Risk Factors and Social Vulnerability

Thomas W. Schmidlin, Ph.D., Professor, Certified Consulting Meteorologist
Department of Geography, Kent State University, Kent OH USA

ABSTRACT

Bangladesh has among the highest death rates in the world from the hazards of tornadoes, strong wind, lightning, and hail. Current technology provides ineffective warning and communication. Social vulnerability to hazards is high due to poverty, weak housing, illiteracy, and lack of emergency services. Four steps are proposed to reduce risks from severe local storms in Bangladesh. (1) Install Doppler radar to detect storms, train meteorologists, and develop methods to convey warnings to villages and residents. (2) Develop severe local storm education materials with text and visual information about storms and storm safety. Distribute these to school children and in billboards, posters, and through emerging technologies such as mobile phones. (3) Construct household-level Bangladesh Ono Storm Shelters in a targeted community and monitor their acceptance and use. (4) Ensure that women are represented at equal numbers to men in the education and decision-making for severe local storm reduction and recovery.

KEYWORDS: Vulnerability, risk, warning, education, shelter, gender

1 INTRODUCTION

Bangladesh is extremely susceptible to natural hazards and these hazards complicate the already precarious socioeconomic and demographic conditions of the country (Haque 1997). Bangladesh is affected by several types of natural hazards, including tropical cyclones, severe local storms (thunderstorms), tornadoes, river floods, drought, erosion, and earthquakes (Karim 1995). A description of the frequencies and severity of severe local storms, the focus of this Forum, is given below. The primary purpose of this paper is to summarize social vulnerability to natural hazards, apply these to the situation in Bangladesh, and suggest means to reduce vulnerability to severe local storms in Bangladesh.

A hazard is an event that is a threat to people, their homes, and their livelihoods. Hazards exist through the interactions of social and natural systems and they exist within a social, political, historical, and environmental context (Cutter 2001). Risk is the probability that an event, the hazard, will occur. A disaster is a hazard event that causes widespread losses to people or the infrastructure in a society. Mitigation is a collection of actions that can be taken to reduce impacts of hazards and reduce vulnerability in society. Vulnerability to hazards is a measure of the potential for loss and is a complex interaction among risk, mitigation, and the social fabric of a place. Social fabric includes community experience with hazards and the ability to respond to, cope with, recover from, and adapt to the hazard (Cutter et al. 2003).

2 RISKS ASSOCIATED WITH SEVERE THUNDERSTORMS IN BANGLADESH

Severe local storms occur in an unstable, moist atmosphere and often take the form of a 'supercell', a long-lived thunderstorm with a rotating mesocyclone in the mid-levels of the atmosphere. They typically form along fronts or other boundaries in the atmosphere and may organize into a linear band called a squall line. If it is a long-lasting and large band of severe winds it is called a derecho. Thunderstorms form rapidly (less than one hour) and may last for several hours. They move at the speed and direction of the general airflow, typically 20-60 km/hr.

The dangerous elements of severe local storms can include lightning, large hail, heavy rains, strong winds, and tornadoes. These dangerous features of the storm may injure or kill people and animals, start fires in buildings or vegetation, flood fields and communities, damage buildings, destroy crops, blow down trees, and disrupt communications.

The most violent severe thunderstorms in Bangladesh develop during the pre-monsoon season of March-May and generally move from the northwest to the southeast (Peterson and Mehta 1981). These are commonly called nor'westers or kalbaisakhi. Peterson and Mehta (1981) identified a 'severe storm corridor' that extends from Peshawar to Bangladesh that is prone to severe thunderstorms with hail and high winds and a region of greatest tornado frequency centered within a 350 km diameter circle centered just west of Dhaka. They are most common in the afternoon and overnight (Peterson and Dewan 2002).

2.1 *Tornadoes*

Reports of tornadoes are not well-documented in Bangladesh and most studies have relied on newspaper accounts. Peterson and Mehta (1981) investigated tornadoes in India and Bangladesh and reported that about three tornadic events occurred per decade from 1931-70 with an increase to 14 during 1971-78 (about 2 per year). The increase was most likely due to better reporting of the events. They reported a median path length of 15 km, median path width of 150 m, and duration of about 20 minutes. Over 1/3 of the tornadoes caused deaths. Ono (1997a, 1997b) examined the record of tornadoes in Bangladesh for 1990-1994. He reported an average of 9 tornadoes per year and more than half were deadly tornadoes, killing an average of 54 annually. The frequency of tornadoes in Bangladesh is similar to the central United States, and is among the highest in the world. Recent tornadoes killed at least 111 people in Mymensingh and Netrokona districts on 14 April 2004, at least 600 people in the Jamalpur and Tangail districts of Bangladesh on 13 May 1996, and at least 800 in the Manikganj district on 26 May 1989 (Paul and Bhuiyan 2004).

2.2 *Strong winds*

The strong winds of severe local storms cause great losses to agriculture and damage to homes and infrastructure in Bangladesh. Winds of 100 km/hr or greater cause damage. Severe damage results from winds in excess of 120 km/hr. The yearly death toll is about 80 people, about 1000 are injured, and damages from these winds leave thousands homeless each year (Peterson and Dewan 2002).

2.3 *Lightning*

Lightning occurs with all thunderstorms. Numerous cloud-to-ground lightning strokes in severe local storms pose a serious threat to people who are outdoors and may even injure people in homes. The maximum occurrence of lightning over the entire Indian subcontinent occurs in central Bangladesh during the pre-monsoon season (March-May) with 40 lightning strikes per square kilometer (Ranalkar and Chaudhari 2009). Over 150 people are killed annually by lightning in Bangladesh, as reported in newspapers, but the actual death toll may be 500-1,000. A single lightning bolt killed nine and injured 23 in a hut in northeastern Bangladesh on 16 February 2006 (Gomes et al. 2006).

2.4 *Hail*

Large hail is fairly common during severe local storms in Bangladesh (Frisby and Sansom 1967). Bangladesh has among the world's largest numbers of human deaths and injuries from hail. The 1888 storm that produced a large tornado in Dhaka was said to have killed 150 people from large hail. In April 1986, hailstones as heavy as 1 kg killed 92 people in Gopalganj, Bangladesh. Hail also damages buildings and crops.

2.5 *Flooding*

Intense rainfall during severe local storms causes local flash flooding. These storms may produce 5-10 cm of rain in a few hours. Bangladesh is a country that is prone to flooding on a large scale. Flash flooding from severe local storms can cause rapid rises of water levels on small streams, flooding homes and crops and disrupting travel.

3 SOCIAL VULNERABILITY TO NATURAL HAZARDS

Social vulnerability to natural hazards is the potential for loss and is a complex interaction among risk, mitigation, and the social fabric of a place. Although social vulnerability may be assessed differently in different geographical settings, Cutter et al. (2003) provided generally accepted factors affecting social vulnerability. These include:

1 lack of access to resources such as information, knowledge, and technology,
2 limited access to political power and representation,
3 social capital including social networks and connections,
4 beliefs and customs,
5 building stock and age,
6 frail and physically limited individuals, and
7 type and density of infrastructure and lifelines.

The literature review by Cutter et al. (2003) showed that social vulnerability is increased for low income and low status persons, females, the elderly, young children, the rural poor and those dependent on extraction economies, those who rent, migrant workers in the service economy, large families, single-parent families, and special-needs populations. Vulnerability also increases in societies with rapid growth, and with loss of employment or infrastructure after a disaster, weak housing, and lack of nearby medical services. Davenport (1988) gave factors that lead to greater loss and suffering from wind storms. These were inadequate warning, social restraints, lack of community awareness, lack of emergency planning, lack of shelters, and

inadequate construction. Ikeda (1995) and Cannon (2002) found that women were more vulnerable than men to natural hazards in Bangladesh.

Vulnerability to natural hazards may be differently perceived and experienced among cultures and these dimensions are not easily comprehended or measured. Populations viewed from the outside as being especially vulnerable may actually be well adapted to their environment, resilient, and capable enough to cope with local hazards (Lein 2009).

The 'Hazards-of-Place Model of Vulnerability' given by Cutter et al. (2003) combines risk of a hazardous event with geographical context and social vulnerability into vulnerability of the place (Fig. 1).

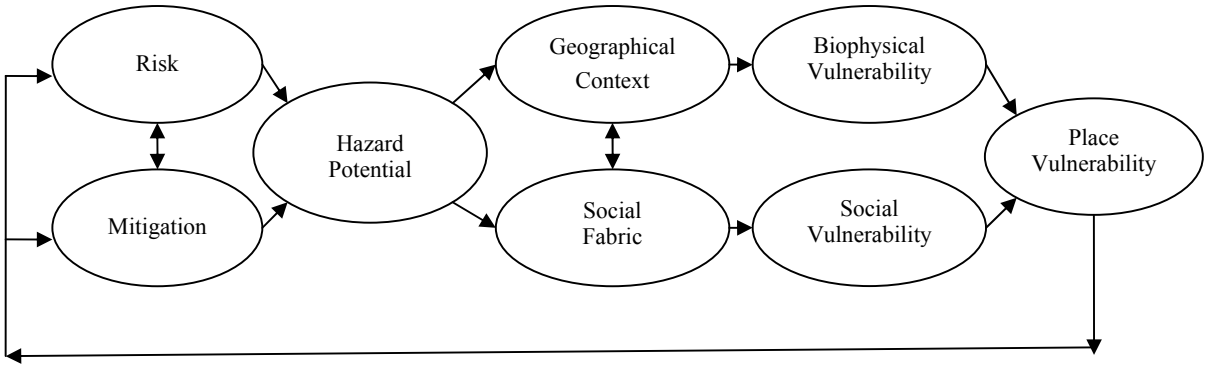

Figure 1. Hazards-of-Place Model of Vulnerability from Cutter et al. (2003).

4 SOCIAL VULNERABILITY TO SEVERE LOCAL STORMS IN BANGLADESH

Bangladesh has made progress in income-poverty reduction since Independence and the pace of poverty reduction increased during the 1990s in both urban and rural areas (Sen 2003). Yet, national poverty rates remained relatively high at 40% in 2000 (urban 26%, rural 44%) (Sen 2003). In Paul's (1998) study of households in areas affected by the 13 May 1996 tornadoes in Bangladesh, he found that 20% of the households were landless and another 65% owned less than 1 ha. Two-thirds of the heads of households were illiterate and 82% had five or fewer years of schooling. A lack of transportation and medical infrastructure results in additional suffering and deaths after severe local storms. Among those injured in the 1996 tornadoes, hundreds waited many hours to be taken by other people, without vehicles, to medical care. Even at medical facilities, electrical failures and overcrowding led to further delays in the care of injuries (Schmidlin and Ono 1996).

With much of the rural population dependent upon agriculture, yet functionally landless, with extensive illiteracy and housing that does not withstand the hazards of severe local storms, it is clear that residents of Bangladesh rank high on the social vulnerability factors listed by Cutter et al. (2003). The crisis that a natural disaster, such as severe local storms, brings to a family or to a community is a leading cause for descent into poverty in Bangladesh (Sen 2003). Thus, Bangladeshi society is highly vulnerable to the hazards of severe local storms and, when storms occur, the impacts cause deeper descent into poverty for families or entire villages.

Improvements in income, education, infrastructure, housing, social status, and political power can reduce social vulnerability to severe local storms. So that specific improvements and

progress can be achieved by this Forum, the remainder of this section proposes steps that could be taken to reduce vulnerability. These recommended steps are aligned with the 'Priorities for Action' in the Hyogo Framework of the United Nations International Strategy for Disaster Reduction (UNISDR 2007).

4.1 *Early Detection and Warning*

Weather observing stations and Doppler radar can give advance warning of severe local storms, including large hail, heavy rain, strong winds, and tornadoes. Bangladesh does not have an extensive network of weather observing stations or Doppler radar. There is no program to warn of severe local storms or to convey warnings to villages at risk. Thus, residents become aware of the hazardous situation only when they see or hear the storm or the storm is already upon them. Paul and Bhuiyan (2004) recommended better tornado warnings through installation of Doppler radar and warnings from the Bangladesh Meteorological Department (BMD) to the radio and television stations. Effective placement of Doppler radar can utilize population-weighted tornado incidence (Newark and McCulloch 1992). Paul and Bhuiyan (2004) also suggested that the BMD notify the Upazilla Nirbahi Officer by telephone and then Union Council Chair and law enforcement personnel could warn residents door-to-door, with megaphones, and with public speakers at mosques and temples. Increased use of mobile telephones (The Economist 2009) may provide a means for warning families and villages. People often seek confirmation of the threat through multiple sources, so redundancy in warning sources may be effective (Hammer and Schmidlin 2002).

To reduce vulnerability: Install more Doppler radar units. Provide training to BMD forecasters to recognize severe local storms. Develop severe storm warning criteria. Develop several methods to convey severe storm warnings to villages and residents.

4.2 *Education and Preparedness*

Limited access to electronic media restricts delivery of severe weather warnings and instructions for safe action, especially in the rural areas that account for 75% of the population and 93% of the area of Bangladesh. In 2005, 44% of residences in Bangladesh had access to electricity (urban 83%, rural 31%), 11.3% had access to a mobile phone (urban 26.7%, rural 6.1%), 2.9% had access to a land-line telephone (urban 10.4%, rural 0.33%), and 1.4% had access to a computer and email (urban 4.9%, rural 0.2%) (Hoque et al. 2007). In addition, the rural adult (age 15+) literacy rate of 42% (male 48%, female 36%) limits opportunities for text-based warnings and instructions for safe actions during a warning and after a disaster. Among patients treated after the 13 May 1996 tornado in Bangladesh, Kunii et al. (1996) reported that 73% of the patients had no radio or television and 94% had not known a disaster was imminent.

Community-level disaster preparedness is an important priority for Bangladesh (Karim 1995). Although education about storms and storm safety may be effective in primary schools, non-formal education in study circles, public talks, leaflets, posters, radio and TV, films, dramas, and folk songs is the more popular and effective way to make people aware and knowledgeable (Khan 2008). The one-page 'Tornado Safety Checklist' produced by the American Red Cross (2009) could be adapted and translated by the Bangladesh Red Crescent Society for distribution.

To reduce vulnerability: Develop severe local storm education materials that utilize text and visual information about storm appearance and the recommended protective actions. Emphasize storm safety materials in schools. Where literacy rates are low, use folk songs, dramas, story telling, billboards, and picture posters to convey information. Utilize technology as it diffuses among the population to provide varied methods of education.

4.3 *Shelter from the Winds*

Protection from the hazards of severe local storms – lightning, hail, flash floods, strong winds, and tornadoes – can be achieved by taking shelter in sturdy buildings above flood levels. However, there are few sturdy buildings to provide shelter from severe local storms in Bangladesh (Paul 1998, Ono 2001, Paul and Bhuiyan 2004). Most rural houses in Bangladesh are of kutcha construction, made of bamboo, thatch, and mud (Chisholm 1999). This results in large numbers of injuries and deaths (Ono 1997b, 2001). Among patients treated after the 13 May 1996 tornado in Bangladesh, Kunii et al. (1996) reported that most (88%) who were indoors took no evasive action while others lay on the floor. Persons outdoors either ran home (57%) when they saw the tornado, jumped into a river (29%), or entered a concrete block building (14%) which later collapsed resulting in many deaths and injuries. There is a need for practical and inexpensive measures using existing resources to minimize the impacts of severe local storms in Bangladesh. Paul and Bhuiyan (2004) found that people who heard the approaching tornado in north-central Bangladesh on the evening of 14 April 2004 were mostly at home when the storm struck. Those in the path sought other family members and took shelter inside their houses, typically under wooden beds. There were 111 deaths and thousands of injuries. Ono (2001) developed and tested the acceptability of an in-house tornado shelter for Bangladesh. This may be called the **B**angladesh **O**no **S**torm **S**helter (BOSS). This BOSS shelter has been endorsed by Paul and Bhuiyan (2004) who also recommended that community storm shelters be constructed in schools, hospitals, and markets, for people who do not adopt the BOSS in-house shelter and for those not at home when the storm strikes.

To reduce vulnerability: Choose a community that has been affected recently by a tornado to introduce the Bangladesh Ono Storm Shelter (BOSS), provide funding and assistance for construction of the BOSS shelter in homes, and monitor acceptance and use of the shelters.

4.4 *Gender*

Women are more vulnerable than men to natural hazards in Bangladesh. This is because they make up a disproportionate share of the poor and due to gendered characteristics of self-protection, social protection, and livelihood resilience (Cannon 2002). Women in Bangladesh have greater vulnerability due to poorer nutritional status than men, less and poorer-quality health care, loss of harvest and livestock income after disasters, responsibility for children, and inhibitions against interacting with men in the close proximity of storm shelters.

To reduce vulnerability: Ensure that women are represented at equal numbers to men in the education and decision-making for severe local storm risk reduction and in recovery after a storm.

5 CONCLUSION

Bangladesh has among the highest frequencies of severe local storms in the world. Bangladesh also has a high population density, weak housing, lack of shelters, social vulnerabilities of poverty and illiteracy, poor communication networks, and a lack of storm warning systems.

These factors contribute to high social vulnerability to injury, death, damages, and financial insecurities caused by severe local storms.

Four actions are suggested to reduce this vulnerability. One (Doppler radar and Observation Stations) will require large financial and technological investments. However, the others, Education and Preparedness, Shelter from the Wind (BOSS), and Gender Inclusion, have the potential to be very effective with small investments.

REFERENCES

1 American Red Cross. 2009. Be Red Cross Ready: Tornado Safety Checklist. http://www.redcross.org/www-files/Documents/pdf/Preparedness/checklists/Tornado.pdf. Last accessed 11 November 2009.

2 T. Cannon, Gender and climate hazards in Bangladesh, Gender and Development, 10 (2002) 45-50.

3 M.P. Chisholm, Improving rural housing in Bangladesh: Context, issues and priorities, Affordable Village Building Technologies, In S.M. Seraj, R.L.P. Hodgson, and J.R. Chowdhury, (Eds.), The Proceedings of H&H DHAKA99 Seminar, Dhaka, Bangladesh, 1999, pp. 110-122.

4 S.L. Cutter, The changing nature of risks and hazards, In S.L. Cutter, (Ed.) American Hazardscapes: The regionalization of hazards and disasters, National Academy of Science, John Henry Press, Washington, DC, 2001.

5 S.L. Cutter, B.J. Boruff, and W.L. Shirley, Social vulnerability to environmental hazards, Social Science Quarterly, 84 (2003) 242-261.

6 A.G. Davenport,The reduction of windstorm hazard through the IDNDR, Natural Hazards, 1 (1988) 235-243.

7 The Economist. A special report on telecoms in emerging markets, 392, no. 8650 (2009) 3-19.

8 E.M. Frisby and H.W. Sansom, Hail incidence in the tropics, Journal of Applied Meteorology, 6 (1967) 339-354.

9 C. Gomes, R. Kithil, and M. Ahmed, Developing a lightning awareness program model for third world based on American-South Asian experience, In Proceedings of the 28th International Conference on Lightning Protection (ICLP), Kanasawa, Japan, 2006.

10 B. Hammer and T.W. Schmidlin, Response to warnings during the 3 May 1999 Oklahoma City tornado: Reasons and relative injury rates, Weather and Forecasting, 17 (2002) 577-581.

11 C.E. Haque, Atmospheric hazards preparedness in Bangladesh: A study of warnings, adjustments and recovery from the April 1991 cyclone, Natural Hazards, 16 (1997) 181-202.

12 A.E. Hoque, A.R. Sikder, and M.S. Alam, Statistics for monitoring attainment of MDGs in Bangladesh. Bangladesh Bureau of Statistics (www.bbs.gov.bd), 2007.

13 K. Ikeda, Gender difference in human loss and vulnerability in natural disasters: a case study from Bangladesh, Indian Journal of Gender Studies, 2 (1995) 171-193.

14 N. Karim, Disasters in Bangladesh, Natural Hazards, 11 (1995) 247-258.

15 M.S.A. Khan, Disaster preparedness for sustainable development in Bangladesh, Disaster Prevention and Management, 17 (2008) 662-671.

16 O. Kunii, T. Kunori, K. Takahashi, M. Kaneda, and N. Fuke, Health impact of 1996 tornado in Bangladesh, The Lancet, 348 (1996) 757.

17 H. Lein, The poorest and most vulnerable? On hazards, livelihoods and labelling of riverine communities in Bangladesh, Singapore Journal of Tropical Geography, 30 (2009) 98-113.

18 M.J. Newark and D. McCulloch, Using tornado climatology to help plan a Doppler radar network, Natural Hazards, 5 (1992) 211-219.

19 Y. Ono, Climatology of tornadoes in Bangladesh, Journal of Meteorology, 22 (1997a) 325-340.

20 Y. Ono, Risk factors in mortality from tornadoes – A case study of the 13 May 1996 tornadoes in Bangladesh, Masters thesis, Department of Geography, Kent State University, Kent OH, 1997b.

21 Y. Ono, Design and adoption of household tornado shelters to mitigate the tornado hazard in Bangladesh, Doctoral dissertation, Department of Geography, Kent State University, Kent OH, 2001.

22 B.K. Paul, Coping with the 1996 tornado in Tangail, Bangladesh: An analysis of field data, Professional Geographer, 50 (1998) 287-301.

23 B.K. Paul and R.H. Bhuiyan, The April 2004 tornado in north-central Bangladesh: A case for introducing tornado forecasting and warning systems, Quick Response Research Report 169, Natural Hazards Center, Boulder CO, 2004.

24 R.E. Peterson and A.M. Dewan. 2002. Damaging nor'westers in Bangladesh, In Preprints of the 21st Conference on Severe Local Storms, American Meteorological Society, Boston, MA, 2002, pp. 389-392.

25 R.E. Peterson and K.C. Mehta, Climatology of tornadoes in India and Bangladesh, Archives for Meteorology, Geophysics, and Bioclimatology, Series B, 29 (1981) 345-356.

26 M.R. Ranalkar and Chaudhari, H.S. 2009. Seasonal variation in lightning activity over the Indian subcontinent, Meteorol. Atmos. Phys, 104 (2009) 125-134.

27 T.W. Schmidlin and Y. Ono, Tornadoes in the districts of Jamalpur and Tangail in Bangladesh, Quick Response Report #90, Natural Hazards Center, Boulder, CO, 1996.

28 B. Sen, Drivers of escape and descent: Changing household fortunes in rural Bangladesh, World Development, 31 (2003) 513-534.

29 UNISDR. Words in action: A guide for implementing the Hyogo Framework. (www.preventionweb.net/ files/594_10382.pdf) 2007. Accessed 12 November 2009.