

## Chapter 2

# An Analysis of the Causes of Non-Responses to Cyclone Warnings and the Use of Indigenous Knowledge for Cyclone Forecasting in Bangladesh

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**Abstract** This paper explores the causes of non-response to cyclone warning and unwillingness to seek refuge and identifies natural methods for predicting cyclones and storm surge through local knowledge, which could be integrated into a modern cyclone forecasting system in coastal Bangladesh. Despite significant progress in cyclone forecasting in Bangladesh, still it lacks in clear communication of warning information to people at risk at the local level, and also in terms of accuracy in the prediction of landfall timing as well as intensity factor. The study reveals that coastal inhabitants are frequently familiar with cyclones and aware of the potential risks; however, they do not respond to cyclone warnings proactively because of poor road networks, long distances between home and cyclone shelters, low capacity of cyclone shelters, fear of burglary and stealing of household assets and goods, disbelief and misinterpretation of warning information, etc. There is also a higher degree of fatalism among the people. There are other reasons why people do not respond to official warnings, such as poor understanding of cyclone warnings, past experience of the failure of warnings, no or limited income-earning opportunities during and after the cyclone if people decide to evacuate, pressure from employers to go fishing, etc. This study also explores the fact that coastal inhabitants can predict the onset of cyclones based on local indigenous knowledge gained through everyday life on the coast. This method of indigenous cyclone prediction is based on a combination of different factors, such as unusual animal behaviour, water and weather conditions, etc. The present study advocates building

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awareness of proactive responses to official cyclone early warnings while integrating local knowledge systems in order to improve the proactive response rate and establish reliable forecasting that would help in disaster mitigation and lessen the emergency management activities.

**Keywords** Cyclone warning • Community vulnerability • Indigenous knowledge • Cyclone sidr • Bangladesh

## Introduction

Severe cyclones and storm surges are quite common in Bangladesh (Wisner et al. 2004; Ali 1999; Paul 2009a). Geographic location, the unique natural setting of the country and its tropical monsoon climate modify and regulate the climatic condition and make the country more vulnerable to cyclones and storm surges (As-Salek 1998; Madsen and Jakobsen 2004; Paul and Rahman 2006; Paul 2009a). The physical and meteorological conditions necessary for generating tropical cyclones exist in the Bay of Bengal (Murty and El-Sabh 1992; Haque 1997), which is considered to be one of the ideal grounds for cyclone formation as it has 6–10 % of tropical cyclones of the world (Gray 1985; Haque 1997; Murty and El-Sabh 1992; Paul 2009a, b). On average, annually 12–13 depressions are formed and at least one powerful cyclone strikes Bangladesh each year (Mooley 1980; Haque 1997; Paul 2009a, b). Global warming is thought to be an important cause of increased cyclone events in the Bay of Bengal (IPCC 2001; Emanuel 2005; Ahmed 2005). A growing body of studies is increasingly drawing attention to the potential impacts of climate change on coastal population, which is quite vulnerable to various natural catastrophes (Nicholls 1995; Nicholls et al. 1995; Mimura 1999; Nicholls et al. 1999). The Intergovernmental Panel on Climate Change (IPCC 2001) reports that cyclone tracts will remain unchanged, with the possibility of increasing peak intensities by 5–10 % under current climate change conditions. This would have severe implications for Bangladesh, which is already vulnerable to several hydro-meteorological disasters (Ahmed 2005).

Several disastrous cyclones have struck Bangladesh: in 1822, 1876, 1961, 1965, 1970, and 1991 (Wisner et al. 2004; Dube et al. 2004; GoB 2008). Earlier studies show that 80–90 % of global losses and 53 % of total cyclone-related deaths worldwide occur in Bangladesh (Ali 1999; GoB 2008; Paul 2009a, b). About 42 % of deaths related to cyclone have been recorded in Bangladesh in the last two centuries (Nicholls et al. 1995). For example, in 1971 the cyclone-induced total death toll was estimated format between 300,000 and 500,000, with 100,000 missing people; estimated damage was about USD 450 million. After the 1991 cyclone, the official death toll was recorded as 140,161 and the total affected population totalled 10,721,707; estimated damage was USD 1.8 billion to 4.3 billion. Compared to the cyclones in 1970 and 1991, the death toll in 2007 was

relatively small: approximately 3,406 people died and 55,000 were injured, with more than 1,000 missing, and estimated damage of USD 1.6 billion (Ali 1980; Haider et al. 1991; GoB 2008; Paul 2009a, b). In addition to the geophysical characteristics of the Bangladesh coast, the poor socio-economic conditions of coastal inhabitants also contribute to increasing the vulnerability of inhabitants to cyclones and storm surges (Paul 2009a). Livelihoods of coastal populations are highly dependent on ecosystems linked with agriculture, fishery, forestry and salt farming, etc. Therefore, the increasing trend of cyclones will certainly affect the livelihoods of vulnerable populations living in low-lying coastal Bangladesh (Mian 2005, Islam 2008).

Despite being poor and vulnerable to a range of natural hazards, Bangladesh has made significant progress in disaster management in recent years (Paul 2009a, b). Studies by Blake (2008), Heath (2007), Hossain et al. (2008), and Shamsuddoha and Chowdhury (2007) confirm that the lower-than-expected death toll and damage caused by Cyclone Sidr in Bangladesh was the result of timely cyclone forecasting and dissemination of warnings, as well as the evacuation of vulnerable people living in cyclone-prone areas. Disaster warning is considered as a linear process of communication between warning-issuing organisations and recipients of the warnings (Sorensen and Sorensen 2006). Irrespective of hazards, the main objective of warning is to reduce disaster impacts through enabling people to take precautionary measures. Therefore, the success of warnings depends on appropriate hazard detection, information dissemination, and responses by affected people (McLuckie 1970; Rogers 1985; Sorensen and Mileti 1987; Quarantelli 1980; Haque 1997). In addition to a variety of socioeconomic factors, psychological and cultural factors may also determine the human response to warning (Drabek 2004; Post et al. 2009). A number of efforts have been made to document such factors during hurricanes (Dow and Cutter 1998), floods (Drabek 2000), and several other disasters (Sorensen 2000). A growing body of literature has recently been developed on human responses to hazard warning at individual and organisational level (Drabek 1986; Lindell and Perry 1992; Mileti and Sorensen 1990; Sorensen 2000; Mileti and Peek 2000), and has used theoretical framework to describe public response to warning messages (Wogalter et al. 1999; Lindell and Perry 2004). However, very little research has been conducted on seeking shelter in response to warnings (Liu et al. 1996; Sorensen 2000).

Apart from modern disaster forecasting, people can understand forthcoming danger by looking at natural signs (Gregg et al. 2006). Coastal inhabitants in Bangladesh can predict impending cyclones by using age-old indigenous knowledge gained from nature and their ancestors through their experiences of recurrent cyclones. Nonetheless, such indigenous knowledge and experiences are subsidised neither by government nor non-government organisations; nor is it formalised in policy mechanisms. Even coastal communities are not aware of their potential capabilities to face the challenges of the disasters. Research on understanding the relationship between natural hazard-warning signs and human behaviour is relatively scarce (Gregg et al. 2006). A few sporadic attempts have been made to address this issue, such as by documenting local knowledge on cyclone warning (Howell 2003)

and ambiguous, seldom specific natural signs that can be used to predict tsunamis (Gregg et al. 2006). In Bangladesh, local knowledge on disaster mitigation has mostly emphasised riverine hazards; it includes methods of community response, cropping pattern adjustment and indigenous strategies for coping with flooding (Islam 1980; Paul 1984; Rasid and Paul 1987; Schmuck 1996; Rasid 1993, 2000; Haque and Zaman 1989, 1993, 1994; Rasid and Mallik 1995; del Ninno and Dorosh 2003; Rasid and Haider 2003; Few 2003; Brouwer et al. 2007; Khandker 2007; Paul and Routray 2010a), and for coping with riverbank erosion (Haque and Zaman 1989; Mamun 1996; Hutton and Haque 2004). Few studies focused only on measures to adapt climate change induced rise in sea level, coping with cyclone, storm surge and mitigation measures (Islam 1971, 1974, 1992; Murty and Neralla 1992; Murty and El-Sabh 1992; Khalil 1992, 1993; Matsuda 1993; Chowdhury et al. 1993; Ali 1999; Choudhury, et al. 2004; Karim and Mimura 2008; Paul 2009b; Paul and Routray 2010b), community responses to multiple coastal hazards (Parvin et al. 2008), dissemination of cyclone forecasting, or adaptive responses, preparedness and management issues (Haque 1995, 1997; Schmuck 2003; Paul and Rahman 2006; Khan 2008).

A review of the existing literature shows that, although a number of studies have been carried out in Bangladesh looking at different aspects of flooding, cyclone and storm surge, a systematic documentation of the causes of human ignorance of cyclone warning, reluctance to seek refuge, and the natural signs of cyclone and storm surge, is lacking. Systematic and in-depth studies on responses to cyclone forecasting in general and indigenous knowledge for predicting cyclones in particular virtually do not exist. It is therefore imperative to collect, compile and systematise the diverse range of indigenous knowledge before it disappears. This paper aims to fill this gap by showing human behavioural responses to cyclone warnings and identifying indigenous knowledge on natural warning signs of cyclones and storm surges. The paper also provides some policy measures to integrate local knowledge in modern cyclone forecasting, with particular reference to Cyclone Sidr in Bangladesh. The practical significance of these findings may help policymakers, planners and practitioners to advise on interventions for enhancing the effectiveness of current cyclone forecasting systems, with a broader goal of building a disaster-resilient coastal community.

## Study Area and Methodology

The study was conducted in Angulkata Village of Amtoli Thana, Tatulbaria Village of Taltoti Thana in Bargona District, and Charkashem Village of Rangabali Thana in Patuakhali District in the central coastal area of Bangladesh (Fig. 2.1). Study villages were selected purposively based on earlier studies, which indicated vulnerability of all three locations to multiple coastal disasters (Ortiz 1994; Huq et al. 1996; Ali and Chowdhury 1997; Ali Khan et al. 2000; World Bank 2000; Singh et al. 2001). Considering such vulnerability, three study villages

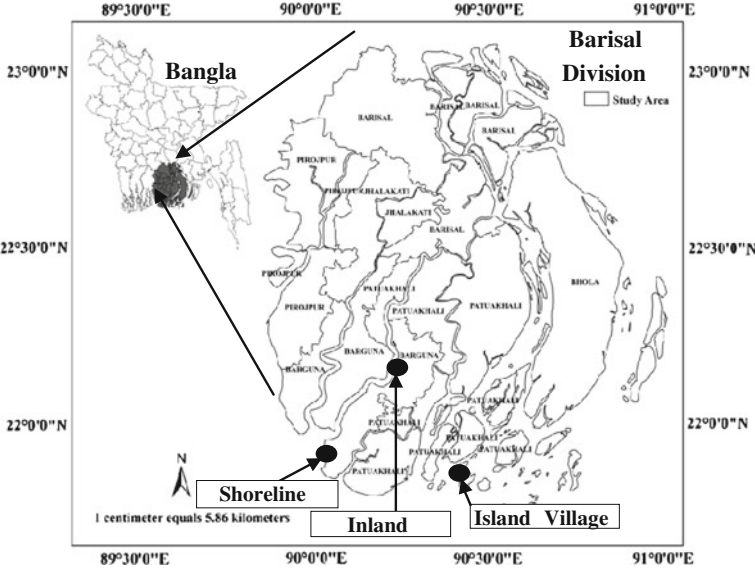


Fig. 2.1 Location map of the study villages

were selected to represent Island, Shoreline and Inland villages to explore the location variations in awareness among inhabitants. **Charkashem** is an offshore island, whereas Tatulbaria is located on the shoreline of the Bay of Bengal; Angulkata is approximately 30 km inland and located on the bank of the River Paira. Angulkata and Tatulbaria villages are surrounded by polder. The southern part of Charkashem Village is covered by planted mangroves. In the present study, Angulkata Village will be termed as Inland, Tatulbaria as Shoreline and Charkashem as Island village to understand the comparative pictures of three locations.

The research is based on both secondary and primary data. Primary data was collected by the first author through key informant interviews, focus group discussions and a household questionnaire survey. By assuming a 95 % confidence level, the total sample size for the household questionnaire survey was 331 out of 788 households. Samples were drawn proportionately by using simple random sampling from three villages. However, this provides opportunity to select households without any bias. Descriptive statistics are used to analyse data, while in a few cases a Chi-square test is used to identify similarities and differences among the villages. The present study is solely focused on the respondent’s perception of various awareness-related issues. In-depth understanding, cross sectional data and expert opinion is to some extent missing for the confirmation of findings. Reliability and validity of study variables are not properly explored through triangulation.

Out of the total respondents, approximately 90 % were males and 10 % were females. About 86 and 64 % of respondents have settled in Island and Shoreline villages respectively from various inland locations. Respondents’ spatial mobility

in terms of permanent migration to vulnerable disaster-prone locations is very common in coastal Bangladesh. More than 64 % of the respondents are illiterate; 31 % have grade five and grade ten educational attainment, and 5 % a higher level of education. The most dominant primary occupation of respondents is fishing (34 %), followed by agriculture (29 %) and daily-wage labour (15 %). Dependency on agriculture is higher in Inland than in both Shoreline and Island villages. Average ownership of agricultural land is 0.35 acres. More than half (52.3 %) of the respondents do not own any farmland. The average annual household income is 72,483 Taka (USD 1049; 1 \$ = 69.1 BDT in September 2010).

## **Cyclone Forecasting System in Bangladesh: A Brief Review**

The Bangladesh Meteorological Department (BMD) is the main responsible organisation and authority of cyclone warning in Bangladesh. It not only prepares warnings but also provides warnings to the public media for dissemination (Miyan 2005); the Cyclone Preparedness Programme (CPP), meanwhile, is responsible for the dissemination of warnings to the coastal villagers. The Storm Warning Centre (SWC) is a specialised body of the BMD, responsible for weather forecasting and issuing warnings to sea and river ports, public, non-governmental organisations (NGOs), relief and rehabilitation authorities and local level administrative officials (Chowdhury 2002). CPP was established after the devastating cyclone of 1970. The League of Red Cross, currently the International Federation, was asked by the General Assembly of the United Nations to carry out pre-disaster planning for Bangladesh. In 1972, the CPP of Bangladesh Red Crescent Society (BDRCS) started its operations. In June 1973 it was jointly brought under the Bangladesh Ministry of Disaster Management and Relief (MDMR) and the Bangladesh Red Crescent Society (BDRCS) (CPP 2009).

After the formation of a cyclonic storm in the Bay of Bengal, the Storm Warning Centre of the BMD issues special weather bulletins from time to time till landfall. The volunteers are provided with a Depression Tracking Map, and they receive radio instruction from the CPP Control Room to plot the track on the map as bulletins are received from the BMD. The tasks of the volunteers include the arduous wide dissemination of warnings by bicycle, walking, using megaphones, sirens, signal lights, and signal flags (Paul 2009a). The cyclone warning flags are hoisted in port, cyclone shelters, public buildings, community centres, or local government organisations in coastal areas following a warning from the BMD to communicate an impending cyclone. The CPP volunteers ensure the hoisting of flags. One flag is hoisted for caution, two flags for danger and three flags for great danger. Such displays can serve as a means of warning dissemination and at the same time prepare the community for an appropriate response, which will in turn increase the effectiveness of warning (Miyan 2005).

In recent times, cyclone warning systems have improved a lot because of information and communication technology, especially Internet, mobile phones,

and improved broadcasting technology with global television channels (Hossain et al. 2008). However, though significant improvements have been made in cyclone warning in Bangladesh, it still has several limitations (see Haque and Blair 1992, Jahan 1992, Hossain et al. 2008, Tatham et al. 2009). The existing warning system is cumbersome, not easy to understand and even sometimes incomprehensible to educated people as well (Haque and Blair 1992, Miyan 2005). Due to the criticism of having different signal systems for maritime and river ports, the BMD has recently unified the warning system with eight sets of signals using the Beaufort scale (Habib 2009). Tables 2.1 and 2.2 gives the cyclone warning signals for maritime and river ports (signal numbers five through seven are used for a weak or moderate cyclonic storm, depending upon the landfall point). Moreover, the language used in warning signals and special weather bulletins at the time of depression formation in the Bay of Bengal, which are disseminated through electronic media, is not simple. People are not conscious of the implications of different signal numbers; nor are they aware of the different signals for maritime and river ports. Therefore, the actual message often fails to be conveyed to the common people (Jahan 1992; Miyan 2005). Inaccurate predictions in terms of the precise location of cyclones, landfall timing, cyclone intensity and movement, intensity of impacts (for example the amount of rainfall from an impending cyclone), and storm surge height with specific stage (e.g. high/spring tide and low/neap tide) during the landfall, has often been criticised (Haque and Blair 1992; Miyan 2005; Hossain et al. 2008).

In the past, in many cases warnings were inaccurate on the landfall time of destructive cyclones. This is not a new phenomenon, as is revealed when the earlier studies of Frank and Hossain (1971), after the great Bhola cyclone in 1970, are compared with a study carried out after Cyclone Sidr in 2007 (Hossain et al. 2008). These weaknesses in the cyclone warning system of Bangladesh need to be addressed properly to improve the efficiency of the existing warning system for making people proactive and more resilient against future cyclones.

## **Discussions on Community Preparedness and Response to Cyclone Warning Based on Survey Results**

The cyclone warning in November 2007 (Sidr) was disseminated among the coastal inhabitants more efficiently than with any other cyclone in the contemporary history of Bangladesh. Even though dissemination of warning was efficient, millions of people were trapped on tiny islands along the coastline with no place to go because of the flatness, low elevation of the land, and having no higher ground for shelters. In general due to effective early warning and massive evacuations, the death tolls were less in 1991 and 1970 cyclones. However, property damage was severe or even more than that caused in 1991. The super-cyclone Sidr was first detected on 9 November 2007 between the Andaman and Nicobar Islands; it turned into a cyclonic storm with a

**Table 2.1** Cyclone and storm surge impacts and other characteristics of study villages

Cyclone and storm surge Impacts and other attributes	Inland village	Shoreline village	Island village
Location	30 km away from the coast	Shoreline of the Bay of Bengal	Island in the Bay of Bengal
Storm surge height during Sidr (m)	1–1.5	3–4	>4
Coastal embankment	Earthen embankment on riverside	Earthen embankment along the coast	No embankment
Cyclone shelter	Available (one)	Nil	Nil
Educational institution	One primary school	Nil	Nil
Number of deaths due to Sidr in 2007	Male = 0 Female = 6 Children = 6 Total = 12	Male = 3 Female = 13 Children = 14 Total = 30	Male = 1 Female = 0 Children = 0 Total = 1
Number of injured people due to Sidr in 2007	Male = 26 Female = 39 Children = 22 Total = 87	Male = 27 Female = 23 Children = 8 Total = 58	Male = 11 Female = 11 Children = 9 Total = 31
Average damage (including loss of earnings, damage to houses, reconstruction cost, damages to crops, household assets, poultry, livestock, fishery, trees, boat, net and fishing accessories, and healthcare cost) per household (Taka)	64,597	96,796	69,033
Sickness per household (persons/100 household)	96	117	142
Households having access to food during and post cyclone (% household)	36	15	5
Migrated permanently	Six persons	Two persons	None

*Source* Key informants interview and household survey, 2009

core wind speed of 216 kph (135 mph) on 13 November. The cyclone struck off-shore islands at around 6.30 p.m. and made landfall by the evening of 15 November on the Khulna-Barisal coast of Bangladesh. Aslight difference was noticed in the landfall timing, which was predicted to be at noon on 15 November by the Bangladesh Meteorological Department (BMD). On 15 November, the Bangladesh Meteorological Department had advised the maritime port of Mongla to keep the Great Danger Signal No. X and Cox's Bazar signal No. IX hoisted. Messages had been sent out regularly to the coastal communities through electronic media, and Warning signal flag 3 was hoisted. The CPP mobilised its 44,000 volunteers to implement a community-based warning system utilising megaphones and other



**Table 2.2** Cyclone signal system for maritime and river ports in Bangladesh

No.	Maritime signals		Riverine signals	
	Warning signal	Wind speed (kph)	Warnings signal	Wind speed (kph)
1	Distant cautionary signal No. I	51–61	Not applicable	–
2	Distant warnings signal No. II	62–88	Not applicable	–
3	Local cautionary signal No. III	40–50	Local cautionary signal No. III	40–50
4	Warning signal No. IV	51–61	Warning signal No. IV	51–61
5	Dangers signal No. VI	62–88	Dangers signal No. VI	62–88
6	Great dangers signal No. VIII	89–117	Great danger signal No. VIII	89–117
7	Great dangers signal No. IX	118–170	Great danger signal No. IX	118–170
8	Great dangers signal No. X	>170	Great danger signal No. X	>170

*Source* Adopted from BMD (2009)

devices. Apart from the dissemination of warning the emergency response authority had prompted a massive evacuation of about 2 million people from low-lying coastal areas (GoB 2007).

People usually pass through several socio-psychological steps in the process of responding to a warning. These can include hearing the warning, understanding the meaning of the warning, personalising the risk, and finally deciding to respond to the warning (Mileti 1995). Therefore, the first step is receiving or hearing the cyclone warning as siren or message (Mileti and Sorensen 1987). The present study finds that among the surveyed respondents, 83.38 % had received warning prior to the landfall of Cyclone Sidr. However, Haque (1995) reported that more than 95 %—and Haque and Blair (1992) reported almost 99 % of respondents had received cyclone warning prior to the 1991 cyclone on the south-eastern coast of Bangladesh. Such findings reveal comparatively weaker dissemination of cyclone warning in the central areas of the coast of Bangladesh in 2007. The study also finds regional variation in the dissemination of cyclone warning; for example Inland villagers (95.45 %) had received more warning than Shoreline (90 %) and Island (13.95 %). Such disparities in cyclone warning dissemination were closely associated with the different levels of situation severity at different locations. Similarly, primary sources of cyclone warning significantly varied among the villages. Bangladesh Red Crescent Society Volunteers had played a vital role in disseminating the warning among Inland and Shoreline villagers, while radio broadcasting and word-of-mouth from neighbours were the major sources of cyclone warning in all three study villages. This finding is inconsistent with Haque (1995), who stated that BDCRS volunteers were the more important source of information in offshore islands. Local government officials and NGOs also played a vital role in Inland village, which is close to the sub-district headquarter. However, this finding is consistent with Haque's (1995) conclusion that local

**Table 2.3** Primary sources of early warning for Cyclone Sidr, 2007 (multiple responses)

Sources of early warning	Study villages							
	Inland (N = 189)		Shoreline (N = 81)		Island (N = 6)		All (N = 276)	
	N	% of cases	N	% of cases	N	% of cases	N	% of cases
Radio	83	43.9	66	81.5	3	50	152	55.1
Television	5	2.6	2	2.5	0	0.0	7	2.5
Newspaper	4	2.1	0	0.0	0	0.0	4	1.4
Bangladesh red crescent society volunteers	139	73.5	71	87.6	1	16.7	211	76.4
Local government, NGOs	44	23.3	3	3.7	0	0.0	47	17.1
Word-of-mouth (peers, relatives, neighbours)	135	71.4	57	70.4	6	100	198	71.7

Source Household Survey, 2009

government officials were more important source of information in urban areas than islands. The warnings were received from a wider range of primary sources in the Inland and Shoreline communities than in the Island community. In general, radio broadcasting and word-of-mouth from neighbours or relatives were the most common sources of information in all three locations (Table 2.3).

Several earlier studies show that mass media and broadcast media are the most effective sources of primary information for warning dissemination (Perry et al. 1982; Quarantelli 1980), though some scholars argue that television is more effective than radio (Turner et al. 1981; Baker 1979). Some scholars in fact suggest that radio is more effective than television (Dillman et al. 1982, Drabek and Stephenson 1971). The findings of the present study suggest radio was an important broadcast media for disseminating cyclone forecasting in remote rural coastal areas of Bangladesh. The present study finds that 18.20 % of respondents in Inland, 21.10 % in Shoreline, and 14.00 % in Island, had radio. The majority of respondents in all three villages were detached from modern warning facilities and vulnerable to impending cyclones due to not having radio or any other means of communication. The present study explores the fact that 28.3 % respondents in the Inland, 34.4 % in Shoreline and 27.9 % in Island had rarely listened cyclone forecasting information. Only 13.6, 12.2 and 2.3 % of respondents regularly listened to weather forecasting in Inland, Shoreline and Island respectively (Table 2.4). Moreover, respondents with radio or television did not necessarily regularly listen to cyclone forecasting. Although many respondents in rural areas might not have had their own radio or television, many of them frequently listened to news using a neighbour's radio or television. When they heard news of cyclone formation in the Bay, they became more curious to know about the further development of the cyclone. Significant differences do not exist between villages in terms of listening of weather forecasting.

After receiving cyclone warning, the next stage is to understand such a warning in order to take proactive action (Mileti 1995). The present study finds that 48.5,

**Table 2.4** Distribution of households based on numbers of people who listen to cyclone warnings

Listening pattern	Study villages						All villages	
	Inland		Shoreline		Island			
	N	%	N	%	N	%	N	%
Rarely	56	28.3	31	34.4	12	27.9	99	29.9
Sometimes	42	21.2	26	28.9	16	37.2	84	25.4
Often	50	25.3	16	17.8	8	18.6	74	22.4
Very often	23	11.6	6	6.7	6	14.0	35	10.6
Always	27	13.6	11	12.2	1	2.3	39	11.8
Total	198	100	90	100	43	100	331	100

Chi-square  $\chi^2$  Value = 12.696, df = 8,  $p = 0.123$

Source Household Survey, 2009

64.4 and 34.9 % of household members in Inland, Shoreline and Island respectively had some understanding of cyclone warning. This study also finds significant differences between villages in terms of family members' understanding of cyclone warning ( $\chi^2$  Value = 11.480, df = 2,  $p = 0.003$ ). A higher number of household members in the Shoreline village had a good understanding of cyclone warning than the Inland and Island. Thus variation exists in the respondents' understanding of warning, which could be linked with the education level of household members (Perry et al. 1981). The present study also finds that a majority of respondents in all three villages did not have any idea about the implications of cyclone signals. About half of the respondents or family members in the Inland, about one quarter in the Shoreline and two-thirds of respondents in the Island village did not understand or did not have any idea about official cyclone signals. 17.2, 51.1 and 11.6 % of respondents or respondents' family members understood cyclone signals superficially, without having a clear idea about the implications of signals. 28.8, 12.2 and 14 % respondents understood some signals in the Inland, Shoreline and Island villages respectively (Table 2.5). By contrast, very few respondents in all three villages had some understanding about all the signals (5.1, 4.4 and 9.3 % in Inland, Shoreline and Island respectively). This study also finds that respondents with an understanding of all cyclone signals were in most cases the volunteers of CPP. Understanding of cyclone signals was better in Shoreline than in inland and Island. Better-educated people in all three villages had perhaps a better understanding of cyclone warning, while huge numbers of illiterates were incapable of grasping the meaning of cyclone forecasting signals.

Avoiding locations exposed to cyclones for fishing reveals a consciousness and personalisation of risks among fishing communities (Mileti 1995). This study finds that although the majority of the fishermen usually avoid cyclone-exposed locations for fishing, some of them were still forced to go fishing even though they had received a cyclone warning message. About half of the respondents in the Inland village who went fishing after the formation of the depression on the sea mentioned that their main reason was earning money for meeting daily household needs, compared with

**Table 2.5** Distribution of households by household member's level of understanding of cyclone warning

Level of understanding	Study villages						All villages	
	Inland		Shoreline		Island			
	N	%	N	%	N	%	N	%
Understand all signals	10	5.1	4	4.4	1	2.3	15	4.5
Understand some signals	57	28.8	11	12.2	6	14.0	74	22.4
Understand superficially	34	17.2	46	51.1	5	11.6	85	25.7
Cannot understand	97	49.0	29	32.2	31	72.1	157	47.4
Total	198	100	90	100	43	100	331	100
Chi-square	$\chi^2$ Value = 48.45, df = 6, $p = 0.000$							

Source Household Survey, 2009

12.5 and 17.4 % of respondents who went fishing for this reason in the Shoreline and Island villages. Non-availability of alternative jobs forced a large number of respondents to go fishing (29.2, 24 and 17.4 % in the Shoreline, Inland and Island villages respectively). Pressure to repay loans from “mahajans” or “arotdars”, or paying regular instalments to NGOs, forced the behaviour of many of the respondents in Island (26.1 %), Shoreline (22.9 %) and Inland (4 %). These reasons were mentioned by the small-scale subsistence fishermen in all three villages, who live below the poverty line for most of the year. Moreover, comparatively high poverty is revealed in Island (39.1 %), followed by Shoreline (35.4 %) and Inland (24 %). Focus group discussions and field observations have found that this is linked to deep sea fishing. Arotdar usually provide conditional money to selected fishermen for preparing boat, nets and other fishing accessories. Some arotdar have their own fishing boats and nets, and usually employ fishermen on a seasonal basis. In many cases they provide advance money to the fishermen to work for whole season.

## Factors Discouraging People from Seeking Refuge

Prior to the landfall of Sidr, a majority of households had received a cyclone warning and were aware of the potential impacts of damage from the cyclone and storm surge; responses, however, were varied. Only 18.7 % of respondents in Inland and 8.9 % in Shoreline responded to the cyclone warning by seeking refuge in nearby cyclone shelters; none of the respondents at all sought refuge in Island (Table 2.6). One cyclone shelter and one primary school-cum-cyclone shelter were available in Inland, while one cyclone shelter was available in the neighbouring village for Shoreline villagers. However, no cyclone shelter was available in Island. Due to the limited capacity and facilities of the cyclone shelters, very limited numbers of households (13.6 %) sought refugee in Inland and Shoreline.

This study finds that a majority of the respondents in all three villages were reluctant to follow and respond to the cyclone warning. In very few cases were all the members of a family evacuated; mostly women and children were sent to

**Table 2.6** Households seeking refuge in cyclone shelters during Sidr

Refuge in cyclone shelter	Study villages							
	Inland		Shoreline		Island		All	
	N	%	N	%	N	%	N	%
Yes	37	18.7	8	8.9	0	0	45	13.6
No	161	81.3	82	91.1	43	100	286	86.4
Total	198	100	90	100	43	100	331	100
Chi-Square	$\chi^2$ Value = 12.833, df = 2, $p = 0.002$							

Source Household Survey, 2009

**Table 2.7** Causes of not seeking refuge in cyclone shelters during Cyclone Sidr

Causes of not seeking refuge	Study villages							
	Inland		Shoreline		Island		All Villages	
	N	%	N	%	N	%	N	%
Poor road network and long distance from home	108	22.09	42	22.95	39	33.05	189	23.92
Fear of stealing	105	21.47	28	15.30	5	4.24	138	17.47
Disbelieve	152	31.08	79	43.17	24	20.34	255	32.28
Cyclone was “God’s will, so He will save us”	38	7.77	11	6.01	7	5.93	56	7.09
Low capacity of cyclone shelters	50	10.22	4	2.19	0	0.00	54	6.84
Thought that own house will provide protection	34	6.95	19	10.38	2	1.69	55	6.96
River barrier	0	0.00	0	0.00	41	34.75	41	5.19
Too old to move	2	0.41	0	0.00	0	0.00	2	0.25
Total	489	100.00	183	100.00	118	100.00	790	100.00

Source Household Survey, 2009

cyclone shelters. Many respondents, especially in Shoreline, mentioned that they were trying to move towards cyclone shelters but due to the high surge of water they attempted to make their way back home. However, they neither reached the shelter nor got back to the village. On the way many of them were washed away. The remaining vast majority of household members stayed in their own home or opted for some other emergency response, such as seeking refuge in a neighbour’s house or simply inaction, thus facing potential loss and damage whilst remaining vulnerable to the impending cyclone and storm surge. A number of factors were responsible for this en masse inaction amongst respondents in the face of ruthless danger. The factors identified are presented in Table 2.7.

Poor communication and the long distance of cyclone centres from homes was a major cause (22.1, 23.0 and 38.2 % in Inland, Shoreline and Island respectively) for not seeking refuge in the cyclone shelters. The road network connecting coastal villages is in very poor condition and paths to cyclone shelters were unsafe prior to the cyclone because of excessive rainfall, high winds, flooded terrain and tidal

waves. Island Village is less than one meter above the mean sea level, and, without the protection of any embankments or cyclone shelters, it remains extremely unsafe during cyclones and induced surges. About 40 % of respondents in Island identified poor road communication as one of the major causes for not seeking refuge in cyclone shelters located in other villages off the island. A large number of respondents (21.5 and 15.3 % respectively) mentioned fear of stealing or looting during evacuation as an important cause of inaction in Inland and Shoreline. Usually inhabitants in these two villages had more valuable household items than in Island. Hence, if they had taken refuge elsewhere and left their houses unattended, strangers might have stolen household goods and assets. Considering this, many of the respondents, especially in Inland, were reluctant to seek refuge. This response implies maintaining post-disaster law and order is a prerequisite for encouraging people to seek refuge in an emergency.

Disbelief of cyclone warnings was a major underlying factor mentioned by 31.08, 43.17 and 20.34 % of respondents in Inland, Shoreline and Island respectively. Respondents mentioned that they had received a high-alert tsunami warning two months previously, but nothing had happened. In fact, people had received cyclone warnings several times since the severe cyclone of 1991, but in most cases the storm had changed trajectory to hit elsewhere on the coast. Official communications and disseminated cyclone early warnings had turned out to be false on many occasions in the past. It was mentioned that coastal people sought refuge several times and stayed in the shelters for several hours; when the storm weakened, they returned home. In November 2007, the BMD warned that Sidr was going to make landfall at noon in Bangladesh: unfortunately it struck that evening at 6.30 p.m. Some respondents therefore mentioned that they went to the cyclone shelters, waited there for some time, then went back home. Cyclone warnings issued through radio, television and by CPP volunteers usually indicated the degree of potential hazard along with preparatory activities that should be undertaken. However, it is very important to observe and understand to what extent signals were transmitted to the community at this level. Another cause of disbelief was the relatively small number of occurrences of severe cyclones. Many respondents mentioned that they could not remember the 1970 incident, and only a few elderly people could recall the cyclone of 1991. Due to the 16-year time-gap, the incident had effectively been forgotten. Therefore people were encouraged to take no action firstly by the failure of tsunami warnings in the recent past, and secondly by the low frequency of severe events of this kind. Many respondents stated that the severity of the events is not as high as in the past. However, this finding confirms Perry and Lindell (1986), Landry and Rogers (1982), Turner et al. (1981) and Anderson (1969) in the assertion that previous experiences of similar severe disasters are positively linked with relaying warning and responses.

Fatalism is another cause of inaction: this accounted for 7.77, 6.01 and 5.93 % of respondents in Inland, Shoreline and Island respectively. Respondents in all three villages are Muslims, and a common statement was "The cyclone is Allah's will. Allah will save us and people can do very little". This finding is consistent with Haque (1993), Haque and Blair (1992) and Schmuck (2000), in that fatalism

is a common psychological coping mechanism in rural Bangladesh. It also confirms Landry and Rogers (1982) and Turner et al. (1981), in that fatalism is negatively related to listening to warnings and the subsequent response. Rural people usually consider cyclone or other natural disasters to be punishments from God. Disaster-exposed people with no alternative but to live under socio-economic, infrastructural and logistical constraints usually surrender to God and try to find solutions through praying. Fatalism is seen as a passive measure in much of the literature, but the remote offshore village Island (Charkashem) has weak infrastructures that could hardly withstand strong cyclones and surge water. Hence, during cyclones and surges, climbing trees and praying to God provide the people with the psychological strength to overcome disaster impacts, which is reflected in the lower number of deaths in Island than in the other two villages. Religious belief is deep-rooted in coastal Bangladeshi society; hence some studies find association between gender aspects of hazard response and fatalism. For example, women in conservative Muslim societies are not allowed to leave home to go to cyclone shelters because of so-called “purdah” culture (Bern et al. 1993; Haider 1992). Cyclone shelters entail a lack of privacy, and men and women need to stay together for long hours until the disaster is over. Therefore, leaving homesteads and staying together with unknown males in a crowded room is not only uncomfortable for women from a conservative society but also creates a negative impression of women’s status in the family and kinship group (Haque 1993). Many women are not allowed to seek refuge without prior permission from their husbands. In such a situation, women stay in the home and pray to God until the last minute, when they are forced out by surge water to evacuate with their children. However, this kind of behaviour and reliance on fatalism is gradually decreasing in coastal Bangladesh. A study by Haque (1991) revealed that 23 % of the surveyed population were dependent on fatalism as a survival strategy, while the present study affirms that a small percentage (7.9 %) of respondents belong to this category. However, this could be linked with the cultural aspect: traditionally people in south-west coastal areas are less conservative than on the south-east coast of Bangladesh.

Low capacity of cyclone shelters was a cause of inaction for 10.22 and 2.19 % of respondents in Inland and Shoreline respectively. However, no cyclone shelter is available in Island. Cyclone shelters are often found to be overcrowded and unhygienic, with no separate sanitation facilities for males and females, and very much uncomfortable to women (Islam et al. 2004; Paul et al. 2007). In many cases, shelters are occupied by nearby local elites first, and there is rarely space for marginalised vulnerable people. Thus, they are more likely to stay in highly vulnerable low-lying areas and take refuge on earthen embankments. Many respondents were found to be more optimistic, and strongly believed that their own house would provide greater protection as they could stay closer to their assets and livestock.

Cyclone shelters or other protective infrastructures are scarce and unavailable in most of the small islands; hence, anyone seeking refuge needs to cross the river to go to the mainland. A large proportion of respondents (34.75 %) opined that the river was a major barrier for Islanders to reach the cyclone shelter. Thus, locational

**Table 2.8** Distribution of household able to predict cyclones using indigenous knowledge

Prediction of cyclone	Study villages						All villages	
	Inland		Shoreline		Island			
	N	%	N	%	N	%	N	%
Yes	47	23.7	49	54.4	17	39.5	113	34.1
No	151	76.3	41	45.6	26	60.5	218	65.9
Total	198	100	90	100	43	100	331	100
Chi-square	$\chi^2$ Value = 26.589, df = 2, $p = 0.000$							

Source Household Survey, 2009

barrier is considered as a contributing factor towards inaction in response to cyclone warnings. As outlined above, religious belief, disbelief in cyclone warning, scarcity of safe infrastructure, socio-economic vulnerability and locational insecurity are the integral causes of the inaction of inhabitants always striving to survive in the fragile environment. Thus, without having a reliable and responsive warning system, even the existing availability of options remains under-utilised. As early warning is not simply a linear process of information dissemination, the success of a warning depends on the proactive response of individuals and the community as a whole. Therefore, effective early warning and awareness building among the potential victims of disaster is absolutely essential.

## Indigenous Knowledge about Natural Warning Signs of Cyclones and Storm Surges

People can predict a forthcoming cyclone by observing nature with methods from their own experience. An attempt has been made in the present study to identify the indigenous knowledge system on cyclone prediction. Senior and elderly members of households have knowledge of cyclone prediction, as they have gone through several exposures and experiences in the past. The study reveals that 34.1 % of total respondents, and 23.7, 54.4 and 39.5 % of respondents in Inland, Shoreline and Island respectively, have the ability to predict cyclones (Table 2.8). This ability is also linked with a respondent's occupation. For instance, fishermen—especially deep-sea fishermen—closely observe nature every day. Hence, they have practical experiences of extreme weather, water conditions and animal behaviour to relate to the occurrence of cyclones. The respondents also mentioned that those who can predict forthcoming cyclones can anticipate the intensity of them as well.

Such knowledge varies significantly from village to village, and is rarely common to all three villages. In general, indicators can be grouped into three broad categories: observing the weather, observing the condition of the sea and rivers, and observing the unusual behaviour of animals. Moreover, people do not use



**Table 2.9** Indigenous cyclone rediction indicators in coastal Bangladesh

Predicting variables and indicators	Study villages						All villages	
	Inland		Shoreline		Island			
	f	%	f	%	f	%	f	%
<i>Unusual weather condition</i>								
Drizzling and gloomy Sky and abnormal wind circulation <sup>a,b</sup>	13	7.2	15	5.8	16	7.5	44	6.7
Strong wind circulation from south or south-east <sup>a,b</sup>	10	5.6	12	4.6	17	8.0	39	6.0
Weather is unusually hot followed by rain <sup>a,b</sup>	8	4.4	11	4.2	18	8.5	37	5.7
Wind blowing in the deep sea as a circle	0	0.0	5	1.9	4	1.9	9	1.4
Muddy smell in the air <sup>b</sup>	7	3.9	5	1.9	4	1.9	16	2.5
<i>Unusual water conditions</i>								
Abnormally hot water in river/sea <sup>a,b</sup>	12	6.7	22	8.5	17	8.0	51	7.8
Dark/smoky/cloudy colour of water	2	1.1	19	7.3	12	5.6	33	5.1
Increase of water in the river, while cyclone move towards the coast	14	7.8	11	4.2	9	4.2	34	5.2
Huge roar of the sea/river	10	5.6	22	8.5	19	8.9	51	7.8
Gigantic weaves of water in the sea	0	0.0	13	5.0	12	5.6	25	3.8
<i>Abnormal animal behaviours</i>								
Cattle and dogs low and howl endlessly at night before strong cyclone <sup>a</sup>	14	7.8	17	6.5	9	4.2	40	6.1
Ants climb towards the roof of houses <sup>a</sup>	19	10.6	16	6.2	13	6.1	48	7.4
Sea birds, pigeons, move towards inland	6	3.3	21	8.1	16	7.5	43	6.6
Abnormal behaviour (jumping) of fish in ponds	17	9.4	15	5.8	1	0.5	33	5.1
Insects (flies) bite cattle to take shelter <sup>b</sup>	12	6.7	18	6.9	13	6.1	43	6.6
Bees/locusts move in clusters in the sky	9	5.0	7	2.7	4	1.9	20	3.1
Flies and mosquitoes increase <sup>a,b</sup>	16	8.9	19	7.3	17	8.0	52	8.0
Crabs come into courtyards or high places	2	1.1	5	1.9	7	3.3	14	2.1
Birds fly without destination	9	5.0	7	2.7	5	2.3	21	3.2
Total	180	100.0	260	100.0	213	100.0	653	100.0

<sup>a</sup> Most common indicators in all three villages; <sup>b</sup> observed at least one day before

Source Household Survey, 2009

single indicators for cyclone prediction, but follow a combination of factors for higher reliability to anticipate the forthcoming danger. Among others, drizzling and gloomy skies, abnormal wind circulation (6.7 %), strong wind circulation from the South or South–East (6.0 %), unusually hot weather followed by rain (5.7 %), circular wind patterns over deep-sea waters (1.4 %), and a muddy smell in the air (2.5 %), are all major indicators (Table 2.9). The first three of these indicators were commonly identified by all villagers in the three locations among those able to predict cyclones from their own experiences. “Circular wind patters over deep-sea waters” was identified by the respondents of Shoreline and Island, while “muddy smell oin the air at least a day before cyclone” was noticed most commonly in Inland, but also in Shoreline and Island villages.

Indicators in water conditions identified by the respondents were: abnormally hot water in river/sea (7.8 %), dark/smoky/cloudy colour of water (5.1 %), increase of water in the river while cyclone moves towards the coast (5.2 %), roaring sound of the sea/river (7.8 %), and gigantic waves of water in the sea (3.8 %). These were the most commonly reported water-related indicators. Abnormally hot water in river/sea and roaring sound of the sea/river were identified by the respondents irrespective of village locations. By contrast, indicators such as dark/smoky/cloudy colour of water, increase of water in the river, and gigantic waves of water in the sea, were mostly identified by the respondents from Shoreline and Island. However, variation exists in identifying water conditions, which is linked to the location and occupation of the respondents; for example, deep-sea fishermen can experience these indicators easily and clearly. They monitor sea water characteristics closely almost every day, so any deviation from normal water, for example in colour and temperature, is easily noticed by them.

Unusual animal behaviour was identified in all three villages, such as cattle and dogs howling endlessly at night before the strike of a strong cyclone (6.1 %), ants climbing towards the roof of houses (7.4 %), sea birds moving towards inland (6.6 %), abnormal jumping behaviour of fish in the pond (5.1 %), flies biting cattle to take shelter on them (6.6 %), bees/locusts moving in clusters in the sky (3.1 %), an increase in the number of flies and mosquitoes (8.0 %), crabs coming into courtyards or high places (2.1 %), and birds flying seemingly without destinations (3.2 %). The most common indicators noticed in all three villages were cattle and dogs lowing and howling endlessly at night before the occurrence of the strong cyclone, ants climbing towards the roof of houses, and the number of flies and mosquitoes increasing prior to cyclone strikes. Variations also existed for some indicators: for example, noticing the movement of sea birds and crabs was identified by an indicator by the respondents from the Shoreline and Island villages. Table 2.9 presents the indicators in general and their distribution among the three villages.

A majority of the respondents mentioned that they had learned these indicators through experience (63.7 %); others had learned them from elderly persons in the family or village (11.5 %), or from neighbours (24.8 %). No variation existed among the villages in terms of the learning sources of these indigenous natural means of cyclone prediction. This study finds that coastal communities' experiences are the main sources of such knowledge. It was also noticed that intergenerational transfer of such local knowledge is less among coastal communities, although it is important to transfer this knowledge from elderly to younger people. 34.1 % of the total respondents believed these prediction techniques were effective in anticipating the impending danger (Household Survey, 2009). More than half of the respondents in Shoreline, more than one-third in Island and about one quarter in Inland reported that such indigenous prediction techniques were very effective: this showed significant differences across the villages.

## Conclusion and Policy Implications

Cyclones and storm surges are recurrent phenomena in coastal Bangladesh, causing significant damage every time they occur. In recent times the cyclone forecasting system in the country has been improved significantly in terms of identifying, monitoring and disseminating warnings among coastal inhabitants. Though progress has been made, criticisms should still be made of the complexity of warning language, the differing warning signals for maritime and river ports, the inaccuracy in the prediction of landfall timing and level of intensity (Haque and Blair 1992; Jahan 1992; Hossain et al. 2008; Tatham et al. 2009; Miyan 2005; Jahan 1992). Coastal inhabitants are quite familiar with the regular occurrence of cyclones and aware of the related potential risks. The present study reveals that the majority of the respondents in Inland and Shoreline had received a cyclone warning, while Island villagers were still beyond the reach of BDRC volunteers, government organisations and NGOs. Broadcasting media and word-of-mouth from relatives and neighbours were the main sources of early warnings; this was in spite of the fact that the government has given top priority to the islands and remote char lands for early warning dissemination (GoB 1999a, b). About 83.38 % of respondents had received warning prior to the occurrence of Sidr, while only 18.7 % in Inland and 8.9 % respondents in Shoreline had responded to the warning by seeking refuge in nearby cyclone shelters. None of the respondents in the Island village sought refuge. Many factors were responsible for this mass inaction, such as the poor road network and the long distance of cyclone shelters from homes, the fear of stealing, disbelief, fatalism, and the low capacity of shelters. People did not believe official warnings for several reasons, including a lack of understanding of cyclone warnings, past experience of the failure of warnings, a lack of income-earning activity at the place of removal, and pressure from an employer on inhabitants to continue fishing.

This study also reveals that coastal inhabitants can predict cyclones based on their indigenous knowledge by combining a number of indicators mostly founded on the unusual behaviour of animals and weather conditions. Therefore, it is important to accept and propagate the most reliable indicators; that is to say combinations of these indicators that will best predict the onset of a cyclone and the accompanying storm surge. Identification of those indicators should be used as supplementary information along with official cyclone warnings, in order to encourage wider acceptance among coastal communities. Most importantly, understanding of such indicators does not require any special or sophisticated equipment; a deep understanding and close monitoring of environmental factors are the only requirements. Many of these indicators provide enough time—from one to 2/3 days, depending on specific indicator(s)—for people to be proactive and take precautionary and preparatory measures. For example, ants climbing the wall toward the roof or insects biting cattle is usually observed at least 1–2 days before the occurrence of a cyclone. Abnormally hot weather and abnormally warm water in rivers or the sea is usually observed 6–24 h before the cyclone strikes. Hence, it

is important to document and spread this indigenous knowledge among the people at risk, in order to help save their lives and assets in the absence of a scientific warning system.

This study also recommends increasing the number of cyclone shelters along the coast in remote locations, improving shelter environments and conditions, and ensuring post-cyclone law and order, in addition to providing timely early warning. Proper integration of indigenous knowledge-based cyclone forecasting with modern early warning systems is essential for greater acceptance and of disaster risk reduction. Therefore, the present study strongly advocates about the building of awareness on local knowledge and the official warning process. The transfer of such knowledge to the vast majority of the population of the coastal community would lead to better disaster mitigation and emergency management in coastal Bangladesh.

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