All types of natural disasters occur in the area commonly have a high damage to production sector. The infrastructural damage in the location causes only due to cyclonic storm and sometimes nor'westers. So, it is clear that the tropical cyclone is the major hazard occurred in the study location with severe damage within the combination of different sectors. However, in the Table 4, it is indicate that the last priority to vulnerabilities was earthquake (.08)

Table 4. *Community Vulnerability Assessment.*

Hazards	Human condition / gender	Physical vulnerability	Functional vulnerability	Economic vulnerability	Environmental vulnerability	Administrative vulnerability	Value of Vulnerability (V)
River bank erosion	0.25	0.00	0.25	0.50	0.50	0.25	0.29
Cyclone/Storm Surges	0.75	0.75	0.75	1.00	1.00	0.75	0.83
Saline water intrusion	0.00	0.25	0.00	0.50	0.50	0.00	0.21
Sea level rise	0.00	0.25	0.00	0.25	0.50	0.00	0.17
Earthquake	0.00	0.25	0.00	0.00	0.00	0.25	0.08
Flood	0.50	0.50	0.25	0.50	0.25	0.00	0.33
Excessive rainfall	0.50	0.25	0.50	0.50	0.75	0.50	0.50
Thunderstorm	0.50	0.75	0.00	0.50	0.50	0.00	0.38
Water crisis	0.50	0.50	0.25	0.50	0.00	0.00	0.29

4.4. Capacity Assessment

The third stage is to capacity assessment in local level through identifying different types of capacitates such as physical, social, economic, environmental, human and human. Communities capacities depends on some factors such as

- Degree of awareness regarding disasters risk on behalf of key stakeholders
- Condition of early warning system and in responses to a warning.
- Condition of vertical evacuation shelters and evacuation routes.
- Time required for the local community to reach shelters and safe areas.
- Risk transfer condition

Coping mechanisms for any disaster refers to the strategy applied by individuals, families, communities, institutions, firms and societies or governments to cope with the adverse condition. Coping strategies differ among the local communities that depending in most cases on what is available in the environment, the market and survival options [7], [8], [11], [26].

Communities' capacity is considered as an essential first step for resilience building. The studies examined the existing capacities against different natural disasters that were practiced by the individuals or communities. The research have found some capacities that were acquired by the rural communities to cope up with different natural climatic shocks. Communities has raised some capacities that were categorized into five such as physical, economic, social and environmental and human capacity. For assessing communities' capacity, five indicators (Physical, Social, Economic and Environmental and human Capacity) were considered. In the five indicators they were divided into different sub variables for assessing the communities' capacity in the study area. The coastal communities in the study area are capacitated in terms of increasing resiliency and the study found that the top priority was given to the cyclone capacity (0.40). Cyclones clearly indicate greater capacity comparing to other natural hazards. Because of its frequency and intensities, the study found that communities were developed additional capacities against cyclone in the study area. Experiencing the past extreme events, they are also developed in different sectors such as infrastructure, technology, health, livelihood, culture, skills etc. However, it is indicates that the less priority to community capacity was Thunderstorm (0.10). Every year a distinctive number of people were died due to thunderstorm. There is no formal or informal capacity for reducing the risk of thunderstorm. Majority of people mentioned that they did not take any preventive measures when any thunderstorm occurred. Again there is no specific rules and policies for coping with thunderstorm. Thunderstorm that affected the communities most and its coping capacity of communities is so much lower. As a result, the communities the priority response for different capacities for each hazards are shown in Table 5. These results therefore suggest that the management of identified hazards also need to re-work their plans in order to lessen the risks.

Table 5. *Community Capacity Assessment Index.*

Hazards	Physical capacity	Social capacity	Economic capacity	Human capacity	Environmental capacity	Value of Capacity (C)
River bank erosion	0.25	0.50	0.25	0.25	0.00	0.25
Cyclone/Storm Surges	0.50	0.50	0.25	0.50	0.25	0.40
Saline water intrusion	0.00	0.25	0.25	0.00	0.25	0.15
Sea level rise	0.00	0.00	0.25	0.25	0.00	0.10
Earthquake	0.25	0.00	0.25	0.25	0.00	0.15
Flood	0.50	0.50	0.25	0.25	0.25	0.35
Excessive rainfall	0.00	0.25	0.25	0.25	0.50	0.25
Thunderstorm	0.00	0.25	0.25	0.00	0.00	0.10
Water crisis	0.25	0.50	0.00	0.25	0.25	0.25

4.5. Disaster Risk Assessment

Hazard and vulnerability variables are considered in the Wisner equation as the important variables in determining the level of risk [25], [27] equation also considers hazard and vulnerability variables as important factor in risk analysis, but they includes capacity to respond to the identified hazards. Through using the UNISDR (2002) equation, the results found that the risk of cyclone is the highest value in the study area. Cyclone capacity is so much rich comparing to others disaster, but due to its maximum hazards and vulnerability score, it gets the highest value in the Table 6.

Table 6. *Community Disaster Risk Assessment Index.*

Hazards	Value of Hazard (H)	Value of Vulnerability (V)	Value of Capacity (C)	Value of Risk R= (H*V)/C	Ranking
River bank erosion	0.46	0.29	0.25	0.53	IV
Cyclone/Storm Surges	0.83	0.83	0.40	1.74	I
Saline water intrusion	0.33	0.21	0.15	0.46	V
Sea level rise	0.25	0.17	0.10	0.42	VI
Earthquake	0.13	0.08	0.15	0.07	IX
Flood	0.38	0.33	0.35	0.36	VII
Excessive rainfall	0.67	0.50	0.25	1.33	III
Thunderstorm	0.42	0.38	0.10	1.56	II
Water crisis	0.17	0.29	0.25	0.19	VIII

The analysis output shows that the level of risk varies due to its existing capacities. The second highest risk at thunderstorm (1.5), followed by excessive rainfall (1.33) and the last lowest value of risk is earthquake (0.07). The risk of earthquake is negligible in the study area, due to the geographical location. It is also marked that community capacity is low and gaps are significant to cope with different disasters. There is no existing effective emergency management (mitigation, preparedness or response) system that would save them from natural climatic shocks.

4.6. Impact of Disasters Using UNISDR Equation

The disaster risk assessment results showed that there is less existing effective community emergency management system. Though the cyclone warning System does exist but it is not community based and has limited functionality due to its separation from the community. Furthermore, it stops at early warning providing no effective evacuation, sheltering, food and water distribution, search and rescue, etc. There is no effective risk assessment process and not established an urgent emergency management system. It is clearly told that every need capacity needs to build in different sectors such as water, health care, education, gender equity etc. There are small scale examples of shared labor which can help them to cope with different kinds of climate change induced natural disasters. With increase vulnerability and impact particularly female headed households and landless, the level of capacity is not upgraded. The study area is used to vulnerable to many climates resulted vulnerabilities such as saline water intrusion, water crisis could increase the potential for higher incidence of vector-borne and water borne diseases. Lands are frequently flooded by excessive rainfall, sea surges associated with cyclone and various disasters are relatively common phenomena in the study area. The results also found that crop damage, reduced income, communication breakdown, drinking water problem, sanitation problem are occurring due to various disasters

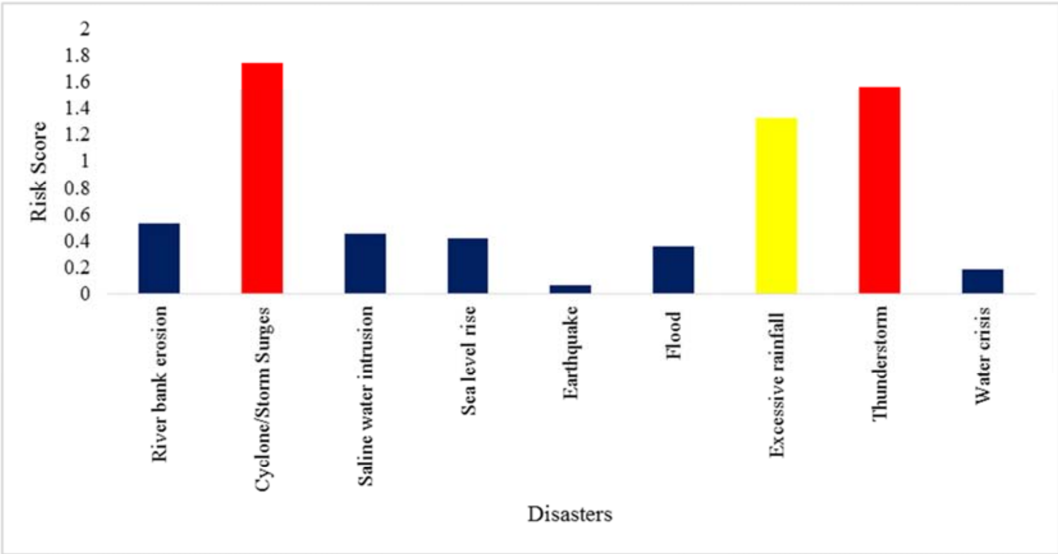

Figure 1. *Extent of risk at Amtali Pourashava using the UNISDR equation.*

5. Proposed Model for Coastal Community Resiliency

Conceptual framework for coastal community resiliency in context of capacity building mainly promotes to reduce the impact of disaster and increasing communities capacity that lead towards resiliency in the study area.

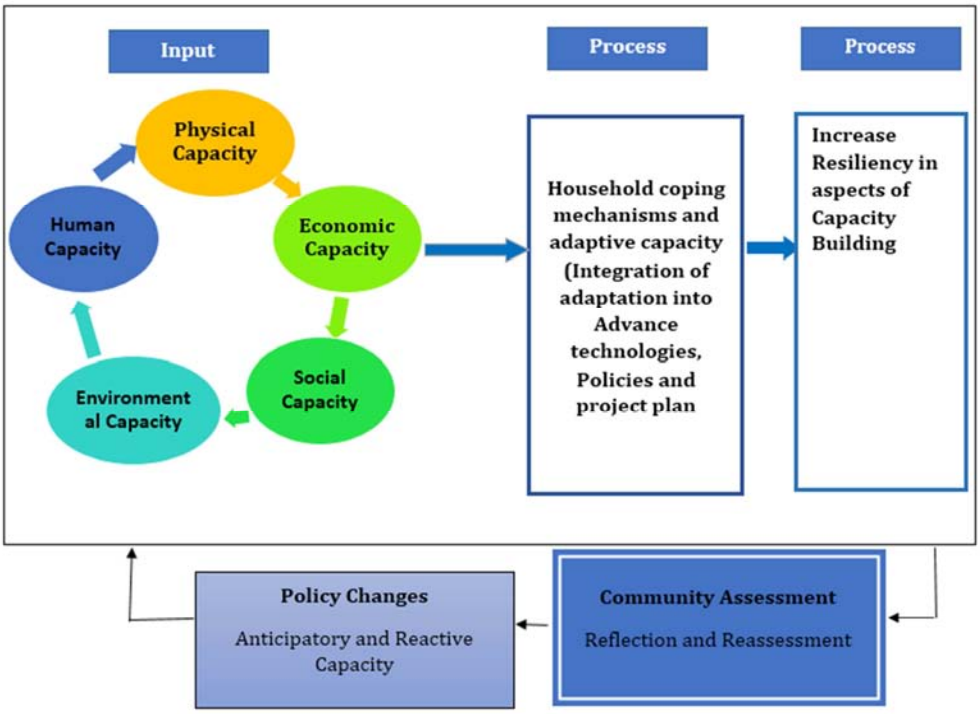

Figure 2. *Proposed model for coastal community resiliency in context of capacity building.*

6. Conclusion

The study proved that the process of disaster risk assessment is not only to find out where risk related problems are located, but also to quantitatively and qualitatively determine the significance of risks [29]. All disaster risks have been taken into account that are related to the study and it was found that Amtali Pourashava is highly exposed to cyclone risks. The study also found that the impact of disaster mainly effect on agriculture production which triggering food insecurity, reduced income, damaged transportation system, increasing the rate of migration as well as the livelihood insecurity. Preventive measures should be taken for reducing the risk and the main advantage of preventing risk is that it significantly reduces the cost associated with disaster response, recovery and development, particularly in the long term. The disaster risk assessment process helps to develop any new policies at national level or start a new project for the local community. However, the general concept and calculations of risk assessment process may not be possible to demonstrate the situation at local context especially for developing countries like Bangladesh. There are various complex processes for assessing the disaster risk and for that reason, there should be flexible and cost effective risk assessment approach that suits the local conditions of Bangladesh.

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