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Atmospheric Hazards Preparedness in Bangladesh: A Study of Warning, Adjustments and Recovery from the April 1991 Cyclone

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Abstract. In probabilistic terms, Bangladesh is prone, to at least one major 'tropical cyclone' every year. This situation is primarily due to the geographical location of Bangladesh in tropical Asia, and to its concave coastline and shallow continental shelf. The devastating impact of such cyclones on humans stems from a combination of intense human occupation of the area, predominance of traditional sociocultural values and religion, the precarious socioeconomic conditions of the majority of the coastal inhabitants, and the lack of a coordinated institutional disaster planning and management strategy. Bangladesh has experienced several catastrophic environmental disasters during the last decade; among these events, the 1991 April cyclone was the most catastrophic in terms of both physical and human dimensions.

An initial study was carried out in the coastal regions of Bangladesh less than two weeks after they were hit by the severe cyclone of 29 April 1991. This research examined the process through which warning of the impending disastrous cyclone was received by the local communities and disseminated throughout the coastal regions of Bangladesh. It was found that the identification of the threatening condition due to atmospheric disturbance, the monitoring of the hazard event, and the dissemination of the cyclone warning were each very successful. The present study followed up on the initial research by surveying 267 respondents with an elaborate survey instrument, focusing on the most crucial academic and planning issues identified in the 1991 study. In particular, the nature and characteristics of the cyclone preparedness of the coastal inhabitants were assessed by the study; other factors considered included rural-urban variations, mainland-island differences, the nature and role of previous knowledge, and the disaster experience.

The survey results show the variety of indigenous adjustment mechanisms that help to rehabilitate the survivors; also visible are the profound roles played by the social inequality variables and the magnitude of physical vulnerability in influencing the disaster loss and recovery process. The study recommends that hazard mitigation policies should be integrated with national economic development plans and programs. Specifically, it is suggested that the cyclone warning system should incorporate the human response to warnings as its constituent part, and in this way accommodating human dimensions in its operational design.

Key words: cyclone, forecasting, warning, adjustment measures, response, recovery, relief and rehabilitation, Bangladesh, urban/mainland, offshore island.

1. Introduction

The geography of Bangladesh, as a humid tropical region, has largely caused the country to be extremely susceptible to catastrophic disasters such as floods, cyclones and storm surges; these environmental phenomena complicate the already

precarious socioeconomic and demographic conditions of the country. In probabilistic terms, Bangladesh is prone to at least one major tropical cyclone every year (Mooley, 1980), but an analysis for the period of 1890–1969 shows that, on average, 13 depressions were generated annually, of which 4.6 transformed into tropical cyclones (Raghavendra, 1973). A number of meteorological conditions that are necessary for the formation of tropical cyclones exist in the Bay of Bengal. In the bay, the water temperature remains at least 26°C throughout the year (Hastenrath and Lamb, 1979); this factor is probably of greatest importance as sea temperature of this magnitude to a depth of about 60 m is needed in the area for the development of a cyclone (Anthes, 1982; Emanuel, 1988). The second general requirement is a minimal vertical shear in the horizontal wind near the prospective cyclone. This situation exists in the Bay of Bengal during two periods of the year, namely, April–May and September–November, when the wind field over the bay is conducive to the necessary low-level inflow and high-level outflow. In addition, the shallowness of the deltaic coastal shelf contributes to surge elevation (Johns *et al.*, 1983), while the concavity of the bay and its estuaries further amplifies the surges (Dube *et al.*, 1982).

Encompassing an area of 147 570 km^2, Bangladesh presently contains a population of more than 118 million. The per capita income is less than $220 U.S. per annum and the majority of the rural inhabitants are functionally landless. Consequently, neither the institutions (i.e., collective entities) nor individuals can afford to implement capital-intensive preventive measures to avoid or minimize hazard-loss. Modifications in preparedness may therefore significantly improve the nation's ability to mitigate disasters.

Hazard warning systems (Sims and Baumann, 1983) and preparedness programs have generally proven to be effective in the developed world for informing people of impending danger as well as for modifying resource use systems (Smith, 1992: 198–199). However, since the reactions of people to hazard warnings have not been adequately and systematically investigated, literature on the overall effectiveness of the warning systems is meager. This study is primarily intended to examine the different components of the existing warning system in Bangladesh, the individual and institutional preparedness and adjustment measures to cope with cyclones, and the nature and characteristics of the disaster-recovery process.

2. Hazard Warning and Mitigation Measures: Conceptual Considerations

In general, reduction of losses due to extreme physical events can be achieved in two ways. The first option is the preventive 'environmental control', which involves modifying the hazard event itself. However, this type of large-scale environmental control is viable in only a few cases; usually, the suppression of 'natural events' is either impossible or, at best, entails uncertain side effects (Smith, 1992: 81). Also, due to economic, social, political and technological constraints, an absolute security against natural hazards can hardly be realized. For this reason, the modification

of human-made structures to make them hazard-resistant tends to be confined to small-scale interventions, such as developing and implementing building codes and other local regulations.

The second method of reducing loss involves changing human attitudes and behaviors towards nature. This approach, termed as 'human vulnerability modification', integrates technological means and human elements for hazard loss reduction. Smith (1992) has attempted to group the range of vulnerability modification options into the following categories: (i) forecasting and warning; (ii) community preparedness; and (iii) land-use planning. Due to the complete absence of an organizational structure to regulate and implement land-use planning in rural Bangladesh, home to the majority of the population, the scope of the third option is extremely limited in this country. The first two categories are then the focus of the present study because of their relevance to the context of Bangladesh.

The main purpose of warning systems is two fold: to enable people to take precautionary measures to minimize loss, and to insist on evacuation of an area in advance of an approaching hazard; success depends on the reactions and responses of people. Human responses to these warnings involve a complex set of sociopsychological, socioeconomic and cultural variables, which together lead to a wide variation in reactions, even including a reluctance to either take precautionary action or evacuate. In this connection, psychological block factors that might hamper effective warning responses are stressed by some investigators (Williams, 1964). In the face of this complexity, an assessment of responses of those being warned is crucial to develop an effective feedback system, considering that delays or halts in the flow of messages have been cited as problems both in the developed and the developing world (Warrick *et al*., 1981). Consider, for example, the problematic cyclone warning which was issued from the Meteorological Center at Gandhinagar, India to alert the population along the coastal districts of Gujarat in December of 1981. Sinha and Avrani (1984) found that a lack of coordination among the three responsible authorities (i.e., the civil administration, the port authority, and the observatory) left hundreds of thousands of fishermen and settlers uninformed and thus at the mercy of nature.

Although response to a hazard is largely related to perception of the threat and to awareness of opportunities to make adjustments, like the response to warnings, it is also profoundly influenced by socioeconomic and cultural constraints (Haque and Zaman, 1990; Haque, 1988; 1991). Human response and adjustment research in Bangladesh has focused primarily upon floods (Rasid and Paul, 1989; Haque and Zaman, 1993), riverbank erosion (Haque and Zaman, 1990; Mamun, 1996), droughts (Paul, 1992; Rahman, 1995), and storm surges (Islam, 1971; 1974; 1992; Khalil, 1992). By its absence from this list the nature of response to high winds and cyclones in the country has remained relatively unknown. Also, the degree to which individual resource managers and users are active in undertaking pre-disaster adjustment measures, as well as how they react during the onset of the event, have remained unexplored in Bangladesh disaster studies.

Other gaps are noticeable in relief efforts after a disaster. The issues concerning long-term effects due to disaster occurrences, recovery and rehabilitation of the victims at the local level usually do not receive continued attention from the concerned agencies. One of the reasons for such a pattern appears to be that the investment in disaster rehabilitation and recovery pays-off mainly in the long-term. Another significant reason is that, in most cases, recovery and rehabilitation measures, as undertaken by the development, emergency, relief and rehabilitation agencies and government ministries, are intended to address the welfare of the people. Such measures, in turn, deal with the problem of social opportunity costs involved with disruptions in normal functions of life and economic activities, rather than direct economic costs. Overall, both methodological difficulties and the lack of due institutional interest in the long-term recovery and rehabilitation process have left this a relatively neglected aspect in natural hazards research.

Palm (1990) has assessed the nature and contributions of hazards research by different disciplines of the social sciences. She criticizes the functionalist approach for its narrow scope; found mainly in sociology, it places its sole emphasis on organizational and community-related issues during the onset and post-event period. In contrast to this, the array of hazards studies in geography, anthropology and ecology in the past two decades indicates that a broad ecological framework is more useful to explain the complexity of environment-society relationships. In predictive terms, this latter approach can provide a more effective analytical tool by encompassing all phases of disaster process. The ecological framework prescribes the study of the characteristics of individual, group and institutional preparedness, and their responses and resilience to hazards. Specific disasters in Bangladesh will now be examined by using this framework.

3. Cyclone Preparedness in Bangladesh: The National Warning System

3.1. THE WARNING SYSTEM

As noted earlier, the Bay of Bengal which forms Bangladesh's coastline is one of the world's most active areas for the development of tropical low pressure systems. The cyclone of November 1970 has been the worst of this century, causing the deaths of 225 000 people, loss of 280 000 cattle, and destruction of properties worth U.S. $63 million (Frank and Hussain, 1971: 439). Development of this cyclone was initially noticed by the meteorological service of India and later detected by satellite and radar at Cox's Bazaar (Burton *et al*., 1993), but no warnings could reach the rural communities in coastal districts.

Following the catastrophic cyclone, a plan was formulated to protect against similar kinds of events which may occur in the future. The Bangladesh Meteorological Department (BMD) presently now takes responsibility for preparing all weather forecasts and disaster warnings. These tasks are accomplished through five interconnected subdivisions, all coordinated by the Storm Warning Center (SWC): (i) observations, (ii) communications, (iii) display and manipulations, (iv) analysis,

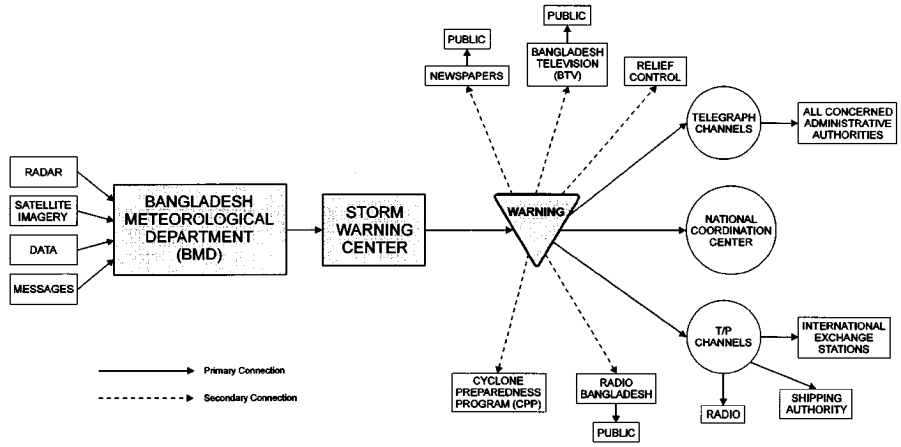

Figure 1. The flow of atmospheric information administered by the Bangladesh Meteorological Department.

and (v) prognosis (i.e. preparation of forecast) (Figure 1). The Center gathers data from four different sources. There are 35 surface observatories in the country which collect hourly data and send them to the Center in Dhaka; these data include wind speed, direction, humidity, air temperature and other meteorological variables at different elevations. The BMD also has three radar stations, at Dhaka, Khepupara and Cox's Bazar, transmitting hourly and half-hourly data (Figure 3). The Center receives U.S. NOAA (National Oceanic and Atmospheric Administration) satellite imagery via an earth station in Chittagong, and data from NOAA satellites 10 and 11 and the Japanese satellite GMS-4 via the Bangladesh Space Research and Remote Sensing Organization (SPARRSO). The World Meteorological Organization network also provides data to the BMD. The current organizational structure to procure, process, and disseminate atmospheric information, as shown in Figure 1, is efficient and effective. The nature and degree of coordination and cooperation between different subsets of the structure have improved due to regular review and feedback.

When the Storm Warning Center determines an impending threat, storm and cyclone warnings are disseminated to three areas: seaports, river ports, and the public. The Center also sends warnings directly to the National Coordination Committee (NCC), chaired by the Prime Minister, with representatives from the Cyclone Preparedness Program (CPP), user agencies (such as the Bangladesh Red Crescent Society, health administration, relief and rehabilitation authorities, and non-governmental organizations), mass media, and local administration.

The Cyclone Preparedness Program, an important link in the national warning system, was established in 1972 under an agreement between the Bangladesh Red Crescent Society (BRCS) and the Government of Bangladesh; it aims to undertake effective cyclone preparedness measures in the coastal belt prevent the loss of more

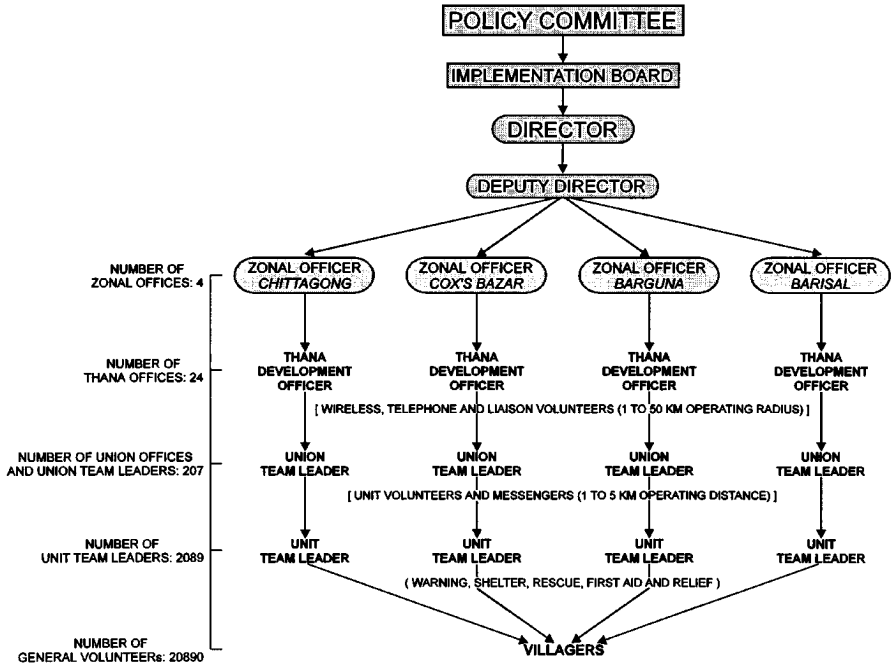

Figure 2. The organizational structure of the CPP.

than 70 million lives. The administrative structure of the CPP is depicted in Figure 2. Presently, the CPP has 20 890 trained volunteers in 2,089 units, divided among 207 unions under 24 *thanas* (subdistricts) of eight coastal districts, which further divide into four zones. Each union roughly has 10 units, individually involving at least 10 volunteers – usually these include school teachers, social workers, *moulavis* (clergymen), local government officials, and community leaders (Figure 2). At the zonal offices volunteers receive daily CPP communications, and in the case of potential hazards, disseminate warning signals, assist people in the evacuation process, execute rescue operations, provide first aid and help in the distribution of relief goods.

As a further measure, the national government of Bangladesh provides specific directives in the Standing Orders for Cyclones to ensure speedy and systematic management of any emergency situation. Several administrative groups are given specific functions and responsibilities during pre-disaster, disaster occurrence and post-disaster stages; these include: the concerned ministries, regional administrations (such as divisional commissioners), district commissioners, local administrations such as (*thana parishads* or councils, union *parishad*) and the Bangladesh Army, Navy, and Air Force. The National Coordination Committee (NCC) in Dhaka regulates the necessary steps as the central national body, while the Ministry of

Relief and Rehabilitation coordinates the post-disaster activities in collaboration with the BDRCS and other voluntary and international agencies.

3.2. THE 1991 CYCLONE WARNING PROCESS

On 24 April 1991, the BMD first recognized a low pressure system as a potential meteorological hazard at 2400 Greenwich Mean Time (GMT) (i.e., 06:00 a.m. local time) the system was then located near 10° N, 90° E, with sustained winds of 55 kph and gusts to 75 kph (Climate Analysis Center, 1991; Figure 3). At 1200 GMT (i.e., 06:00 p.m. local time) on April 27 the system was upgraded to a tropical cyclone, with winds of 130 kph gusting to 160 kph. This message was transmitted to CPP field officers, and the volunteers were immediately moved to alert the public with house-to-house contact . When the storm curved towards the northeast at 0600 GMT (i.e., 12:00 a.m. local time) on 28 April the SWC advised hoisting of 'local cautionary signal' number 3. Altogether, there are eleven signals, the most extreme indicating that the warning and communication system may completely collapse due to the impending disaster. Signal number 3 implies wind gust in the range of 40 to 50 kph. At 0800 GMT (i.e., 02:00 p.m. local time) on the same day the SWC upgraded the warning to 'local warning signal' number 4, and this message was transmitted to the CPP field officers. This signal indicated that wind would gust between 51 and 61 kph and that ports could be affected by the event (Mirza and Pal, 1992). Field officers were further advised to organize meetings of the coordination committees at all administrative levels and to take all possible precautionary measures in the face of the impending cyclone.

As the situation worsened, the mass media joined the effort to alert the public. Radio Bangladesh and Bangladesh Television broadcasted warnings from the morning of 27 April. On 29 April, the media cancelled all of their normal schedules and concentrated on issues of cyclone preparedness, including evacuation procedures, disaster recovery, first aid and emergency measures. The daily newspapers, however, did not print warnings as the headline events, although the immediacy and serious nature of the threat was indicated in the text of the newspaper coverage.

The cyclone reached its maximum strength on 29 April, with sustained winds estimated at 260 kph, gusting to 315 kph. At 0400 GMT (i.e., 10:00 a.m. local time) the SWC advised 'Great Danger Signals' to all communication channels. The CPP field officers hoisted three signal flags in all the alert points and suggested that people move to safer places; before the onset of the catastrophic event the local volunteers evacuated more than 350 000 people to 308 cyclone shelters.

At around 1800 GMT (i.e., 12:00 p.m. local time) on 29 April, the cyclone made landfall along the Cox's Bazar and Chittagong coastline. This depression of pressure, in conjunction with the full moon of 28 and 29 April, resulted in the highest level of the normal range of pre-surge tides (Haque and Blair, 1992). The central pressure of the 1991 cyclone was at least as low as 938 mb, according to measurements taken from ships at anchor outside the port of Chittagong (Seven-

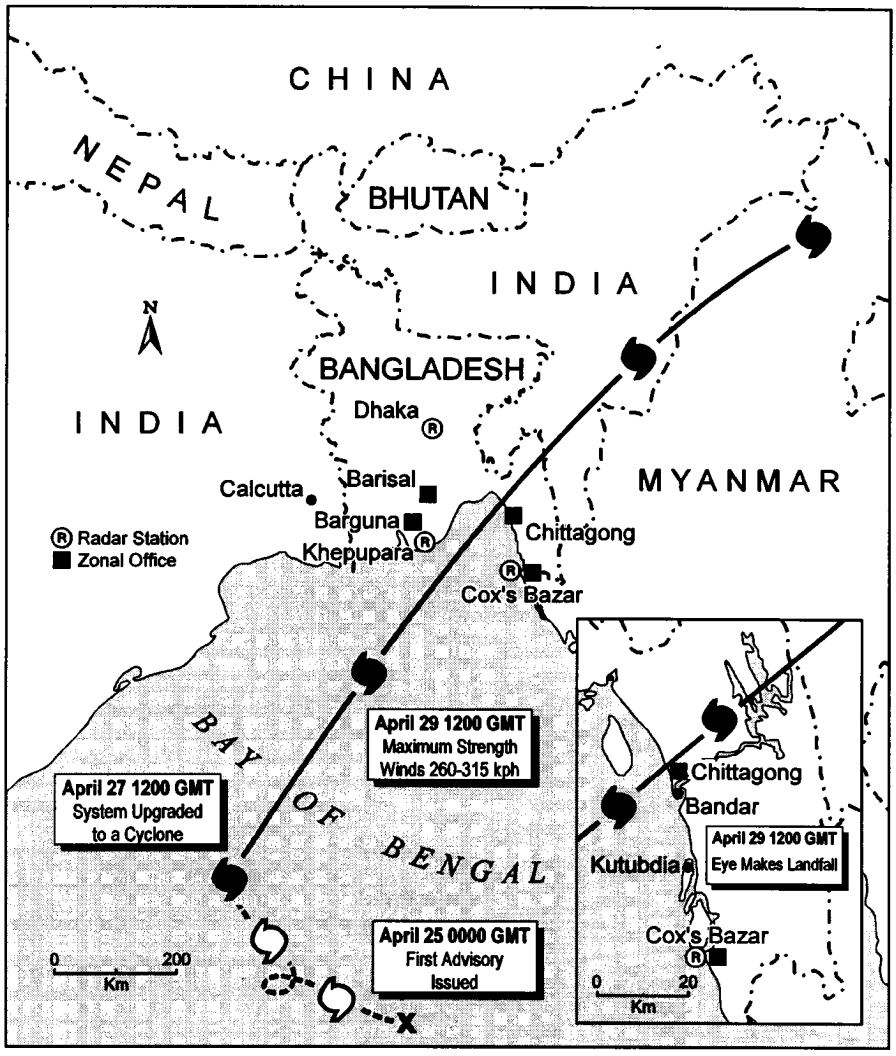

Figure 3. Location and path of the April 1991 cyclone into coastal Bangladesh.

huysen, 1991). Consequently, the surge and its related waves exceeded a height of six meters in the offshore islands and submerged more than 160 km of the country's coastline, including vast areas of Cox's Bazar, Chittagong, Bhola, and Noakhali districts.

The official death toll was recorded at 138 868, of which 23 were CPP volunteers who died while performing their duties. The government also recorded more than 460,000 injuries; among them 775 were CPP volunteers. The unprotected islands lost 40 to 50 percent of their population, while islands protected by embankments suffered a 30 to 40 percent loss of life – this in contrast to affected mainland

Table I. List of damages caused by the 1991 cyclone

Total affected districts	19
Total affected subdistricts (*thanas*)	102
Total affected municipalities	9
Total number of affected population	10 798 275
Damages to crops (in hectares)	
(i) fully	53 975
(ii) partly	320 607
Total number of houses damaged	
(i) fully	819 608
(ii) partly	882 750
Total number of deaths	138 882
Total number of people injured	139 054
Number of people missing	1225
Total number of livestock killed	
(cows, goat, sheep, poultry included)	1 061 029
Total number of educational institutions damaged	
(i) fully	3865
(ii) partly	5801
Total earthen-roads damaged (in kms)	
(i) fully	1230
Total number of bridges, culverts damaged	
(i) fully	496
Total number of embankments damaged (in kms)	
(i) fully	196
(ii) partly	941

Source: Islam *et al*., 1992.

areas, which suffered a 20 to 30 percent fatality rate (Sevenhuysen, 1991). The estimated economic loss, according to the National Coordination Committee, was more than two billion dollars U.S. Agricultural losses were recorded at 1 061 029 head of cattle, along with the complete destruction of 51 108 hectares of crops and partial damage of another 156 500 hectares (Crossette, 1991; Sevenhuysen, 1991; BDRCS, 1992). Table I presents a list of damages caused by the devastating cyclone.

4. Community Preparedness and Individual Responses: Sample Survey Results

In order to gain insight into the varying responses to the 1991 cyclone, two distinct communities were surveyed in the months of June and July of 1992, one from an urban/mainland area, and one from a rural/offshore island area. It was presumed that variations in communication and infrastructural facilities might result in cyclone

warnings being received more readily in the urban communities than in the offshore and rural communities. A similar survey was carried out by the author just after the April 1991 cyclone (Haque and Blair, 1992), but the sample size was limited to only 117 due to the unsuitable psychological state of the cyclone victims. The 1992 study was carried out with a larger and more authentic sample design in order to substantiate the validity of some of the previous findings.

In the 1992 survey, household units were considered as primary sampling units (PSU). Only the heads of the households were directly interviewed with a questionnaire. The PSUs were then drawn randomly to ensure the best possible representation of the target population. A total of 268 PSUs were covered – 162 from the urban/mainland sample and 106 from the offshore/rural sample. The urban/mainland sample was taken from the Bandar *thana*, consisting of the southwestern part of the City of Chittagong (Figure 3). The area felt severe effects, particularly by staggering economic losses, since it contains the major sea port facilities of Bangladesh, along with major industrial and commercial complexes. The rural/offshore island sample was obtained from the Kutubdia Island (Figure 3), a *thana* administrative area located 90 km south of Chittagong, along the northwestern coastline of Cox's Bazar district.

4.1. WARNING RECEPTION AT THE LOCAL LEVEL

The public received the hazard warning quite efficiently prior to the April 1991 Cyclone. The Chittagong municipal authorities, the district administration and nongovernmental organizations were first informed about the impending cyclone on 28 April, both by the NCC and the local CPP. Easy access by both paved and unpaved roads facilitated a rapid mobilization of the BDRCS volunteers, who reached all local 'wards' and communities of the Bandar *thana* area. Some relatively distant communities, settled mostly by poor fishermen, were not easily accessible, but the use of megaphones allowed these people to hear the warnings. The local mobilization of volunteers in Kutubdia began on 29 April. Although the Kutubdia *thana* headquarters is quite isolated from the mainland information sources, it does have a wireless center, operated by the CPP, which receives messages primarily from the surrounding *thana* CPP centers, or the regional centers stationed in Cox's Bazar. All of the six unions of the *thana* area were covered in warning dissemination efforts, including the villages in remote unions. The most distant communities experienced delays, especially those in Dhurong and North Dhurong, where they received cyclone warnings as late as the afternoon of April 29.

Among the survey respondents, more than 95 percent were present in the survey areas during the April 1991 cyclone. Out of a total of 162 respondents in the Bandar sample, only seven were out of the area; similarly, only six, out of a total of 106, were not on the Kutubdia island during the catastrophic event. Again, the communication system worked well all but five of the surveyed heads of households in Bandar received an early warning about the cyclone. Of all those who

Table II. Primary sources of early warnings of the 1991 cyclone

Source of early warnings	Bandar (urban/mainland)		Kutubdia (rural/offshore)	
	N	%	N	%
Radio broadcast	98	65.3	65	65.0
BDRCS	19	12.7	22	22.0
Newspapers	nil	–	nil	–
Local government officials/ community leaders	13	8.6	3	3.0
Neighbours	10	6.7	8	8.0
Other sources	10	6.7	2	2.0
Total	150	100.0	100	100.00

Source: Author's field survey, 1992.

heard the warning in both urban/mainland and rural/offshore island communities, about two-thirds received their warnings from radio broadcasts. Other aspects of the system were more effective in particular areas. The announcements and personal communications by the BDRCS volunteers were a more important source of information in the offshore islands than in the mainland, while local government officials and community leaders were more important in urban areas (Table II). It is observed that the warnings were widely received in both communities, but from a limited number of primary sources. Overall, the warning dissemination system that had been active in coastal Bangladesh since 1972 could be credited as very efficient. This success compares favorably to the enormous management problems of warning dissemination in India; as stated earlier, Sinha and Avarni (1984) cited a failure in passing out an early warning during the 1981 Gujarat cyclone in India.

4.2. RESPONSE TO WARNING AND ADJUSTMENT MEASURES

Responses to warnings among the coastal inhabitants were quite varied. In some instances, all the members of a household evacuated their usual place of residence if they were not residing in masonry construction. In some other cases, only the most vulnerable members such as women and children were evacuated. The remaining population stayed at home, and opting either for some alternative emergency measures or inaction, thereby accepting the potential loss and damage. The survey results indicate that about 49 percent of the urban/mainland and 71 percent of the rural/offshore island sample took this route, avoiding any deliberate emergency action after receiving the cyclone warning (Table III). Thus, the vast majority of the potential hazard victims remained vulnerable to the cyclone and storm surge strike.

A combination of factors contributed to such *en masse* inaction in the face of a severe threat, however, three of explanations stand out as the principal factors.

Table III. Distribution of measures taken by respondents after receiving early warning and before onset of flooding (multiple response possible)

Hazard mitigation measures taken	Bandar (urban/mainland) N = 162		Kutubdia (rural/offshore) N = 106	
	Frequency	%	Frequency	%
A. *'Active' measures*				
All household members evacuated	23	14.2	11	10.4
Women and children evacuated	22	13.6	5	3.1
Household goods and utensils moved	13	8.0	5	4.7
Household goods stored underground for future recovery	4	2.4	5	4.7
Anchorages placed	4	2.4	1	0.9
Livestock set free	3	1.9	18	16.9
Livestock moved to safer places	3	1.9	1	0.9
B. *'Passive' measures*				
No measures taken and prayed to to 'Allah'	79	48.9	75	70.7

Source: Author's field survey, 1992.

These are: (1) fatalism; (2) disbelief in the warnings; and (3) fear of loosing household assets (i.e., fear that home would be looted if abandoned for cyclone shelters) (Table IV). The unqualified acceptance of 'inevitable as inevitable' (Ittelson *et al*., 1974) was, and generally has been, one of the common factors for staying home and not responding to a warning. Disbelief of warnings, due to experience of false warnings in numerous past occasions, was another principal factor causing inaction against warnings. The surveyed communities had received alarms frequently over the last two decades, particularly after the establishment of the early warning system in 1972. Due to the random and unpredictable nature of the track of tropical cyclones, as well as uncertainty associated with the life cycle of these meteorological disturbances, early warnings in many cases had appeared to be 'false' to the local communities. Since people gradually become immune to alarms, it may be suggested that there is a trade-off between the gains of advance warning dissemination even when the probability of hazard is low, and the gains of reducing false alarms to enhance response to high-probability warnings. As discussed earlier, the storm signal numbers issued by the CPP indicate the degree of threat and the required precautionary measures. However, to what extent such distinctions are transmitted to the local units is not fully known. Further research is required for a better understanding of this issue.

In addition, a low frequency of events may discourage people from undertaking precautionary measures, and thus leave them unprepared for coping with hazards.

Table IV. Reasons for staying home by household heads after receiving cyclone warning (multiple response possible)

Reasons stated	Bandar (urban/mainland) N = 139		Kutubdia (rural/offshore) N = 95	
	Frequency	%	Frequency	%
Did not believe warning	69	49.6	34	35.8
Fear of burglary	74	53.2	56	58.9
Thought that 'it would not happen here'	24	17.3	13	13.7
Thought house would provide protection	21	15.1	9	9.5
Too many people at shelters, embankments, and high grounds	10	7.2	18	18.9
Cyclone was 'Allah's will'	87	62.6	86	90.5

Source: Author's field survey, 1992.

In the case of Chittagong and Cox's Bazar districts, many young adults had not been exposed to any severe tropical cyclones before 1991, and only the elderly had experienced the last catastrophic cyclone of 1960. A common statement of the survey respondents was, 'It never happened here – we thought it's not going to happen this time, too'.

Almost half of the urban sample and slightly over one-third of the rural sample stated that people stayed home because they were afraid of having their homes looted during the evacuation (Table IV). This response implies that a denser network of smaller shelters would be preferable to less numerous larger shelters, since such a policy would reduce the house-to-shelter distance, allowing for better protection of home property. There was also an inadequacy of cyclone shelters, particularly in the offshore islands. In Kutubdia, about one-third of the respondents indicated that the lack of shelter did not allow them to evacuate females and children.

Aside from the evacuation option, a few other alternative emergency measures have been used to minimize hazard-loss. Setting livestock free to provide them an opportunity for survival was a preferred action among the offshore inhabitants while saving household goods received priority among the urban dwellers (see Table III). It has been observed that potential hazard victims tend to take emergency measures primarily under the threat of intensive stress (Hewitt and Burton, 1971), which implies that the opportunity cost of increased risk associated with delaying is measured in terms of post-event predicament.

As noted in Section 3.2, the Bandar *thana* area was devastated by the vigor of the wind and the accompanying storm surge. Many residential buildings were severely damaged, and roofs of factories, commonly made of corrugated iron sheets were blown away (Figure 4). Furthermore, communication and electric poles were broken, most trees in the area were uprooted, and hundreds of boats and dinghies,

Figure 4. A retail shopping area in Bandar *thana* where cyclonic winds destroyed roofs and walls. Masonry buildings often cannot withstand the high-velocity winds. Although material losses due to cyclones are high in urban areas, the loss of human lives is comparatively lower here than in rural and island communities.

locally known as *sumpans*, were completely demolished (Figure 5). Consequently, the magnitude of damage and economic loss was immense, affecting almost all industrial and commercial establishments. However, the loss of human lives was substantially lower in these urban communities, compared to the rural and isolated islands. Overall, the urban areas felt the benefits of better preparedness among organizations and individual household owners, superior infrastructure, and quicker response by the potential victims.

The storm surge was much more intense in the islands since these communities are more exposed to the Bay of Bengal and surrounded by shallow shorelines. High gusts of wind, indeed, caused severe economic and material damage, but the loss of human lives was, by and large, the result of people being literally washed away by the tide of the storm surges. As a result of these factors, 58.5 percent of the Bandar sample lost at least one family member due to the impact of the cyclone and its associated storm surges. By contrast, only 8.6 percent of the Bandar sample experienced a similar loss. In both locations, more than 60 percent of such human casualties were women. Furthermore, in Kutubdia the most significant damage was done to housing structures which are normally made of a combination of clay and earth, bamboo, thatch, and corrugated iron sheets (Figure 6). Other economic losses

Figure 5. A shipwreck in the outport near Chittagong. Although the amount of economic value is considerable, such losses are generally recoverable from insurance.

included livestock, poultry, trees, crops, household goods, farming equipment, boats, fishing nets and other equipment. Economic losses at the household level in Kutubdia also were much higher than in Bandar, which was also reflected in the disaggregated data by economic-loss groups (Haque, 1993).

4.3. POST-DISASTER RESPONSES: RELIEF AND REHABILITATION

With regard to the resilience and rehabilitation of disaster victims, linkages between the institutional and individual spheres are crucial (Palm, 1990; Burton *et al.*, 1993; Hewitt, 1983). The analysis of data on emergency relief and long-term rehabilitation measures taken by the macro-level institutions to articulate the community and local level units is thus worth investigating.

In the rural/offshore island sample (i.e., Kutubdia), all but two of the survey respondents received emergency assistance and/or relief (Table V). Such assistance from external sources or collective organizations was provided in several forms; the provision of food, medicine, tents and shelter, and cash-money were the main emergency relief measures, while corrugated iron sheets and seedlings were principal items supplied through rehabilitation programs. Due to extremely poor transportation and communication links with the mainland, and more importantly, within the island, relief supplies could not reach the more remote villages for many

Figure 6. A rural community in Kutubdia island devastated by the April 1991 cyclone. Storm surges and coastal flooding, along with high winds, caused the loss of myriad human lives; survivors had to also face the destruction of their cattle herds and subsistence livelihood. The relative effects of cyclones upon household economy in islands and rural aras thus can be catastrophic and far-reaching.

days. In some cases it took more than a week to detect and reach the affected areas. During this delays many survivors lived on only coconuts, particularly in the northern villages of the island. Although the entire affected population here eventually received some forms of relief assistance, the time lag created an acute problem for many survivors.

In the urban/mainland area (Bandar), more than three-quarters of the households received relief assistance. In a few cases in this locality, the affected but relatively well-off families refused relief to allow others access to assistance. Due to the well-developed road network and easy access, food and drinking water quickly reached most affected zones of the Bandar *thana*. Two types of institutions, specifically foreign relief organizations and various departments of the national government of Bangladesh, provided the most important emergency supports – such as food, medicine, and drinking water – to the victims. Notably, in the case of other types of natural hazards such as riverbank erosion and floods, it has been observed that relatives, friends, and other traditional social institutions play a predominant role in disaster recovery and rehabilitation (Haque, 1989; Haque and Zaman, 1991). Contrary to this finding, the role of traditional institutions was found to be minimal in the aftermath of the cyclone (Table V).

In rehabilitation measures, only two types of programs were undertaken by the prevailing national and regional governments and nongovernmental organizations. As noted above, one program offered help to reconstruct houses and the other provided inputs for agricultural rehabilitation. Once again, the involved institutions included both foreign relief organizations and local governments, the latter a lower-order arm of the national government.

A key question that arises here is the extent to which relief met the actual needs of the hazard victims. More than half of the respondents, both in Kutubdia and Bandar, indicated that more than three-quarters of their crucial emergency needs were fulfilled. Nonetheless, in the case of rehabilitation, a relatively smaller proportion of respondents were satisfied; only a nominal proportion of their requirements were provided by the macro-scale organizations. These patterns altogether support the postulation of this study that the prevailing institutions generally ignore the importance of rehabilitation.

In the present study, further attempts were made to substantiate the above hypothesis. Based on methodology drawn from perceptual and psychological studies, a number of questions were structured. Results from the 1992 survey regarding the two most relevant responses are presented in Table VI. The vast majority of the respondents, both in urban/mainland and rural/offshore islands stated that they did not receive any information from government departments regarding coping strategies with cyclones and relevant loss-mitigation measures (Table IV). A few respondents had been informed of the tree-planting program offered by the Department of Forestry; other programs had only been suggested to a nominal number of respondents. Nonetheless, implementation of tree-planting programs, in cooperation with the nongovernmental organizations, has been viewed as one of the desired actions among the rural inhabitants. However, only a very few respondents mentioned the need for improvement of nonstructural measures, such as information and communication facilities, emergency medical and health care, relief and rehabilitation, and land-use zoning.

5. Policy Implications and Recommendations

This study assessed the nature and characteristics of cyclone preparedness in Bangladesh at the institutional and individual level. The specific focus was given to the April 1991 cyclone warning process, the emergency preparedness and responses among coastal inhabitants, and the state of institutional actions to provide relief and rehabilitation assistance to the cyclone victims. The phenomenal magnitude of human losses and economic setbacks due to the disaster has generated serious adverse impacts on the resiliency of the affected people.

Since the general vulnerability of the coastal occupants to extreme environmental threats is not a new phenomenon, the local inhabitants are familiar with the cyclones and are quite aware of the related risks. Despite that awareness, lack of a choice to move elsewhere, combined with the relative economic benefits of

Table Va. Cross tabulation of post-cyclone assistance received by item and source, Bandar *thana*, Chittagong (urban) (percent; multiple response possible)

Source	Food	Tent/shelter	Medicine	Cash money	Seedlings	C.I. sheets
Relatives	11.9 (17)[a]	13.6 (3)	6.9 (6)	9.5 (2)	nil	nil
Friends	5.5 (8)	4.6 (1)	2.3 (2)	4.8 (1)	nil	nil
Local government	21.0 (30)	4.6 (1)	8.2 (7)	23.8 (5)	nil	9.4 (3)
National government	12.6 (18)	22.7 (5)	9.3 (8)	19.1 (4)	100.0 (1)	21.8 (7)
National relief agencies	10.5 (15)	9.1 (2)	11.6 (10)	4.8 (1)	nil	9.4 (93)
Foreign relief agencies	24.5 (35)	45.4 (10)	46.5 (40)	38.0 (8)	nil	43.8 (14)
Others	14.0 (20)	nil	15.2 (13)	nil	nil	15.6 (5)
Total	100.0 (143)	100.0 (22)	100.0 (86)	100.0 (21)	100.0 (1)	100.0 (32)

[a] Frequencies are shown in parentheses.
Source: Author's field survey, 1992.

Table Vb. Cross tabulation of post-cyclone assistance received by item and source, Kutubdia *thana*, Cox's Bazar (rural) (percent; multiple response possible)

Source	Food	Tent/shelter	Medicine	Cash money	Seedlings	C.I. sheets
Relatives	1.3 (2)[a]	nil	nil	nil	nil	2.0 (1)
Friends	nil	nil	nil	nil	nil	2.0 (1)
Local government	17.5 (27)	6.9 (2)	3.1 (3)	38.5 (10)	36.4 (16)	25.5 (13)
National government	35.1 (54)	3.5 (1)	22.5 (22)	19.2 (5)	15.9 (7)	9.8 (5)
National relief agencies	18.8 (29)	6.9 (2)	20.4 (20)	7.7 (2)	18.2 (8)	9.8 (5)
Foreign relief agencies	22.1 (34)	17.2 (5)	54.0 (53)	34.6 (9)	29.5 (13)	50.9 (26)
Others	5.2 (8)	65.5 (19)	nil	nil	nil	nil
Total	100.0 (154)	100.0 (29)	100.0 (98)	100.0 (26)	100.0 (44)	100.0 (51)

[a] Frequencies are shown in parentheses.
Source: Author's field survey, 1992.

living in the region, especially from the salt industry, fishing, and agriculture in and around the offshore islands, contribute to the dense rural settlement. Similarly, the favourable geographical sites for the seaport and heavy industries, and again fishing aid the economic and demographic growth of Chittagong and its environs.

In general, the disaster warning system in Bangladesh functions quite effectively in terms of identification, monitoring, and forecasting of meteorological conditions. Given resource constraints and the lack of infrastructural facilities in the country, the cyclone warning dissemination process in 1991 successfully alerted people to the potential threat and recommended emergency measures. Yet, a vast majority of the potential victims in coastal regions reacted passively to warnings due to disbelief, fear of burglars, and lack of proper cyclone shelters. The results of this study suggest that the cyclone warning system, in order to attain its goals, should regard the human response to warnings as its constituent part, and accommodate

Table VI. Distribution of recipients of precautionary suggestions from government sources since 1991 cyclone

Response	Bandar (urban/mainland)		Kutubdia (rural/offshore)	
	Frequency	%	Frequency	%
A. 'Have you received any suggestions on cyclone impact mitigation/rehabilitation measures from government departments?'				
Yes	15	9.3	17	16.0
No	147	90.7	89	84.0
	N = 162	%	N = 106	%
B. 'What type of suggestions have you received?' (multiple response possible)				
To plant more trees	13	8.0	17	16.0
To build *pucca* (brick/masonary) houses	5	3.1	2	1.9
To obtain a radio or television	7	4.3	6	5.7
Others	9	5.6	4	3.8

Source: Author's field survey, 1992.

these human dimensions in its operational design. It is recommended that the cyclone warning system must account for the response component, an analysis of which, together with the overall performance of the program, should form a basis for future strategies and policies. Rather than merely an isolated system, the hazard warning system should be regarded as a subset of a comprehensive disaster preparedness and management program.

In order to improve the rate and nature of response – that is, to make people more aware of the severity of the hazards and of precautionary options – educational and developmental schemes need to be formulated. Such plans however should be developed as part of income generating activities in order to help ameliorate the socioeconomic plight of the rural population. The study recommends that hazard mitigation policies should also be integrated with national economic development plans and programs. At the present time, the region has less than a thousand cyclone shelters, which together can accommodate less than a million people; the five million people vulnerable to cyclone damage all require access to such shelters. This expensive effort could be economized by constructing multipurpose shelters, buildings which could also serve as schools, health facilities and agricultural extension centers. Many communities in India have already adopted such a policy (Mishra and Prakash, 1982).

Resilience of the cyclone victims in sociopsychological terms is seen to be quite remarkable. But the perpetual process of impoverization and marginalization of the vast majority of the population is accelerated by the impact of environmental

events. Due to the lack of appropriate rehabilitation, the ongoing process of cumulative vulnerability of these people will only cause more loss and damage in future hazard events. The trend of national and international resource allocation solely towards physical prevention and control of environmental events ignores the need to link the poor and marginalized disaster victims with the development process. The current system offers only partial solutions in disaster-mitigation efforts. It is therefore recommended that policy development that concerns disaster prevention and mitigation should integrate approaches from science and technology, and societal management.

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References

Anthes, R. A.: 1982, *Tropical Cyclones: Their Evolution, Structure and Effects*, Monograph Number 41. American Meteorological Society, Boston, Massachusetts.

BDRCS (Bangladesh Red Crescent Society): 1992, *A Guide to Volunteer Training. Cyclone Preparedness Program*, Dhaka (in Bengali).

Burton, I., Kates, R. W., and White, G. F.: 1993, *The Environment As Hazard*, 2nd edn, Guilford Press, New York.

Climate Analysis Center: 1991, *Weekly Climate Bull.* **91/18**, May 4, 1991, National Weather Service, NOAA, United States Department of Commerce, Washington, D.C.

Crossette, B.: 1991, Bangladesh toll now laid in part to poor aid plan, *The New York Times*, 4 May, New York.

Dube, S. K., Sinha, M. C., and Balasubramanyam, V.: 1982, The effect of coastal geometry on the location of peak surge, *Mausam* **33**, 445–450.

Emanuel, K. A.: 1988, Toward a general theory of hurricanes, *American Scientist* **76**, 371–379.

Frank, N. L. and Hossain, S. A.: 1971, The deadliest tropical cyclone in history?, *Bull. Amer. Meteorol. Soc.* **52**, 438–444.

Haque, C. E.: 1988, Impact of River-Bank Erosion in the Brahmaputra-Jamuna Floodplain: A Study of Population Displacement and Human Response Strategies, PhD Dissertation, University of Manitoba, Winnipeg.

Haque, C. E.: 1989, Human adjustments to river bank erosion hazard in the Jamuna Floodplain, Bangladesh, *Human Ecology* **16**, 421–437.

Haque, C. E.: 1991, Human responses to riverbank erosion hazard in Bangladesh: Some lessons from indigenous adjustment strategies, in K. M. Elahi *et al.* (eds), *Riverbank Erosion, Flood and Population Displacement in Bangladesh*. Jahangirnagar University, Dhaka, pp. 191–217.

Haque, C. E.: 1993, An appraisal of the disaster process in Bangladesh: What has been happening to the April cyclone victims?, in M. R. Wilson (ed.), *Proceedings of the Prairie Division*, Canadian Association Geographers, Department of Geography, University of Saskatchewan, Saskatoon, pp. 205–220.

Haque, C. E. and Blair, D.: 1992, Vulnerability to tropical cyclones: Evidence from the April 1991 cyclone in coastal Bangladesh, *Disasters* **16**, 217–229.

Haque, C. E. and Zaman, M. Q.: 1990, Coping with riverbank erosion hazard and displacement in Bangladesh: Survival strategies and adjustments, *Disasters* **13**, 309–323.
Haque, C. E. and Zaman, M. Q.: 1991, Working together: reflections on collaborative research in Bangladesh, *Canadian J. Development Studies* **12**, 387–403.
Haque, C. E. and Zaman, M. Q.: 1993, Human responses to riverine hazards in Bangladesh: A proposal for sustainable floodplain development, *World Development* **21**, 93–107.
Hastenrath, S. and Lamb, P. J.: 1979, *Climate Atlas of the Indian Ocean*, Part I: Surface Climate and Atmospheric Circulation, The University of Wisconsin Press, Madison, Wisconsin.
Hewitt, K.: 1983, The idea of calamity in a technological age, in K. Hewitt (ed.), *Interpretations of Calamity from the Viewpoint of Human Ecology*, Allen and Unwin, London, pp. 3–32.
Hewitt, K. and Burton, I.: 1971, *The Hazardousness of a Place: A Regional Ecology of Damaging Events*, Department of Geography, University of Toronto, Toronto.
Islam. M. A.: 1971, *Human Adjustment to Cyclone Hazards: A Case Study of Char Jabbar*, Natural Hazards Research Working Paper No. 18. University of Toronto, Toronto.
Islam, M. A.: 1974, Tropical cyclone, coastal Bangladesh, in G. F. White (ed.), *Natural Hazards: Local, National, Global*, Oxford University Press, New York, pp. 19–24.
Islam, M. S. *et al*.: 1992, A case study on April 1991 cyclone of Bangladesh, A paper presented at the workshop on Improving Cyclone Warning Response and Mitigation, January 19–30, 1992, Dhaka.
Ittelson, W. H. *et al*.: 1974, *An Introduction to Environmental Psychology*, Holt, Rinehart and Winston, New York.
Johns, B., Sinha, Dube, P. C., Dube, Mohanty, U. C., and Rao, A. D.: 1983, On the effect of bathymetry in numerical storm surge simulation experiments, *Computers and Fluids* **11**, 161–174.
Khalil, G. M.: 1992, Cyclones and storm surges in Bangladesh: Some mitigative measures, *Natural Hazards* **6**, 11–24.
Mamun, M. Z.: 1996, Awareness, preparedness and adjustment measures of river-bank erosion-prone people: A case study, *Disasters* **20**, 68–74.
Mirza, M. M. K. and Pal, S.: 1992, *Prakritik Durjog O Bangladesher Poribesh*, Centre for Environmental Studies and Research, Dhaka (in Bengali).
Mishra, D. K. and Prakash, H. R.: 1982, An evaluation of the Andhra Pradesh cyclone shelters programme, *Disasters* **6**, 250–255.
Mooley, D. A.: 1980, Severe cyclonic storms in the Bay of Bengal, 1877–1977, *Monthly Weather Review* **108**, 1647–1655.
Palm, R.: 1990, *Natural Hazards: An Integrative Framework for Research and Planning*, John Hopkins University Press, Baltimore and London.
Paul, B. K.: 1992, Farmers' response to drought in Bangladesh: Lessons for planners and administrators, Paper presented at the Annual Meeting of the Association of American Geographers, San Diego, April 18–22.
Raghavendra, V. K.: 1973, A statistical analysis of the number of tropical storms and depressions in the Bay of Bengal during 1890–1969, *Indian J. Meteorol. Geophys.* **24**, 125–130.
Rahman, M. H.: 1995, Responding to drought in Bangladesh, *The Daily Star* 15 May, 6–10.
Rasid, H. and Paul, B. K.: 1984, Perception of and adjustment to floods in Jamuna floodplain, Bangladesh, *Human Ecology* **12**, 3–19.
Sevenhuysen, G. P.: 1991, Report on cyclone disaster response in Bangladesh, Disaster Research Unit, University of Manitoba, Winnipeg, Canada.
Sims, J. H. and Baumann, D. D.: 1983, Educational programs and human response to natural hazards, *Environment and Behaviour* **15**, 165–189.
Sinha, A. K. and Avrani, S. U.: 1984, 'The disaster warning process: A study of the 1981 Gujarat cyclone', *Disasters* **8**, 67–73.
Smith, K.: 1992, *Environmental Hazards: Assessing Risk and Reducing Disaster*, Routledge, New York.
Warrick, R. A. *et al*.: 1981, *Four Communities Under Ash*, Monograph Number 34, Institute of Behavioral Science, University of Colorado, Boulder.

Williams, H. B.: 1964, Human factors in warning and response systems, in G. Grosser *et al.* (eds), *The Threat of Impending Disaster: Contributions to the Psychology of Stress*, MIT Press, Cambridge, Massachusetts, pp. 75–83.