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Household response to cyclone and induced surge in coastal Bangladesh: coping strategies and explanatory variables

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Abstract The purpose of this research is to explore indigenous coping strategies and identify underlying demographic, socio-economic and other relevant variables that influence the adoption of coping strategies in three distinct cyclone-prone coastal villages of Bangladesh. The study finds that cyclones and induced surges are a recurrent phenomenon in coastal Bangladesh; hence people are used to adjusting their lifestyle and adopting their own coping strategies intelligently. Adoption of a particular set of coping strategies depends not only on the magnitude, intensity and potential impacts of the cyclone and induced surge, but also age, gender, social class, dissemination of early warning information, locational exposure, external assistance, social protection and informal risk sharing mechanisms within the community. Indigenous cyclone disaster prevention and mitigation strategies significantly minimize the vulnerability of the people. Under extreme situations, when such disasters surpass the shock-bearing capacity of the victims, informal risk sharing mechanisms through social bonding and social safety-nets become vital for short-term survival and long-term livelihood security. Therefore, proper monitoring and understanding of local indigenous coping strategies are essential in order to target the most vulnerable groups exposed to disasters. Additionally, proper dissemination of early warning and government and non-government partnerships for relief and rehabilitation activities should be prioritized to ensure pro-poor disaster management activities. The study also recommends effective monitoring of the impact of aid to ensure corrective measures to avoid the development of relief dependency by disaster victims.

Keywords Cyclone and induced surge · Vulnerability · Coping strategy · Coping ability · Bangladesh

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1 Introduction

Different natural disasters, including the results of extreme climatic events in terms of intensity and frequency of cyclones, floods and droughts, have increased globally in recent years (IPCC 2001a, b; Khan and Rahman 2007). A further increase of global temperature might lead to an increasing trend of tropical cyclones with significant damages in the twenty-first century (Emanuel 2005). Cyclones and induced surges are considered the world's foremost natural hazard that even surpasses the earthquake (Murty and El-Sabh 1992; Finkl 1994; Dube et al. 1997; Zerger et al. 2002; Benavente et al. 2006). Unfortunately, the Bangladesh coast is well-known for severe cyclones and induced surges (Blaikie et al. 1994; Ali 1999; Paul 2009a). At least one major tropical cyclone strikes the Bangladesh coast each year (Mooley 1980; Haque 1997) with powerful tidal surges that impact hundreds of thousands of lives and make it more unsafe than many other regions of the world (Murty and Neralla 1992). Moreover, the basic prerequisite physical and meteorological conditions necessary for the generation of tropical cyclones exist in the Bay of Bengal (Murty and El-Sabh 1992; Haque 1997). The Bay of Bengal is considered an ideal ground for cyclonogenesis with 6–10% of world's tropical cyclones forming here (Gray 1985; Paul 2009a). For instance, from 1891 to 1985, a total 174 powerful cyclones occurred (Haider et al. 1991) and during 1969–1990 an average of thirteen depressions were formed annually. Of these, about five developed into cyclones (Raghavendra 1973; Paul 2009a).

Existing literature shows that several disastrous cyclones hit Bangladesh in 1822, 1876, 1961, 1965, 1970, 1991 and 2007 (Blaikie et al. 1994; Dube et al. 1997; GOB 2008). During the cyclones of 1970, 1991 and 2007 about 500,000, 138,000 and 3,406 people were killed respectively (Ali 1980; Haider et al. 1991; GOB 2008; Paul 2009a). In fact, more than 50% of total deaths of the world due to cyclones and induced surges occurred in Bangladesh (Ali 1999; GOB 2008). The geographic location, unusual characteristics of tropical monsoon climate, a shallow continental shelf with the confluence of three mighty river systems and funnel shaped estuary exacerbate cyclone and surge impacts in Bangladesh (Haque 1995; As-Salek 1998; Madsen and Jakobsen 2004; Paul and Rahman 2006; Paul 2009a).

The total population living in 19 coastal districts of Bangladesh is about 36.8 million. Of this population, 54% are functionally landless[1] and over 30% are absolutely landless (PDO-ICZMP 2004a). The total population of the coastal area is expected to increase from 36.8 million in 2001 to 41.8 million in 2015, and 57.9 million by 2050. The current average size of agricultural land per capita is 0.138 acre, but this will be reduced to 0.0617 acre by 2050 (PDO-ICZMP 2004b). Population density in coastal area has increased about fourfold during the last century. This has forced thousands of people to reside in low lying areas that are highly susceptible to various natural calamities (Suliman 1991; Shalaby and Tateishi 2007; Islam 2008). The Bangladesh coast is increasingly prone to the problems of salinity, arsenic contamination and pollution of water, etc. (MoWR 2005). The livelihood of the coastal population is primarily dependent on natural resources, agriculture, fishery, forestry, near shore transportation and salt farming etc. (Mian 2005). Under the current situation of unfavorable man-land ratio and fragile resource base, livelihoods and lives of coastal people become vulnerable following any hazardous event.

[1] Functionally landless means having less than 0.49 acre of land (FAO 2004).

Despite poverty and their proneness to multiple natural hazards (cyclone, storm surge and flooding, etc.), coastal people make relentless efforts to cope with severe impacts through age-old indigenous knowledge and practices. Such indigenous knowledge systems and experiences are never formalized, either by the government or non-government organizations, in line with supporting livelihood activities. Even coastal communities are not fully aware of their strengths and capabilities to combat disasters. In the present study, vulnerability to hazards is considered as the susceptibility of individuals to the negative impacts of cyclones and induced surges; and their ability to cope and recover from such events (for comprehensive review see Burton et al. 1993; Cannon 1994; Moser 1998; Dercon 2001, 2002, 2005; Cannon et al. 2003; Pelling 2003).

Earlier studies dealing with household coping are narrowly focused on famine and food security (Watts 1983; Richards 1986; Rahmato 1987; Corbet 1988; Rocheleau et al. 1995; de Waal 2004; Smucker and Wisner 2008). Little attention has been paid to coping with other types of natural disasters (Adams et al. 1998). In Bangladesh, human response to disaster has mostly placed emphasis on riverine hazards; such as how different groups of people and communities respond to flooding (Schmuck 1996; Rasid 2000; Delap 2000; Del Ninno and Dorosh 2003; Rasid and Haider 2003; Few 2003; Brouwer et al. 2007); indigenous adjustment strategies to flooding (Islam 1980; Rasid and Paul 1987; Rasid 1993; Haque and Zaman 1989, 1993, 1994; Rasid and Mallik 1995; Khandker 2007; Paul and Routray 2010); adjustment strategies to agricultural cropping patterns (Islam 1980; Paul 1984; Rasid and Mallik 1995) and; coping with riverbank erosion (Haque and Zaman 1989; Mamun 1996; Hutton and Haque 2004). A few studies have also been conducted on agricultural and non-agricultural adjustment and mitigation measures to droughts (Brammer 1987; Paul 1992, 1998; Rahman 1995). In addition to coping with riverine hazards, literature on cyclones and induced storm surges is also available for Bangladesh. Some have focused on numerical modeling and forecasting of cyclones and storm surges (Dube et al. 1986; Madsen and Jakobsen 2004; Azam et al. 2004; Dube et al. 2004; Jakobsen and Azam 2006; Islam and Peterson 2008); adaptation measures for climate change induced sea level rise, cyclones, flash floods and storm surges (Ali 1999; Choudhury et al. 2004; Karim and Mimura 2008); causes of cyclones and storm surges, impacts 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; Paul 2009b); community response to multiple coastal hazards (Parvin et al. 2008). Recently, Paul (2009a) has identified the causes of reduced deaths and injuries in recent cyclones in Bangladesh. A few studies have also focused on cyclone warning, dissemination of forecast information and adaptation responses (Haque 1995, 1997); cyclone disaster reduction, preparedness and management issues (Schmuck 2003; Paul and Rahman 2006; Khan 2008); and the gender dimensions of climatic hazards (Cannon 2002).

A review of existing literature finds that, although a number of studies have been carried out in Bangladesh looking at different issues of coastal flooding, cyclone and storm surge, the systematic documentation of indigenous knowledge and practices and the identification of how different underlying factors influence coping behavior is still lacking. Therefore, the present study intends to explore different pre-disaster, during disaster and post-disaster coping measures, and their effectiveness to mitigate the impacts of cyclones and induced surges on coastal Bangladesh. An attempt has also been made to explain how different variables such as age, gender, income, education, occupation, and other exogenous factors influence the adoption of coping measures.

2 Study area and methodology

Purposive selection of the study areas is based on various earlier studies which indicated that all locations were severely affected by a number of natural calamities such as cyclones, storm surges, salinity intrusion and tidal flooding (Ortiz 1994; Huq et al. 1996; Ali and Chowdhury 1997; Ali Khan et al. 2000; World Bank 2000; Singh et al. 2001). The study has been 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 coast of Bangladesh (Fig. 1). Charkashem is an offshore island, whereas Tatulbaria is located on the shoreline of the Bay of Bengal and 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.

The research is based on both secondary and primary data collected through key informant interviews, focus group discussions and a household questionnaire survey. Both descriptive and inferential statistics are used to analyze the data. By assuming a 95% confidence interval, the total sample size for the household questionnaire survey was 331 out of 788 households. Samples were drawn proportionately from three villages. Out of the total respondents approximately 90% are males and 10% are females. The average age of the respondents is 46 years and their average duration of stay in the same village is about 31 years. Majority of the respondents have migrated from different inland locations. About 86 and 64% of the migrants are in Charkashem and Tatulbaria villages respectively. Respondents' spatial mobility in terms of permanent migration to disaster-prone, vulnerable locations is very common in coastal Bangladesh. More than 64% of the respondents are illiterate followed by educational attainment of grade five (31%) and grade ten and higher (5%). The most dominant primary occupation of respondents is fishing (34%),

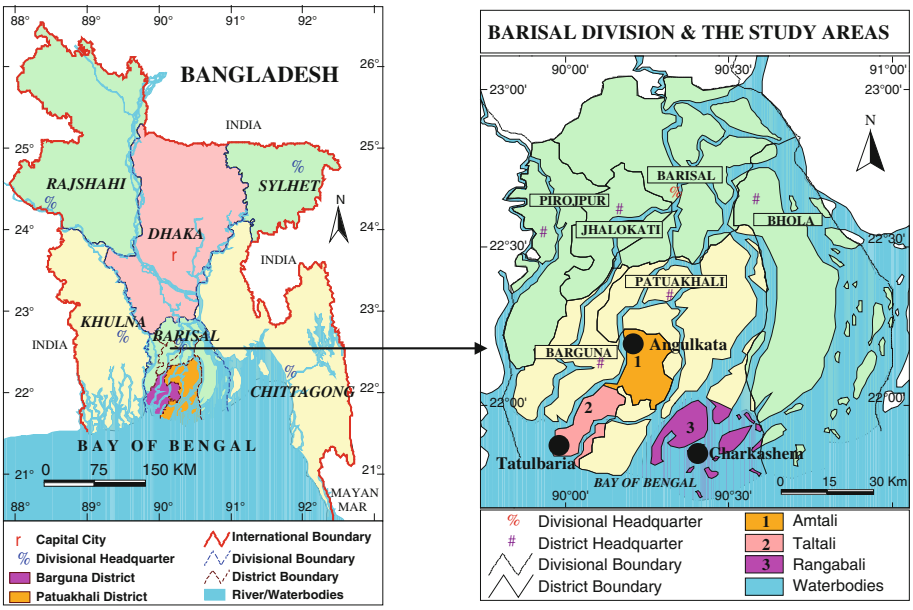

Fig. 1 Location of study villages

followed by agriculture (29%) and daily wage laborer (15%). Other common occupations are small trade, business, service and various on-farm and off-farm activities. Dependency on agriculture is higher in Angulkata than in both Tatulbaria and Charkashem 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 (US$ 1,049; 1 $ = 69.1 BDT in February 2009).

In the first section of this study, various indigenous coping strategies in response to cyclone and induced surge have been identified and discussed. In the second section, the chi-square test is applied to various demographic and socio-economic variables such as age, gender, education, land ownership, income and occupation against different coping measures. It is assumed that such demographic and socio-economic variables[2] have significant influence on the adoption of coping strategies against cyclones and induced surges.

3 Impacts and dynamics of cyclones and induced surges in the study villages

The present study reveals that during the super cyclone *Sidr* in November 2007, Charkashem and Tatulbaria Villages were severely affected but Angulkata was moderately affected. Similarly, the cyclone induced surge height was more than 3 m in Charkashem and Tatulbaria; and about 1.5 m in Angulkata. All tube wells were submerged under saline water. Consequently, drinking and domestic water was highly polluted in Charkashem and Tatulbaria villages. The decomposition of animal corpses in stagnant water caused a pungent odor and water borne diseases were widely spread in both locations. Surge waters from the river had entered into Angulkata with less height and for a shorter duration; hence Angulkata was comparatively safer. Exposure to cyclones is highest in Charkashem followed by Tatulbaria and Angulkata as evidenced from previous cyclone impacts. Other attributes to depict the dynamics of cyclone and induced surge impacts are presented in the Table 1.

4 Indigenous coping strategies for cyclone and induced surge mitigation

Coping response reveals an individual's perceptions and efforts to manage resources for mitigating the adverse consequences of hazards (Haque 1997; Wisner et al. 2004). It usually begins when the household is required to mobilize its assets to respond to a crisis; such as consumption of savings, asset disbursement, borrowing from kin and patrons etc. (Adams et al. 1998). Coping strategies may be successful if a household is able to allocate resources to overcome a crisis without compromising the long term objective of livelihood security. In contrast, coping may fail when all efforts to overcome a crisis are abortive, such as selling of productive assets and labor, consumption smoothing and collection of wild foods; and in worst case result in destitution (Devereux 1992). This study shows that people in three villages have developed their own coping strategies which are distinct in character as compared to other regions of the country. Based on a specific situation, the adoption of a particular set of strategies depends on people's cultural and socio-economic background, physical location, the characteristics of the cyclone and induced surge and the level of the individual's vulnerability and ability to absorb shock. Moreover, people do not

[2] Such variables are used in previous studies of Khandker (2007), Mozumder et al. (2008), Smucker and Wisner (2008), Ray-Bennett (2009), and Paul and Routray (2010).

Table 1 Cyclone and induced surge impacts and other attributes of study villages

Different attributes and impacts	Angulkata	Tatulbaria	Charkashem
Locational exposure	30 km. away from the coast	Shoreline of the Bay of Bengal	Island in the Bay of Bengal
Average storm surge height	1–1.5 m	3–4 m	>4 m
Embankment around the village	Earthen embankment on riverside	Earthen embankment along the coast	No embankment
Mangroves	Do not exist	Do not exist	Planted mangroves in southern part
Cyclone shelter	Available (one)	Nil	Nil
Soil salinity	None	Moderate in dry season	High in dry season due to shrimp culture
Cropping pattern	Triple cropped	Single cropped	Single cropped
Educational institution	One primary school	Nil	Nil
Number of deaths due to *Sidr* in 2007	Male = 0 Female = 6 Children = 6 Total = 12 (About 6 persons/100 households)	Male = 3 Female = 13 Children = 14 Total = 30 (About 33 persons/100 households)	Male = 1 Female = 0 Children = 0 Total = 1 (About 2 persons/100 households)
Number of injured people due to *Sidr* in 2007	Male = 26 Female = 39 Children = 22 Total = 87 (About 44 persons/100 households)	Male = 27 Female = 23 Children = 8 Total = 58 (About 63 persons/100 households)	Male = 11 Female = 11 Children = 9 Total = 31 (About 72 persons/100 households)
Sickness per household	96 Persons/100 household	117 Persons/100 household	142 Persons/100 household
Average damage (loss of earnings, damage of houses, reconstruction cost, damages of crops, household assets, poultry, livestock, fishery, trees, boats, nets and fishing accessories, and healthcare cost) per household	64,597 Taka	96,796 Taka	69,033 Taka
Households having access to food during and post cyclone	36% Household	15% Household	5% Household
Migrated out permanently	Six persons	Two persons	None

Source: Key informants interview and household survey, 2009

adopt coping strategies arbitrarily, but rather follow a sequence of coping measures (Corbet 1988). This study has considered the sequence of coping measures well in advance of the hazard event, immediately before the hazard event, and post event. The following section provides a brief description of coping strategies adopted by different households in response to cyclones and induced surges in the study villages.

4.1 Coping strategies well in advance of the cyclone and induced surge event

In this stage people commonly adopt some impact minimizing strategies and preparedness measures based on their past experiences of cyclone and surge events. Impact minimizing strategies refer to activities that minimize loss and facilitate recovery. The present study finds that unique design and construction method of houses, building *Machan* and *Pataton*, and other measures to save household items, foods and goods are some common strategies that households adopt to minimize impact of the disaster. In this regard, an initial attempt to protect shelter starts with erecting the dwelling unit or courtyard on a raised earth platform (Fig. 2a, c) to protect it from normal tides, and avoiding the use of housing materials susceptible to surge water. This includes a preference for corrugated iron sheets, bamboo, thatch and wood etc. One quarter of the total respondents prefer semi-flat roofed houses with separable tin sheets, while in Charkashem the preferred housing is small thatched roof houses (54.2%; Fig. 2d), as these can be prepared from rice straw and materials collected from nearby forests. The frame, made from hard bamboo, is prepared in such a way that it can be dismantled during the surge and used as a raft. Additionally, temple-shaped houses (Fig. 2a) are found mostly in Angulkata and Tatulbaria villages. This has more than one roof with less space in the upper floor and is usually square in shape. This is where people keep their valuables and take shelter as well during cyclones. Plantations of coconut, betel nut and banana trees around the house are also very common. This is done so densely that it provides protection for the houses, contributes towards a regular income and provides privacy, especially for women who follow '*purdah*' system (Islam 1981). In low surge locations, such as Angulkata, people support four sides of the house with guy ropes tied to bamboo poles or trees (Fig. 2a) with the hope that such extra support will prevent houses from blowing or washing away during a cyclone and surge (Parvin et al. 2008). Gentle sloping of the house roof towards the south-east is also common (Fig. 2b) as strong winds from that direction usually occur with cyclones. This construction technique helps the wind to flow over the house and thus the house has to withstand less severe wind forces. This study is consistent with Vasta (2004) that housing structure has a significant influence on the household's survival rate against disaster.

People prepare a *Machan*[3] inside the house (12.4%) to save household utensils, furniture, foods, goods, seeds and other assets in all study villages. A significant number of respondents in Angulkata (16.2%) and Tatulbaria (12.4%) prepare a *Pataton*[4] in their house, while none of the respondents have followed the same design and structure in Charkashem, as most of the houses are small with thatched roof. Moreover, when it is realized that it is no longer safe to stay inside the house, people usually pack useful

[3] *Machan* is an indigenous structure made of bamboo or wood. It is a platform prepared for sleeping, tied with bamboo or wooden pillars. People live and keep all the belongings on it during storm surge.

[4] In coastal areas people prepare houses in such a way that they can use the upper part of a house as a shelter to save their lives and belongings and is called *Pataton*.

Fig. 2 **a** Temple shape house. **b** Gently sloping of the roof of the house. **c** Elevated house on wooden structure. **d** Thatch roofed house

materials in wooden boxes (11.3%), tin pots (3.1%), *dola*/*gola*[5] (3.8%), *motka*[6] (9%) or in jute bags and place these on to the *Machan* or *Pataton* or hang them in a *shika*.[7] Alternatively they will place their useful materials in a net or jute bag and throw these into a shallow pond or tie them to strong trees with cloth or rope in the hope of retrieving these after the disaster. In the case of the study villages, people prefer to use the *motka* (11.4%), polythene bags (8.2%), plastic containers (8.5%), and aluminum pots (5.6%) to store food and seeds, and keep these on a *Machan* or hanging from the roof by a *shika.* In contrast, most valuable items, such as jewelry, are wrapped in cloth and kept inside a cooking-hole in the kitchen or by digging a *safety-hole*[8] in the floor to protect them from inundation and being washed away by the surge water. About 7, 6 and 4% of respondents in Angulkata, Tatulbaria and Charkashem villages respectively use *safety-holes* for preserving food and seeds. In addition, as wooden boxes float on water, people place belongings in them and retrieve them afterwards if they have been washed away to other places. As cyclones and induced surges severely threaten a household's food availability during and after the event, people usually save precautionary food and money (56 and 48% household respectively) to overcome the crisis. Though significant differences exist among the

[5] *Dola* or *Gola* are giant basket made of bamboo and polished with soil and cow dung, where people keep their household items, seeds etc.

[6] *Motka* is an indigenous earthen pot to store food, seeds etc.

[7] *Shika* is prepared by jute or hugla plants, by which people hang their valuables from the roof.

[8] A *safety-hole* needs to be dug about 2–3 feet into the floor of the house or in an open place to keep food, goods, jewelry or other valuables. People usually wrap the items in polythene-bags and cloths, and put a soil layer over it. They can retrieve these when the disaster is over.

villages in terms of food savings ($\chi^2 = 7.876$, $p = 0.019$); scarcity of food was higher in Charkashem followed by Tatulbaria and Angulkata due to the poor economic situation of the inhabitants. Most preferred saved food items were rice, flattened rice, fried rice, chili, onion, *gur*,[9] potato, pulses, oil, biscuits, dry fish etc. Nonetheless, majority of the respondents mentioned that such strategies are effective (48.9%) followed by moderately effective (29%), sometimes effective (10.3%), highly effective (8.2%) and rarely effective (3.6%) to minimize the disaster impacts on the Five Point Likert Scale.

Along with impact minimizing strategies, pre-cyclone preparedness measures at individual or small group level involves measures such as avoiding the disaster event, the dangerous period, exposed locations for housing and other relevant efforts that might help to avoid disaster (Wisner et al. 2004). This study has revealed that more than 80% of total households do not have radio or television. But 30% of total respondents rarely, 25% sometimes, 22% often, 10% very often, and 11% always listen to cyclone forecasting either from their own or others' radio and television. However, about half of the respondents do not understand the forecast, and few understand superficially or get some signals. Similarly, 85% of the fishermen do not have radios in their fishing boats; and rarely listen (81%) to weather forecasts. Apart from the country's existing weather forecasting mechanism, people can predict impending cyclone by indigenous means (34% of households). Examples of such indigenous cyclone prediction methods include observations of the abnormal south-easterly wind circulation along with a dark and cloudy sky (31%); the tendency of ants to climb walls carrying grain and moving purposefully towards higher ground or the roofs of houses (23%); sea birds coming inland in groups (20%); abnormal increase of water temperature in the sea and rivers (15%); and flies attaching themselves to cattle for protection against the surge water and wind (8%). Majority of the respondents mentioned that they have learned these methods through experience (64%), or from elderly people and neighbors. Nonetheless, more than one quarter of the respondents can make predictions and perceive these indigenous predictions as effective. This is measured by a Five Point Likert Scale for this study. Despite indigenous cyclone prediction techniques, more than half of the total fishermen do not avoid the cyclone period and exposed fishing locations. The main reasons are to increase household earning (30%), non-availability of alternative employment (29%), pressure from the *arotdar*[10] and employers (27%), and loan commitments (14%).

4.2 Coping strategies immediately before the cyclone and induced surge event

In disaster-prone localities, coping measures immediately before the hazard event start with the saving of human lives (Rasid and Paul 1987; Thompson and Tod 1998). This study finds that a majority of the household members (86.4%) do not take shelter in traditional cyclone shelters, but prefer to stay in the ceilings or on top of the thatched roof of their own houses (35%), or seek refuge in neighbor's houses (29.3%). No cyclone shelters are available in Charkashem and Tatulbaria. Thus, in an emergency people (85.7 and 26.6% respectively) climbed up trees and stayed in their house ceilings until the threat was over. In Angulkata less than 1% of respondents followed such practices. In Charkashem, both male and female did the same as they had previous experiences of surges. A few people made use of plastic containers or banana rafts to save their lives from the fast

[9] *Gur* is a locally made sweet from sugarcane.

[10] *Arotdar* is a moneylender who usually borrows money from local commercial banks and NGOs and distributes it to the fishermen through a middle man.

flow of surge water. In the worst cases, those who did not have any alternatives, took shelter on the embankments, raised roads or other elevated places after the cyclone. Besides saving their own lives, people also try to save poultry and livestock as these are the most valuable assets for rural communities. The study reveals that one quarter of total respondents had initially kept poultry and livestock in open, raised places in their homesteads. However, when it was found impossible to save them, they would be set free to find their own shelter. Owners would be able to locate and retrieve them after the disaster. This practice has limited effectiveness as in most cases they died, and few survived. Respondents in Angulkata (12.2%), Tatulbaria (20.2%) and Charkashem (6.1%) villages mentioned that they could not protect their animals in case of a severe cyclone. Moreover, a majority of the respondents (49%) do not take any protective measures, with the belief that a cyclone is God's will and God will save them; it is beyond the control of people. Likewise, protection of fisheries is almost impossible when a severe cyclone accompanied by a surge strikes. About 97% of respondents did not take any measures and a few used mosquito nets and bamboo fences (2.7%), or catch fish before the arrival of the cyclone (0.6%). Similarly, all the respondents mentioned that they could not protect the field crops, and preferred to save their own lives.

4.3 Post cyclone and induced surge event coping strategies

Post event coping measures include risk management and risk coping strategies. Risk management strategies try to reduce the risk to the income process by activities such as income smoothing—including income diversification, and income skewing by accepting low risk activities with low return (Dercon 2002). It reveals that after a cyclone more than 80% of respondents depend on alternative income sources apart from their primary occupation. In this regard, the highest percentage is found in Tatulbaria (93.3%) followed by Angulkata (77.8%) and Charkashem (76.7%). Majority of respondents were involved in government or NGO sponsored 'food for work' or 'cash for work' programs. A few were also involved in rickshaw-van pulling, fuel wood collection, repairing houses, boats and nets, and a few instances of begging. Many villagers could not get employment (12.9%) and relied on savings (4.1%) for food and other emergency purposes. Majority of the respondents in Tatulbaria (95%) mentioned income diversification strategies were highly effective; while 78 and 77% in Angulkata and Charkashem respectively described this as an effective measure to save family members from starvation in the Five Point Likert Scale.

Additionally, risk coping strategies include self insurance through precautionary savings, gathering of wild foods, fuel woods, and extra income by temporary migration, etc. Besides, households can secure themselves by accumulating resources in good years and depleting them in less productive years (Dercon 2002). The present study finds that while small precautionary food and money savings were not sufficient to manage a crisis, households usually undertook a variety of strategies to overcome disaster. These include measures such as consumption smoothing, relying on inexpensive foods (flattened rice, fried rice, *gur* etc.), collection of wild foods, temporary migration, begging, selling of unproductive and productive assets, and assisting each other within the community, etc. As food scarcity is a common phenomenon during and after cyclone, more than 90% of total respondents had reduced the number of meals per day, which was reflected by 97.7% in Charkashem, 92.2% in Tatulbaria and 88.4% in Angulkata village. Irrespective of village locations, more than two-thirds of the total respondents had a single meal, one quarter had two; and very few had three meals per day; while 5.1% of respondents had no meal at all.

Hence, meal-skipping (39%) is a common coping strategy, as are relying on inexpensive food items (16%), wild food collection (11%), and dependency on dry relief foods (8%).

Disposal of assets is also a common coping strategy for rural households exposed to shocks in order to meet consumption requirements or acquire the means to purchase food (del Ninno et al. 2001; Del Ninno and Dorosh 2003). The study reveals that about 52, 47 and 14% in Angulkata, Tatulbaria and Charkashem villages respectively had sold assets during the post-disaster period. Main disposable items were big trees, jewelry, household utensils, paddies, chickens, cattle, fish, tin sheets, fishing and agricultural equipment, and leasing out or mortgaging of farmland, etc. However, selling of cattle and chickens (44%) was most common in all three villages. About half of the respondents in Charkashem had sold chickens, one-third in Tatulbaria had sold fruit trees, and one-third in Angulkata had sold broken trees. Mortgaging of land was found most common in Angulkata. Along with the disposal of assets, a common strategy was the selling of labor with advance payment; 53.5, 46.7 and 28.3% in Charkashem, Tatulbaria and Angulkata respectively. Similarly, few respondents had sold out field crops (2.8%) in advance to the *mahajans*[11] against borrowing money for emergencies. However, such strategies are common in the lower income groups who borrow conditional money from *mahajan* or *arotdar* against future crops, fish or labor. Similarly, disabled or women headed households could not find any alternative income sources and preferred begging (8.5%) for survival.

The study also reveals that borrowing of money is a common coping measure (Del Ninno and Dorosh 2003) among 80% of total households; while it is more than 90% in Charkashem. In this regard, NGOs (44.8%) are the highest loan providers followed by *mahajans/arotdars* (19.5%), friends/relatives (8.8%) and government banks (4.8%). Dependency on *mahajans/arotdars* is higher in Charkashem than Angulkata and Tatulbaria villages. Most of the respondents borrowed money after a cyclone (79%) to rebuild livelihoods, meet food consumption needs and emergencies. It is also observed that people had borrowed money simultaneously from multiple sources and used one source to repay another and thus were trapped in the 'vicious circle of borrowing'. However, migration after a cyclone is not so common in the study villages. It reveals that about 13% of total household members migrated and it was higher in Angulkata (16.2%) than Tatulbaria (10%) and Charkashem (2.1%). Charkashem and Tatulbaria villages are very remote and many inhabitants settled in these villages from inland areas without having much option to migrate elsewhere. In contrary, Angulkata is well connected with road networks to the capital city and other towns. Hence, following any disaster, people usually migrate for income earning or taking shelter. Majority of the respondents from the three villages had migrated for less than 30 days to nearby Thana or district headquarters, and a few of them (2.4%) from Angulkata migrated permanently to the capital or divisional cities for income earning.

5 Adoption of coping strategies: differentials and explanatory variables

In every disaster-prone locality people have some habitual coping strategies, but the type of response and effectiveness of such strategies may vary over time and the coping ability might be overwhelmed by the scale of the disaster itself (Corbet 1988; Guarnizo 1992; Few 2003). Earlier studies on human response to natural hazard and use of socio-economic variables show two different discourses. In a social stratification approach, some find no

[11] *Mahajan* in general invests money in a variety of businesses for profit making through money lending.

relationships (Roder 1961; Kates 1962; Islam 1974); while others come across positive associations (Baker and Patton 1974; Leigh and Sim 1983; Varley 1994; Blaikie et al. 1994). Therefore, disagreement exists on which socio-economic variables should be considered. The traditional views follow a social stratification approach and use distinct groupings of relevant variables, while other approaches reject the appropriateness of using the cultural indicators of social stratification as true indicators of socio-economic association (Haque 1997). The latter approach supports the use of social class analysis to explain variation in human response to hazards (O' Keefe 1975; Cannon 1977; Watts 1983; Blaikie et al. 1994; Mozumder et al. 2008; Smucker and Wisner 2008; Ray-Bennett 2009; Paul and Routray 2010) and thus places emphasis on determining an individual's entitlement to ownership of land, machinery, and other socially available resources (Wood 1981; Sen 1980, 1981, 1982). However, the present study follows the socio-cultural approach to determine the variation in human coping due to the variation in socio-economic factors. Response to early warning, locational exposure, magnitude of cyclonic events, relief and rehabilitation, social protection and informal risk-sharing within the community are also considered.

5.1 Age

Increasing age gradually erodes the physical capabilities of the poor and puts them in an increasingly disadvantaged situation than the younger cohort (Hutton and Haque 2004). Vulnerability to disaster usually increases with age (Paton 1996; Kaniasty and Norris 1999). The present study finds that old age increases the likelihood of vulnerability to disaster; but experience may help them as well. About 62% of aged (60+ years) and 32% of active household heads (30–60 years) have the ability to predict the forthcoming cyclone by indigenous methods based on their experiences, compared with about 25% among the younger population (<30 years) ($p = 0.000$). Likewise, the level of understanding of the existing cyclone early warning system is comparatively higher ($p = 0.000$) among the aged (62%) and active groups (56.4%) than the younger ones (25.4%). In contrast, post disaster income diversification is higher among the active and younger groups than among the aged ($p = 0.011$); as aged are unlikely to do any labor-intensive work. Similarly, saving of precautionary food ($p = 0.001$) and money ($p = 0.008$) is higher among the active group, while it is lower among the younger and aged groups. Similarly, reducing the meals per day is comparatively higher among the aged and younger groups ($p = 0.007$). As majority of the active population have precautionary food and money, they rely less on reducing meals per day, while the aged and younger groups mostly starved or took one meal a day and consequently experienced higher vulnerability to the disaster. Similarly, begging by household member's after the disaster has increased with the increase of household head's age ($p = 0.000$). This confirms that increasing age erodes their physical capability (Hutton and Haque 2004) and makes them unfit for government and NGO sponsored 'food for work' or 'cash for work' programs or to work as wage labor.

The study also reveals that selling of advance labor and disposal of assets is higher in the active population (22.4%) followed by younger (7.6%) and aged (5.1%). This implies that the aged has less physical capabilities and assets to sell in order to overcome the crisis and is more vulnerable to disaster. Likewise, borrowing is higher among the younger group followed by the active and aged groups. In contrast, while aged household heads cannot manage the crisis, they send younger members of the family to the nearby urban centers for income earning. Hence, it is evident in this study (Table 2) that increasing age might lessen

Table 2 Summary of relationships between coping responses to cyclone and induced surge with some explanatory variables

Coping strategies	Explanatory variables					
	Age	Gender	Education level	Land ownership	Household income	Primary occupation
Indigenous cyclone prediction	$\chi^2 = 22.97$, $df = 2$, $p = 0.000$***	$\chi^2 = 2.93$, $df = 1$, $p = 0.087$ (NS)	$\chi^2 = 0.94$, $df = 3$, $p = 0.816$ (NS)	$\chi^2 = 0.06$, $df = 2$, $p = 0.96$ (NS)	$\chi^2 = 5.73$, $df = 2$, $p = 0.057$ (NS)	$\chi^2 = 32.55$, $df = 4$, $p = 0.000$***
Understanding cyclone warning signals	$\chi^2 = 21.50$, $df = 2$, $p = 0.000$***	$\chi^2 = 0.29$, $df = 1$, $p = 0.590$ (NS)	$\chi^2 = 9.91$, $df = 3$, $p = 0.019$*	$\chi^2 = 9.66$, $df = 2$, $p = 0.008$**	$\chi^2 = 18.49$, $df = 2$, $p = 0.000$***	$\chi^2 = 11.92$, $df = 4$, $p = 0.018$*
Income Diversification	$\chi^2 = 8.99$, $df = 2$, $p = 0.011$*	$\chi^2 = 1.62$, $df = 1$, $p = 0.203$ (NS)	$\chi^2 = 3.80$, $df = 3$, $p = 0.284$ (NS)	$\chi^2 = 0.86$, $df = 2$, $p = 0.648$ (NS)	$\chi^2 = 1.87$, $df = 2$, $p = 0.393$ (NS)	$\chi^2 = 15.50$, $df = 4$, $p = 0.004$**
Precautionary food saving	$\chi^2 = 14.66$, $df = 2$, $p = 0.001$**	$\chi^2 = 24.61$, $df = 1$, $p = 0.000$***	$\chi^2 = 9.95$, $df = 3$, $p = 0.019$*	$\chi^2 = 10.80$, $df = 2$, $p = 0.004$**	$\chi^2 = 43.84$, $df = 2$, $p = 0.000$***	$\chi^2 = 43.24$, $df = 4$, $p = 0.000$***
Precautionary money saving	$\chi^2 = 9.76$, $df = 2$, $p = 0.008$*	$\chi^2 = 22.94$, $df = 1$, $p = 0.000$***	$\chi^2 = 11.80$, $df = 3$, $p = 0.008$*	$\chi^2 = 12.17$, $df = 2$, $p = 0.002$**	$\chi^2 = 43.11$, $df = 2$, $p = 0.000$***	$\chi^2 = 45.15$, $df = 4$, $p = 0.000$***
Reducing meal per day	$\chi^2 = 9.84$, $df = 2$, $p = 0.007$*	$\chi^2 = 3.40$, $df = 1$, $p = 0.065$ (NS)	$\chi^2 = 51.94$, $df = 3$, $p = 0.000$***	$\chi^2 = 11.78$, $df = 2$, $p = 0.003$**	$\chi^2 = 49.67$, $df = 2$, $p = 0.000$***	$\chi^2 = 16.16$, $df = 4$, $p = 0.003$**
Family member's bagging	$\chi^2 = 24.87$, $df = 2$, $p = 0.000$***	$\chi^2 = 9.42$, $df = 1$, $p = 0.002$**	$\chi^2 = 1.80$, $df = 3$, $p = 0.606$ (NS)	$\chi^2 = 12.87$, $df = 2$, $p = 0.002$**	$\chi^2 = 22.44$, $df = 2$, $p = 0.000$***	$\chi^2 = 25.72$, $df = 4$, $p = 0.000$***
Selling labor with advance payment	$\chi^2 = 0.73$, $df = 2$, $p = 0.692$ (NS)	$\chi^2 = 6.77$, $df = 1$, $p = 0.009$*	$\chi^2 = 14.16$, $df = 3$, $p = 0.003$**	$\chi^2 = 11.96$, $df = 2$, $p = 0.003$**	$\chi^2 = 8.20$, $df = 2$, $p = 0.017$*	$\chi^2 = 32.88$, $df = 4$, $p = 0.000$***
Selling of assets	$\chi^2 = 5.89$, $df = 2$, $p = 0.052$ (NS)	$\chi^2 = 1.63$, $df = 1$, $p = 0.201$(NS)	$\chi^2 = 4.48$, $df = 3$, $p = 0.214$ (NS)	$\chi^2 = 14.18$, $df = 2$, $p = 0.001$**	$\chi^2 = 7.17$, $df = 2$, $p = 0.028$*	$\chi^2 = 13.51$, $df = 4$, $p = 0.009$*
Borrowing	$\chi^2 = 1.57$, $df = 2$, $p = 0.455$ (NS)	$\chi^2 = 1.76$, $df = 1$, $p = 0.185$ (NS)	$\chi^2 = 9.27$, $df = 3$, $p = 0.026$*	$\chi^2 = 3.82$, $df = 2$, $p = 0.148$ (NS)	$\chi^2 = 9.90$, $df = 2$, $p = 0.007$*	$\chi^2 = 3.24$, $df = 4$, $p = 0.518$ (NS)
Migration	$\chi^2 = 2.91$, $df = 2$, $p = 0.233$ (NS)	$\chi^2 = 5.45$, $df = 1$, $p = 0.019$ *	$\chi^2 = 11.83$, $df = 3$, $p = 0.010$*	$\chi^2 = 0.37$, $df = 2$, $p = 0.829$ (NS)	$\chi^2 = 9.02$, $df = 2$, $p = 0.011$*	$\chi^2 = 10.93$, $df = 4$, $p = 0.027$*

χ^2 = Chi-square, $n = 331$: *** $p < 0.0001$; ** $p < 0.01$; * $p < 0.05$; and *NS* not significant; *df* degrees of freedom

physical ability of household head to some extent, but increased experience might help them to better understand the disaster risk and discourage them from adopting passive coping measures. In general, however, younger and aged household heads are comparatively less capable to adapt to disaster shocks and thus become more vulnerable.

5.2 Gender

Earlier studies reveal that the impacts of a disaster is much higher on women than on men; and women are always considered the worst victims and consequently become the most vulnerable groups in the society (Agarwal 1990; Begum 1993; Walker 1994; Fordham 1998; Cannon 2002; Hutton and Haque 2004; Ray-Bennett 2009). The present study reveals that 13.3 and 6.7% of female headed households had saved precautionary food ($p = 0.000$) and money ($p = 0.000$) respectively, while more than two-thirds and half of the male headed households had the same situation. Also, engaging family members for begging (23.3%; $p = 0.002$), selling of labor with advance payment (56.7%; $p = 0.009$) and temporary migration (26.7%; $p = 0.019$) were higher among female headed households than male headed households (7, 32.9 and 11.6% respectively in the three villages). Therefore, it is evident in this study (Table 2) that female headed households mostly adopt passive coping measures that increase their vulnerability to disasters compared to their male counterparts.

5.3 Education

Education is considered as one of the crucial determinants of coping and adaptation for both supporting survival and enhancing quality of life (D'Oley et al. 1994). Moreover, it is important to create awareness regarding disaster forecasting to reduce tangible and intangible damage of victims (Parker and Tunstall 1991). According to this study, majority of the household heads having secondary school and college level education (83.3%) are able to understand weather forecasting, while it gradually decreases among primary school level (57.4%) and illiterate (46.9%) household heads ($p = 0.019$). Likewise, saving of precautionary food ($p = 0.019$) and money ($p = 0.008$) is higher among the household heads with secondary school and higher education and gradually decreases with primary school education and illiterates. As the educated households have saved precautionary food, they thus rely less on reducing meals per day ($p = 0.000$) than less educated households. It is found that respondents with secondary school and higher levels of education had neither sold labor with advance payment ($p = 0.003$) nor engaged family members in begging, while such practices are higher among less educated households. Interestingly, migration has shown a significant relationship with education ($p = 0.010$). Higher educated households had sent family members to nearby Thana headquarters to take temporary shelter, while lower educated households sent for income earning. It is evident in this study that the higher the education level, the greater is the scope to understand weather forecasts and the higher is the ability to store precautionary food and save money (Table 2) which reduces the level of vulnerability to disaster.

5.4 Land ownership

The present study reveals that among different landownership groups (i.e., landless, small, medium and large farmers), the landless do not have any cultivable land or valuable assets; hence their major concern is adoption of survival strategies for subsistence. It reveals that

understanding of cyclone warnings ($p = 0.008$) is higher among medium and large farmers (67.7%) and comparatively lower among small farmers (48.7%) and landless households (40%). Similarly storage of precautionary food ($p = 0.004$) and money ($p = 0.002$) saving is higher among medium and large farmers (67.7 and 52.3% respectively) and comparatively lower among small farmers and landless households (56.6, 51.8 and 35, 22.5% respectively). Reducing meals per day is higher among landless households followed by small, medium and large farmers ($p = 0.003$). As landless households have less ability to store precautionary food and save money, in most cases they encouraged family members to beg (22.5%; $p = 0.002$) or sell labor with advance payment (52.5%; $p = 0.003$). In contrast to the landless group, selling labor with advance payment accounted for 36.3 and 20% among small, and medium and large farmers respectively. On the contrary, disposal of assets ($p = 0.001$) is higher among the medium and large farmers (44.6%) followed by small farmers (29.6%) and least among the landless (10%). However, this could be linked with ownership of fewer assets among landless households and small farmers; while medium and large farmers have more assets and they dispose of less important assets to overcome the emergency. The present study confirms the earlier findings of Haque (1997) that land ownership is a vital indicator for social class analysis in Bangladeshi society, and landlessness accounts for the lowest proportion in each of the adjustment strategy options, implying an increasing level of their vulnerability (Table 2).

5.5 Household income

Household income is the composite indicator that reflects assets, education and occupation; hence it is assumed to have influence on an individual's coping response (Haque 1997). It reveals that understanding of cyclone warning ($p = 0.000$) is higher among the upper income group (75.4%) and comparatively less among middle (49.7%) and lower income groups (39.6%). The higher income group is more aware about disaster impacts and has saved more food and money (82.5 and 78.9%) than middle (61.2 and 50.8%) and lower income groups (29.7 and 24.2%; $p = 0.000$ and $p = 0.000$ respectively). Similarly, all respondents in the lower income category, 93.4% among middle income and 66.7% among upper income had reduced meals per day ($p = 0.000$). It is also found that begging ($p = 0.000$) or selling labor with advance payment ($p = 0.017$) is higher within the lower income group than the middle and upper income groups. Similar observations are made for the disposal of assets among the various income groups ($p = 0.028$). This is because the higher income group can manage hardship without selling their valuables, while the lower income group has very few assets to sell, but the middle class cannot manage without the disposal of their productive or unproductive assets. Interestingly, migration is higher among the lower income category (22%) followed by higher (10.5%) and middle (9.3%; $p = 0.011$). Family members from higher and middle income groups usually migrate to take temporary shelter in nearby Thana, district headquarters and friends/relatives' houses while the lower income group mostly migrates for income earning. Therefore, the present study confirms the findings of Green et al. (1994) that higher income households are readily able to help themselves and less vulnerable to any disaster than lower or middle income households (Table 2).

5.6 Primary occupation

Primary occupation of the household head is an important indicator which influences the adoption of coping strategies. It reveals that the ability of indigenous cyclone prediction

($p = 0.000$) and understanding of weather forecasts ($p = 0.018$) differ significantly among different occupational groups. Fishermen have a higher ability to predict forthcoming cyclones as they closely observe the nature everyday. Whereas, understanding of weather forecasts is higher among service holders and businessmen; which could be linked with their higher educational attainment. Following a cyclone, income diversification is higher among all occupational groups; while it is significantly lower among maidservants ($p = 0.004$) as they have less scope to work outside. Similarly, precautionary saving of food ($p = 0.000$) and money ($p = 0.000$) is higher among service holders and businessmen, and farmers while very low among maidservants, daily laborers, and fishermen and fish fry collectors. Therefore, almost all the maidservants, fish fry collectors and daily laborers had either reduced their meals per day or starved during and after the cyclone. In contrast, service holders and businessmen and farmers were comparatively secured for food ($p = 0.003$). In addition, begging ($p = 0.000$) is comparatively higher among maidservants (29.7%), as this group is the most destitute and unable to buy or store food and attempts to cope with the crisis by begging. Selling of labor with advance payment ($p = 0.000$) is higher among the fishing community (50.9%) followed by maidservants (45.9%) and daily laborers (35.4). It is very common among the fishing community to borrow money from *arotdars* with an agreement of selling their future catch of fish to them; while others borrow from *mahajans* with high interest rates. Disposal of assets is higher among farmers, fishermen, businessmen and service holders than daily labor and maidservants. Migration of family members ($p = 0.027$) is higher among maidservants and daily labors, as most of the active family members within these occupational groups move outside for income earning (Table 2).

5.7 Response to early warning

Response to cyclone warnings varies among the coastal inhabitants. About two-thirds of total respondents believe in existing cyclone forecasts. Although they did not have faith in it before the occurrence of the super cyclone '*Sidr*', as a tsunami warning had failed just two months before. As a result more than 85% of total respondents had not moved to cyclone shelters. In Angulkata and Tatulbaria 19 and 9% of household's members respectively took shelter in cyclone shelters, while none in Charkashem village did. Common reasons, such as disbelief in existing cyclone forecasts, fear of theft, fatalism, unfavorable weather, poor communication, long distance and inadequacy of shelters, had discouraged inhabitants from moving to cyclone shelters. Therefore, dissemination of quality and reliable cyclone forecasting information is indispensable for adopting effective coping measures to reduce disaster vulnerabilities.

5.8 Locational exposure and magnitude of cyclone

Geographical location is an explanatory factor for adoption of differential coping responses. The present study reveals that people on offshore islands and adjacent to the coast are more vulnerable to cyclones and induced surges than inland settlers. High wind velocity accompanied by surge waters with strong currents and more height during a cyclone hits the islands and shoreline settlements first causing severe damages. Even within island or shoreline locations, those who are closest to the sea are more vulnerable to cyclone and surge impacts. It also reveals that people on the island (Charkashem village), where about 90% respondents have come from different inland locations in the past, have less resources and practice more passive strategies and hence remain vulnerable to future

disasters. In case of the shoreline location (Tatulbaria village), where about 60% of respondents had migrated from inland and mostly engaged in fishing, are also more vulnerable to cyclone and induced surge than the inland village of Angulkata. This is because a majority of them are migrant population with limited resources and are hence unable to respond quickly to a cyclone often accompanied by surge waters. In Angulkata, due to its long distance from the sea, people get time to take preventive measures and comparatively become less vulnerable to cyclone and induced surge impacts. High velocity cyclones with surge waters create devastating phenomena. If surge water remains stagnant for an extended period, it pollutes both surface and drinking water. Spreading of water borne diseases reduces people's coping ability and increases the state of vulnerability.

5.9 Relief and rehabilitation

The present study finds that external assistance creates relief dependency among the cyclone victims in all the study locations. About 99% in Angulkata and 100% respondents in Tatulbaria and Charkashem village had received relief materials irrespective of their income level. Mostly, cyclone victims had received relief materials from different government, non-government and donor agencies within a period of 3 months; most frequently varying from one to five times in the form of cash, rice, pulses, cooking oil, household utensils and clothes. Relief providers had never provided any support services, money and material assistance for rebuilding the local economy (agriculture and fishery) or reviving the livelihoods of individuals. It was also found that many respondents have deliberately damaged their houses with hopes of receiving more relief materials and new houses. Even 3 years after Sidr, people have strongly expressed their desire to receive further relief and support services for re-building livelihoods. Therefore, based on the field survey and assessment, it was observed that it is necessary and more sensible to provide assistance to produce food that might enhance the coping ability of disaster victims (Devereux 2001). The traditional form of relief operations (food, blankets etc.) seems less effective in the study locations; rather it should acknowledge the real needs raised by the victims such as agricultural inputs, fishing equipment and employment generation etc. Providing food relief and first aid are immediate needs to rescue the victims after a cyclone. Assistance should be given in a way that helps them to rebuild their livelihood and regain their pre-disaster status. Therefore, it is important to provide relief to those who experience greater losses and those at the bottom of the society who are unlikely to recover without external help. Moreover, if relief is made available immediately after a cyclone based on the victim's priority, it may help to save at least some of their assets and avoid disposal of productive assets or reaching the final stages of destitution.

5.10 Social protection and informal risk-sharing within the community

Despite the adoption of different strategies to cope with the disasters, vulnerability remains high in Bangladesh. Therefore, development of social protection is necessary to insure poor households from the adverse impacts of disasters (Dercon 2002; Skoufias 2003). The present study reveals that there are limited measures of social protection, such as food for work (10.6%) and cash for work (30.6%) programs, and scarce provision of agricultural inputs and fishing accessories that could significantly help the cyclone victims to reduce their hardship. Informal risk sharing mechanisms among the community members coupled with a public safety net can reduce vulnerability and cement coping options. The present study reveals that 87.6% of the households helped each other during cyclones and in

post-cyclone periods. The most common helping pattern was providing manual labor (59.5%), food (27.3%), money (8.6%), house reconstruction materials (2.3%), agricultural and fishing equipment and seeds (2.3%). However, such social protection and informal risk sharing mechanisms significantly influence the adoption of coping measures at household level.

6 Conclusion

The study finds that cyclones and induced surges have overwhelming impacts on infrastructure, environment as well as on people's livelihoods. These impacts depend not only on the locational exposure and magnitude of disasters, but are also linked with several demographic, socio-economic, cultural and other exogenous variables. Hence, the study finding is consistent with the earlier propositions made by Haque and Zaman (1993), Haque (1997), Kunii et al. (2002), and Hutton and Haque (2004). The study also finds that, in response to cyclones and induced surges, people habitually come up with various indigenous coping strategies following different sequences. Adoption of such strategies varies over time and space due to the frequency and intensity of the disaster in line with various socio-economic and cultural factors. It is also observed that indigenous coping strategies are effective as long as the cyclone and induced surge does not exceed the tolerable (critical) limit of the community. When such disasters cross the critical limit and suppress the people's ability to cope, they usually take shelter in cyclone shelters or other alternative safer places and adopt several other coping mechanisms, such as consumption smoothing, borrowing, distress selling and migration, etc.

Adoption of coping strategies reveals that indigenous cyclone prediction or understanding of warning is significantly related to the age of the household head due to their level of experience (Anderson-Berry 2003). On the other hand, owing to the erosion of physical capability (Hutton and Haque 2004), the elderly are less capable to store precautionary food and money, and as a consequence reduce meals per day, engage family members in begging or earning outside, dispose of assets and borrow money to overcome the crisis. Similarly, female headed and/or less educated household heads have a lower ability to absorb shocks and mostly adopt aforementioned passive coping measures, which increase their vulnerability to disaster. However, such findings substantiate the earlier research of Kates (1962), Islam (1974), Mileti and Fitzpatrick (1993), Drabek (1986), Faupel et al. (1992), and are inconsistent with the findings of Kates (1971), Burton and Kates (1964), and Hutton and Haque (2004) that education does not play any significant role in response to hazard. Similarly, landownership, income and occupational status have also significant influence on the adoption of coping measures. For example, landless and lower income groups have a very small and risky portfolio of assets. Service and business households have a more stable income than daily laborers, fishermen or fry-collectors. Therefore, they have a higher capacity to procure food and higher ability to capture forecast information for reducing disaster vulnerability. The study confirms the findings of Agarwal (1990), Winchester (1992), and Kesavan and Swaminathan (2007) that prevailing social, gender and economic inequities greatly weaken the coping capacity of the underprivileged sections of society. In addition to the socio-economic variables, locational factor, magnitude and intensity of the cyclone, people's perception of forecasts, informal risk-sharing within the community and social protection measures play a vital role. Moreover, this study finds that the most exposed locations, such as island and shoreline areas with high velocity of cyclonic events, have negative influences on the inhabitants'

coping ability. People's perception about the quality and reliability of disaster forecasts also plays a pivotal role for future preparedness and adoption of coping measures. Timely distribution of relief and undertaking rehabilitation activities in association with community support and response mechanisms can significantly contribute to the quick recovery from disaster shock.

This study confirms that indigenous coping strategies can significantly minimize the cyclone vulnerability. Social protection measures along with informal risk-sharing mechanisms within the community play a vital role for rebuilding the settlements and the livelihoods of victims. Therefore, careful monitoring and understanding of local coping behavior, and identification of the rationale behind the adoption of such coping methods, can substantially support those who are at risk. It is extremely important to promote disaster management planning with focus on the poor as priority group for relief and rehabilitation.

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