Local Determinants of Adaptive Capacity Against the Climatic Impacts in Coastal Bangladesh

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Contents

Abstract

A growing body of literature came up with suggestion to enhance adaptive capacity of poor and marginalized population to build a resilient society against climatic disasters. Although many earlier qualitative works have indicated the factors that should be addressed to enhance such adaptive capacity, however very scanty of them quantitatively assessed the influences of those factors on various dimensions of people's adaptive capacity. This chapter assesses

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quantitatively the influences of various demographic and socioeconomic, past adaptive behavioral, climate/weather information/knowledge products, and physical environmental (spatial/locational) factors on the adaptive capacity of coastal people against the livelihood insecurity that are caused by hydrometeorological events.

The empirical part of this research was conducted in three villages of Kalapara Upazila (subdistrict) located close to the shoreline of Bay of Bengal in southwest part of Bangladesh. A total of 285 respondents were randomly interviewed using a semi-structured questionnaire in 2009. Respondents were asked to rate their adaptive capacity against 25 impacts that cause their livelihood insecure. The principal component analysis (PCA) technique was employed to identify the major dimensions of livelihood insecurity. Livelihood insecurities are related to (a) severe constraints in agriculture farming and allied activities; (b) severe damage of physical and socioeconomic infrastructures; (c) severe constraints in fishing (mostly offshore) related activities; and (d) severe crisis in freshwater supply and public health risk. How does adaptive capacity against each of these four dimensions of livelihood insecurity differ due to the influence of various factors is assessed by employing multiple analysis of variance (ANOVAs) technique.

The ANOVAs show that among the demographic and socioeconomic factors, sex, education, occupation, farmland holding, membership status (of social institution), and social capitals have the strongest influence on differential adaptive capacity in general. Similarly, among the past adaptive behavioral factors, except the freshwater crisis all other variables, namely, adaptation against flood, rainfall, and salinity intrusion have strong influence in making difference in adaptive capacity. Likewise, almost all climate/weather information/knowledge products have statistically significant influence on various dimensions of adaptive capacity. The policy implication is that while launching any program to enhance the adaptive capacity of coastal people against the threats of hydrometeorological disastrous events on their livelihood security, the identified factors need to be accounted.

Keywords

Adaptive capacity • Climate change • Hydrometeorological disasters • Livelihood insecurity • Coastal Bangladesh

Introduction

This chapter identifies the determinants of adaptive capacity of coastal people in their battle against climate change induced various hydrometeorological events including sea level rise (SLR). Despite considerable uncertainty about the extent and timing of climate change, scientific advances have established a clear link among global warming, climate change, and extreme events (IPCC 2001, 2007). Climate change is basically a gradual change in long-term average conditions, greater variability within the range of normal conditions, and changes in the types of extreme events which are possible or probable (Hare 1991). Common manifestations of climate change is change in global mean temperature, pattern of precipitation, amount of melting of snow and ice, and rising global sea level (Nerem et al. 2006). However, all these have the potential to exacerbate various hydrometeorological disastrous events including cyclonic storms, tidal surges, floods, salinity intrusion, and drought (Wilbanks et al. 2007). The spatial and temporal dimensions of these disastrous events may not be the same across the globe. Therefore, the disastrous events that are more likely for tropics and subtopics may be less likely for arid and semiarid regions and vice versa. Such a variation in climatic events may be felt within a region as well. For example, countries that are located at very lower latitude in the tropics/subtopics may experience noticeably different disastrous events than countries located at more high latitude (IPCC 2001). Although effects of climate change will be felt across the globe, the growing body of literature have warned that small island countries and countries having low-lying deltaic coasts are particularly vulnerable to hydrometeorological disasters (Nicholls et al. 1999; Klein et al. 2001; Karim and Mimura 2008; Tol et al. 2008). Vulnerability will even more increase for countries having low adaptive capacity (Adger et al. 2003; Adger 2006; Stern 2006).

Bangladesh is one of the countries that are susceptible to most of the hydrometeorological disasters, such as floods, cyclones, tidal surges, salinity intrusion, and SLR (Singh et al. 2001; Karim and Mimura 2008; UNDP 2009; GOB 2010; Alvi and Dendir 2011; Pethick and Orford 2013; Ravenscroft et al. 2013; Alam and Rahman 2014; Kulatunga et al. 2014). The vulnerability of this country is attributed to low adaptive capacity and high exposure and sensitivity to these disastrous events (World Bank 2000, Agrawala et al. 2003). It is true that people of Bangladesh have been adapting with natural calamities of various types since time immemorial. They have had accumulated experience of coping and adaptation. However, in the changing context of climate, many of the known hydrometeorological disastrous events may appear very differently than what were earlier. Various climate projection and hydrodynamic models have already warned that Bangladesh may experience more intense cyclonic storms, surges, prolonged flooding, salinity intrusion of perpetual nature, and accelerated SLR (Ali 1999, Singh et al. 2001; Karim and Mimura 2008; GOB 2010; Alvi and Dendir 2011; Pethick and Orford 2013; Ravenscroft et al. 2013; Kulatunga et al. 2014). As Bangladesh is located in a very peculiar geographical setting where the Himalayas is in the north and the Bay of Bengal is in the south, the melting of Himalayan glacier may contribute substantially to exacerbate the flooding situation (Alvi and Dendir 2011; Rahman et al. 2011). In fact, two-third of Bangladesh is located only 5 m above the mean sea level (MSL) and one-fifth of the landmass is within 1 m from the MSL (Islam et al. 1999; Brammer 2014). Past experience shows that decadal developmental gains are ruined by a single episode of massive flood or cyclone (World Bank 2000; GOB 2010). Before reaching the middle of this century, this problem may even get worse primarily because of excessive salinity intrusion in surface, subsurface water table, and in top soil. All these will seriously impact the crop agriculture – the mainstay of the country’s economy

(Sarker et al. 2012). Increase in salinity is projected to jeopardize the growth of inland fisheries, horticulture, and forestry as well (Swapan and Gavinb 2011; Islam et al. 2014; Karim et al. 2014). After agriculture, these are the most dominant sources of livelihood in the coastal Bangladesh. Numerous studies already have made strong assertion that if these really happen, a significant number of people with low adaptive capacity will turn out as climate migrants from this fragile coast before the middle of this century (Ali 2006; GOB 2009; Bhuiyan and Dutta 2012; Akter and Mallick 2013; Penning-Rowsell et al. 2013). As any failure to adapt to these impacts of hydrometeorological disasters will cause huge out migration, these massive relocation for a land-scarce country like Bangladesh could only be avoided through enhancing the adaptive capacity of the affected coastal people (Saroar and Routray 2012; Penning-Rowsell et al. 2013).

While enormous literature on adaptive capacity against famine and food vulnerability to natural disasters such as droughts are available in global context, only scanty of literature on adaptive capacity of coastal people against the impacts of hydrometeorological disasters in Bangladesh are found (Adger and Barnett 2009; Adger et al. 2009; Wolf et al. 2010). Often the works of Cannon (2002), Choudhury et al. (2005), Thomalla et al. (2006), Paul and Vogl (2011), Khandker (2012), and Mottaleb et al. (2013) are cited in this regard. While these qualitative studies have unveiled many insightful examples of adaptation against flood, cyclone, drought, even salinity intrusion, those very compelling narratives, however, have the common limitation of analyzing the adaptive capacity qualitatively from a macro perspective. In this regard, notable exception is Saroar and Routray (2012) who have quantitatively assessed the adaptive capacity of coastal people from a micro perspective. However, they have failed to come out from the compartmentalization approach of assessing adaptive capacity. For instance, they have assessed adaptive capacity against major groups of impacts. They have assessed how a person's adaptive capacity differs for different groups of impacts. However, this has little policy significance as it does not empirically tested the causes that make difference in people's adaptive capacity against various hydrometeorological events. Readers may find this chapter as a departure from those qualitative and compartmentalization approaches to identifying the determinants of adaptive capacity at local scale. The practical significance of the finding is that it may help policy makers, planners, and practitioners alike while designing a program of interventions for enhancing people's adaptive capacity.

Adaptive Capacity Against Livelihood Insecurity: Literature Review and the Hypothesis

Livelihood insecurity is often understood as the susceptibility to circumstances of not being able to sustain a livelihood (Alwang et al. 2001; Adger 2006). Therefore, a person's livelihood is considered secure when the person can cope with and recover from stresses and shocks and maintain or enhance capabilities and assets both now and in the future, while not undermining the natural resources base (Scoones 1998). Livelihood security depends on peoples' knowledge and ability to use their assets in such a way that the family can make a living, meet their consumption and economic needs, cope with uncertainties, and respond to new opportunities (de Haan and Zoomers 2005). This means, given the scenarios of changing climate, livelihood security of coastal inhabitants of low-income societies by and large will depend on their ability to adapt to the impacts of climatic disasters as they heavily depend on coastal ecosystem services and agriculture for their livelihood (Wall and Marzall 2006; Allison et al. 2009). Ability to adapt means adaptive capacity which includes some processes or actions, in order to better cope with, manage, or adjust to some changing conditions, stresses, hazards, risks, or opportunities (Fankhauser et al. 1999; Kelly and Adger 2000; Smit and Pilifosova 2001; Brooks et al. 2005; Smit and Wandel 2006). In the changing context of climate, IPCC conceptualizes adaptation as an adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderate harm or exploits beneficial opportunities (McCarthy et al. 2001). Although adaptation is essential, it does not take place automatically. Adaptive capacity largely determines the adaptive potential (Adger et al. 2005; Perry 2007; Norris et al. 2008). Now the question is what motivates individuals to go for anticipatory adaptation against the climatic disasters when there is wide uncertainty?

Although both basic research and empirical studies have identified some of the factors that determine general adaptability of people, none did it quantitatively in the specific context of coastal people. For instance, Kellstedt et al. (2008), and Roser-Renouf and Nisbet (2008) conclude that people adapt when they have the knowledge about the benefit of adaptation and risk of nonadaptive/maladaptive responses (Steel et al. 2005). Their argument is that if the people are well aware about the benefit of adaptive response, they bolster their adaptive capacity. Conversely, people employ their full force to adapt due to fear of loss from no adaptive response. However, other scholars argue that while informedness is necessary but not sufficient. To them, only comprehension of the need for adaptation cannot guarantee any adaptive response in absence of the people's ability to adapt (Smith 1997; Smithers and Smit 1997; Adger et al. 2005). To them, individual's adaptation is largely determined by the material resources that they possess (Blaikie et al. 1994). Drawing on the literature of Maddux and Rogers (1983) personal motivation theory (PMT), some scholars even argue that psychological and behavioral factors also determine people's adaptive capacity. Those who place higher emphasis on disposition of various physical resources argue that a person without these at best can initiate a maladaptive response (Wisner et al. 2004; Pelling and High 2005; Allison et al. 2009). Those who give higher emphasis on psychological matters, they basically point finger to a person's belief about his/her ability to adapt and belief about the effectiveness of such adaptive responses (Maddux and Rogers 1983; Leiserowitz 2006; Semenza et al. 2008; Blennow and Persson, 2009). On the other hand, the proponent of adaptive behavioral factors argues that past experience of adaptive response are invaluable to demonstrate adaptive capacity against a new episode of disastrous event (Patt and Gwata 2002; Grothmann and Patt 2005; Grothmann and Reusswig 2006; Saroar and Routray 2012). The logic here is the utilization of accumulated experience helps them to initiate a new adaptive response. In fact, all arguments have their own merits. Recently, the need for climate information communication appeared as an important determinant of people's adaptive response (Kurita et al. 2006; Collins and Kapucu 2008; Leal Filho 2009; Saroar and Routray 2010). The argument here is timely access to climate/weather information products help people to prepare themselves to adapt. This is vital both for sudden and rapid onset disastrous events such as cyclones, wave surges, tsunamis, and for slow onset or creeping disasters such as desertification or some kinds of floods as well. The bottom line is that timely access to information through various public and private channels help enhancing adaptive capacity. In this respect, another often ignored dimension that some scholars count is the physical environmental or spatial/location factors (Nicholls et al. 1999; Klein et al. 2001; Tol et al. 2008). Some locations due to their geographical/morphological character are more exposed to natural disasters. People who have been living in such marginalized areas are often the disadvantaged groups having very thin adaptive capacity (Adger et al. 2003; Molnar 2010). Although they have very thin physical and financial capital, they often possess solid experience of recurrent adaptation. Apart from these abovementioned factors, various demographic and socioeconomic factors are often counted as cross cutting elements of adaptive capacity (Adger et al. 2003, Moser and Satterthwaite 2009). In fact, adaptive capacity is determined by a bundle of all of the above factors. A right combination of many of these factors can work better in a particular situation, although the same combination may not probe effective while adapting to a very different situation.

The essence derived from various scholarly works cited in the forgoing section leads one to hypothesize that adaptive capacity of coastal people against the threats of various hydrometeorological events on their livelihood security in a multi-hazard-prone area is a function of multiplicity of factors such as demographic and socioeconomic, adaptive behavioral, access to climate/weather information and knowledge products, and physical environmental (spatial/locational) aspects. The general hypothesis is decomposed in the following ways.

Hypothesis 1: Demographic and socioeconomic factors cause differences in adaptive capacity.

Hypothesis 2: Past adaptive behavioral factors cause differences in adaptive capacity.

Hypothesis 3: Access to climate/weather information/knowledge products causes differences in adaptive capacity.

Hypothesis 4: Physical environmental (spatial/locational) factors cause differences in adaptive capacity.

Research Design

Study Area, Survey Procedures, and Respondents

Empirical evidences and many earlier works suggest that "Kalapara Upazila" (subdistrict) of Patuakhali district (an administrative unit below Province/Division) which is roughly above 1 m from the mean sea level (MSL) and located along the Bay of Bengal is worst affected by various hydrometeorological disasters including cyclonic storms, surges, salinity intrusion, tidal floods, and may experience the same in the years to come (Ali 1999; Ali Khan et al. 2000; Singh et al. 2001; Karim and Mimura 2008; Pethick and Orford 2013; Kulatunga et al. 2014). Three villages from three "Union Parishad" (lowest level local government unit) such as Dulasar, Mithaganj, and Nilganj were selected from this subdistrict for the study (See Fig. 1). As a sample unit, individual household was selected. Data and information were collected through administering a semi-structured questionnaire. Randomly selected 285 respondents (usually the head of household) among which 175 males and 110 females were interviewed during January–April, 2009. Although, the original questionnaire was in English, a Bengali version was administered to facilitate the process of data and information collection.

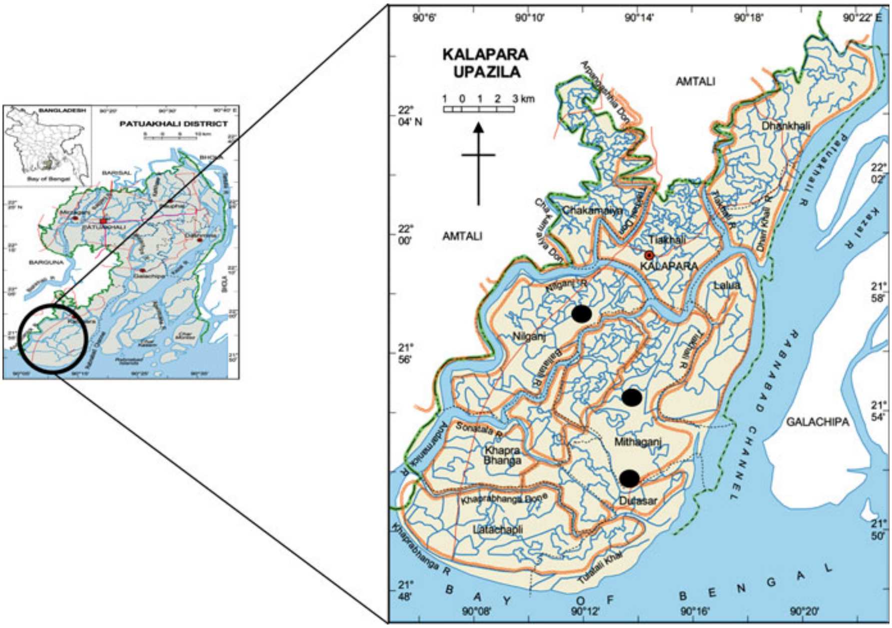

Fig. 1 Study sites (marked with *black circle*) at Dulasar, Mithaganj, and Nilganj *Union Parishad* of Kalapara subdistrict in Bangladesh

The entire study area is crisscrossed by numerous natural cannels/creeks, which are immediately connected to the Bay of Bengal through a network of river system. All the three study sites, which are located roughly within 5–20 km from the shoreline, may experience 10–40 cm inundation due to cyclonic storms, surges, and accelerated SLR before the end of this century (GOB 2005).

The study area is predominantly rural and most land parcels are used for crop agriculture. Cultivation of rice is by far the highest, followed by winter beans, legumes, nuts, and watermelon. Most land parcels are used for wet season rice which is grown during May–November. Peasants and subsistence farmers use family labor, yet agricultural activities generate employment opportunity for a significant number of people during this time. As this time many people go for both freshwater and marine fishing as wel, this brought opportunity for female labors in the farming activities. Usually the day laborers try to earn their maximum during this period to offset the loss of income in unemployed period (winter season). During winter (November to March) people cannot cultivate winter rice because of severe shortage of salt free fresh water. This causes localized seasonal unemployment.

Table 1 shows that the average age of the respondents is 49 years. Nearly half of them belong to senior age group (50 years and above) and almost one-third are in their middle age (35 to below 50). Marginally above 10 % heads of family are within the active age group (below 35 years) who can best utilize their physical labor. Almost 40 % households are comprised of 5 members followed 6-member families (30 %). Almost 60 % of the respondents are illiterate, followed by educational attainment of 5-grade (20 %) and high school graduate (~18 %).

In the traditional society of Bangladesh, the size of landholding determines social position and standing of an individual. Land distribution system is very uneven. Only handful of rich people, locally called *jutders* (landlords) traditionally own most parcels of land. Although one in every four households does not have any cultivable land of their own, some households even have more than 10 acres (~4 hectors) of land. In fact, almost 25 % households do not have any land of their own. Almost half of the households are functionally landless, possessing less than half acre (0.2 hectors) of cultivable land. Yet 8.8 % households possess more than 2.5 acres (~1 hector) of arable land. Even few households possess more than 10 acres of farmland. Therefore, the average farm size is 0.89 acres (0.36 hectors) with a standard deviation of 2.285. This uneven land distribution helps to strengthen a kind of patron–client relationship among the few landlords and the landless/ functionally landless households who cultivate the land of lords accepting often terms and condition unfavorable to them.

The crop agriculture is the most dominant economic activity. Almost one-third of the respondents are engaged in crop agricultural activities. About 20 % families depend on selling labor (day laborer) and almost a similar proportion catch fish (both freshwater and marine) to make a living. Other observed occupations are petty trade, business, transport work, formal job, and various off-farm and on-farm economic activities that combinedly offer livelihood for about 25 % families. However, most of the families possess diversified portfolios of income.

Table 1 Socio-demographic profile of respondents and their families

	Male		Female		Total	
	f	%	f	%	f	%
Age group (year):						
Below 35	19	6.7	12	4.2	31	10.9
35 to below 50	72	25.3	40	14.0	112	29.3
50 and above	84	29.5	58	20.4	142	49.8
Education:						
Nil	101	35.4	70	24.6	171	60.0
Primary level (5th grade)	31	10.9	26	9.1	57	20.
Secondary level (12th grade)	38	13.3	14	4.9	52	18.2
College graduate (14 year plus schooling)	5	1.8	0	0.0	5	1.8
Family size:						
3	16	5.6	8	2.8	24	8.4
4	24	8.4	17	6.0	41	14.4
5	67	23.5	45	15.8	112	39.3
6	52	18.2	30	10.5	82	28.8
7	13	4.6	8	2.8	21	7.4
8	3	1.1	2	0.7	5	1.8
Farmland holding[a]:						
Landless	45	15.8	25	8.8	70	24.6
Functionally landless (<0.50 acre or 0.20 ha)	88	30.9	63	22.1	151	53.0
Peasant farmer (0.50 to <2.5 acres or .20 to 1 ha)	23	8.1	16	5.6	39	13.7
Large farmer (<2.5 acre or 1 ha)	19	6.7	6	2.1	25	8.8

Note: [a]This landholding classification is proposed by BBS (1998) in its Report of the Poverty Monitoring Survey and used to target poor households for poverty-alleviation programs in Bangladesh. It is now widely followed (IFAD 2005).

For most of the occupational groups, flow of income is not smooth throughout the year. The yearly average income of the respondents' families is 141,438 BDT (US$ 2,065; during interview in 2009 the exchange was 68.5 BDT for 1 US$). However, the modal average which is only 65,000 BDT (marginally below US $ 1000) indicates that there are few households who earn much higher than most others.

Selection of Variables and Their Descriptive Statistics

Initially from the review of literature, a total of 23 factors/variables which relate to peoples' adaptive capacity against hydrometeorological disastrous events were selected as explanatory (independent) variables. The dependent variables here are the adaptive capacity of coastal people against various dimensions of livelihood insecurity. Descriptive statistics of these independent variables are presented in Table 2. Following Hardy and Bryman (eds.) (2004), a binary coding procedure is employed for dummy/dichotomous variables. Other variables are measured in their respective SI units. However, as the analysis of variance (ANOVA) technique is

Table 2 Descriptive statistics of explanatory variables used in the research

Original name of the variable and unit of measurement	Variable in abbreviated and dichotomous form	Mean of original variable	Standard deviation
1. Age of the respondent (year)	Age (d): up to 35 is compared with 35 and above	49.34	10.56
2. If sex of the respondent is male? (dummy)	Sex (d): female is compared with male	0.61	0.49
3. Education of the respondent (year of schooling)	Education (d): uneducated is compared with educated	2.86	3.89
4. If agriculture/allied job is the key source of income? (dummy)	Occupation (d): agriculture is compared with non-agriculture	0.76	0.43
5. Total farmland holding (hectare)	Farmland (d): landless is compared with or landholder	0.89	2.29
6. Household's annual income (BDT; 1 BDT = 69.5 US $)	Income (d): up to 60,000 BDT is compared with above 60,000	141438.6	182789.5
7. If member of any social group? (dummy)	Membership (d): no is compared with yes	0.18	0.38
8. Number of times changed settlement since birth due to natural disaster (number)	Change of settlement (number): no is compared with yes	0.20	0.47
9. Distance of settlement from the shoreline (km)	Distance from shoreline (d): up to 10 km is compared with above 10 km	10.00	4.09
10. Distance of safe shelter (e.g., cyclone/flood shelter) (km)	Distance of shelter (d): up to 2 km is compared with or above 2 km	1.73	0.80
11. If safe shelter is easily accessible? (dummy)	Accessibility of shelter (d): no is compared with yes	0.42	0.50
12. If adaptation with flood is recurrent? (dummy)	Flood (d): no is compared with yes	0.75	0.43
13. If adaptation with heavy rainfall is recurrent? (dummy)	Rainfall (d): no is compared with yes	0.63	0.48
14. If adaptation with intrusion of saline water is recurrent? (dummy)	Salinity (d): no is compared with yes	0.53	0.50
15. If adaptation with seasonal scarcity of freshwater or drought is recurrent? (dummy)	Drought (d): no is compared with yes	0.38	0.49
16. If adaptation with cyclone/storm surge is recurrent? (dummy)	Cyclone/surge (d): no is compared with yes	1.00	0.00
17. If always get assistance from relative during income shock? (dummy)	Assistance of relative (d): no is compared with yes	0.42	0.49
18. If always maintain peer network to have weather information? (dummy)	Peer contact (d): no is compared with yes	0.60	0.49

(*continued*)

Table 2 (continued)

Original name of the variable and unit of measurement	Variable in abbreviated and dichotomous form	Mean of original variable	Standard deviation
19. If always use television as a source of weather information? (dummy)	TV (d): no is compared with yes	0.01	0.10
20. If always read newspaper as a source of weather information? (dummy)	Newspaper (d): no is compared with yes	0.04	0.18
21. If always follow radio for weather information? (dummy)	Radio (d): no is compared with yes	0.63	0.48
22. If always adhere weather information? (dummy)	Adherence to information (d): no is compared with yes	0.40	0.49
23. If always maintain contact with officials for assistance? (dummy)	Official contact (d): no is compared with yes	0.20	0.40

intended to use all the independent/explanatory variables (shown in Table 2) are dichotomized based on mean/median values or some logical category as the case applicable. Thus the variable age became younger and elder group; education became uneducated and educated; occupation became agriculture and allied, and others; landholding became landless or landholders; etc. All dichotomized variables are presented alongside the descriptive statistics of original variables in Table 2. However, ultimately the variable – income is not used in the ANOVAs because of the presence of too many outliers (unusually high/low values) at both ends. Likewise, the variable – cyclone is not used because it is appeared as a constant, i.e., 100 % respondents have recurrent exposure to it. Details of the ANOVA procedure are presented later in the respective section.

Result and Discussion

Hydrometeorological Events and Vulnerability of Coastal Livelihood

As the study area is historically exposed to multiple hazards, the respondents are in general familiar with the impacts of cyclones, tidal surges, coastal inundation, salinity intrusion, etc. Although they are not much aware about climate change, global warming or even SLR, they feel that nature has been behaving very differently than what they had seen even one or two decades ago. By and large, respondents have a common perception that recent extreme events are more pronounced than they had been in the past. Furthermore, many of them believe that these extreme events may get even worse in the years to come.

Considering the projected scenario of SLR by the middle of this century, respondents were asked to identify the likely impacts of various hydrometeorological events, including SLR, especially if their farmlands gradually go under half of knee-deep water (20–25 cm) or surge height increases more few meters than they have had in the past. As end-of-the-century projections are large and unstable, so this research has focused on a currently living adult's lifetime as a horizon (for detail arguments, see Allen-Diaz 2009). To facilitate their responses, the respondents were supplied with a list of possible impacts on their livelihood and they were asked to rate their adaptive capacity against each of them in a simple 3-point scale [low to high]. Although the use of 5-point Likert scale is more common, a 3-point simplified scale is preferred to capture the responses of rural illiterate/less educated respondents. Further to assist them, they are suggested to give low adaptive capacity score for impacts that will highly affect their livelihood and vice versa. These simplifications by avoiding complex technical jargons and easing their (ordinary rural people – mostly lay public) understanding of the questions expedited the data collection effort without compromising the quality of data. It is worthy to note that the list of likely impacts of hydrometeorological events on coastal people livelihood security was prepared based on the review of literature having global (see Smith 1997; Middleton 1999; Bosello et al. 2007; Parry et al. 2007; Wilbanks et al. 2007; and Bunce et al. 2010) as well as regional significance with particular reference to the low-lying deltaic coasts of Asia and the Pacific (see Adger et al. 2005; Choudhury et al. 2005; Bi and Parton 2008; GOB 2009).

Table 3 presents the adaptive capacity of people against the impacts of hydrometeorological events that affect their livelihood security. In more than 50 % cases, the adaptive capacity of people against the impacts of recurrent loss of productive/earning days, freshwater crises, harvest failure and the damage of settlements, food, fuel, and fodder are low. Similarly, a significant proportion of people demonstrate low adaptive capacity against the impacts of low wage rate, limited supply of foodstuffs in the markets, high cost of rebuilding of infrastructure, etc. Although their responses show that about 30 % cases, their adaptive capacity is high against the impacts of risky offshore fishing, increased number of non-fishing days, decreased fish catch per go, and difficulty in fish preservation. These impacts affect the livelihood security of large fishing community (both artisanal and commercial). Therefore, the information directly derived from Table 3 are too broad and do not give any precise grouping of impacts that would affect people's livelihood security by impacting their adaptive capacity.

Livelihood Insecurity and Adaptive Capacity Index

The principal component analysis (PCA) method is employed to bring altogether 25 impact statements under few manageable and distinct categories. Following the Kaiser criterion, the varimax rotation method is used to extract four major groups of impacts against which the coastal people need to have high adaptive capacity to secure their livelihood in the changing context of climate. Although these four groups have explained only 72 % of the variance in people's adaptive capacity against livelihood insecurity, the results are considered statistically valid (i.e., model validity high) because of the following reasons (Field 2005; George and

Table 3 Adaptive capacity of people against the impacts of disastrous events that cause livelihood insecure

	Adaptive capacity[a]		
Impacts of disastrous events	Low % (n)	Medium % (n)	High % (n)
Loss of crop production	48.77 (139)	36.49 (104)	14.74 (42)
Complete harvest failure	51.93 (148)	38.60 (110)	9.47 (27)
Increase cost of agricultural production	44.56 (127)	9.82 (28)	45.61 (130)
Degradation of pastureland	35.44 (101)	16.49 (47)	48.07 (137)
Seasonal shortage of fodder	43.86 (125)	7.37 (21)	48.77 (139)
Difficulty in animal/poultry husbandry	38.95 (111)	30.88 (88)	30.18 (86)
Over bank flow of fishponds/fish farm	3.86 (11)	8.07 (23)	88.07 (251)
Higher risk in offshore fishing	20.00 (57)	14.39 (41)	65.61 (187)
Limited scope of festival and social gathering	35.79 (102)	34.74 (99)	29.47 (84)
Increase in number of non-fishing day	29.12 (83)	5.96 (17)	64.91 (185)
Decrease in fish catch per go	31.93 (91)	3.16 (9)	64.91 (185)
Difficulty in preserving fish	21.75 (62)	18.95 (54)	59.30 (169)
Physical damage of settlement	62.46 (178)	12.28 (35)	25.26 (72)
Damage of stock of food, biomass fuel, and fodder	62.11 (177)	10.53 (30)	27.37 (78)
Cost of maintenance and rebuilding of private infrastructure	44.56 (127)	24.21 (69)	31.23 (89)
Damage of road infrastructure	22.46 (64)	43.16 (123)	34.39 (98)
Damage of social physical infrastructure, e.g., market, school, etc.	38.25 (109)	32.28 (92)	29.47 (84)
Difficulty in physical mobility	18.25 (52)	44.56 (127)	37.19 (106)
Difficulty in carrying goods and commodities	32.28 (92)	39.30 (112)	28.42 (81)
Decrease in number of earning/productive day	61.40 (175)	32.28 (92)	6.32 (18)
Fluctuation/decline in wage rate	48.42 (138)	42.46 (121)	9.12 (26)
Limited supply and stock of foodstuff in the market	42.81 (122)	43.86 (125)	13.33 (38)
Spread of contaminated water	28.42 (81)	54.04 (154)	17.54 (50)
Lack of saline free freshwater for drinking	60.70 (173)	20.00 (57)	19.30 (55)
Prevalence of waterborne diseases	26.32 (75)	54.39 (155)	19.30 (55)

Note: [a]Percentage should be read row-wise; the frequency n is in the parenthesis.

Mallery 2006; Hair et al. 2006). First the value of determinant of correlation matrix was found greater than 0; second, the Kaiser–Meyer–Olkin value for sampling adequacy was greater than 0.60 (i.e., 0.85); third, Bartlett's test of sphericity was significant at $p < 0.0001$; and finally the average communality was >0.500. Loading of these 25 variables (load factors <0.300 are not shown) under four major group are presented in Table 4.

In Table 4, the first group of livelihood insecurity against which people may need to have high adaptive capacity could broadly be labeled as "severe constraints in farming-related activities"; this group includes 10 specific impacts and explains 26 % of the variances in people's adaptive capacity against livelihood insecurity. The second group could be termed as "severe damage of physical and

Table 4 Rotated factor's load matrix of variables which indicates the major groups/dimensions of livelihood insecurity in coastal Bangladesh

	Factors load[a]			
Variables/impact statements	1	2	3	4
Degradation of pastureland	*0.880*			
Seasonal shortage of fodder	*0.860*			
Damage of stock of food, biomass fuel, and fodder	*−0.848*			
Physical damage of settlement	*−0.833*			
Increase in cost of agricultural production	*0.786*		−0.307	
Cost of maintenance/rebuilding of private infrastructure	*−0.728*			
Difficulty in animal/poultry husbandry	*0.676*		−0.321	
Decrease in number of earning/productive day	*−0.675*	−0.303	0.322	
Complete harvest failure	*0.620*	−0.606		
Overbank flow of fishponds/fish farm	*0.444*	0.391		
Damage of road infrastructure		*0.899*		
Difficulty in physical mobility		*0.865*		
Difficulty in carrying goods and commodities		*0.846*		
Damage of social physical infrastructure, e.g., market, school		*0.829*		
Loss of crop production	0.359	*−0.766*		
Fluctuation/decline in wage rate	−0.467	*−0.617*		
Limited supply and stock of foodstuff in the market		*0.614*		
Higher risk in offshore fishing			*0.927*	
Difficulty in preserving fish			*0.904*	
Increase in number of non-fishing day			*0.898*	
Decrease in catch per go			*0.896*	
Spread of contaminated water				*0.912*
Prevalence of waterborne diseases				*0.885*
Lack of saline-free freshwater for drinking	−0.436	−0.369		*0.542*
Limited scope of festival and social gathering				
Variance (%)	***26.11***	***21.75***	***15.63***	***8.47***
Cumulative variance (%)	***26.11***	***47.87***	***63.49***	***71.97***

Note: [a]Extraction method: principal component analysis; rotation method: Varimax with Kaiser normalization (rotation converged in 14 iterations); factor loads less than 0.300 are not shown.

socioeconomic infrastructures," which constitutes seven specific impacts and explains 21.75 % of the variance in people's adaptive capacity against livelihood insecurity. The third group could be named as "severe constraints in fishing (mostly offshore) related activities," which constitutes four specific impacts and explains 15.63 % of the variance. Finally, the fourth group which includes three specific impacts and explains 8.47 % of the variances in people's adaptive capacity against livelihood insecurity is labeled as "freshwater crisis and public health risk."

In general, it was observed that people assigned low adaptive capacity scores against impacts that make them highly vulnerable by heavily affecting their

Table 5 Key statistics of adaptive capacity indices for major four dimensions of livelihood insecurity against the hydrometeorological events

Adaptive capacity index	Min.	Max.	Mean.	SD.	Skewness
Severe constraints in farming-related activities	1.20	2.90	1.91	0.28	−0.43
Severe damage of socioeconomic and physical infrastructures	1.14	2.71	1.88	0.40	0.17
Severe constraints in fishing (mostly offshore) related activities	1.00	3.00	2.38	0.83	−0.75
Severe crisis in freshwater supply and public health risk	1.00	3.00	1.80	0.58	0.44

livelihood security. Now following the methodology of Sullivan (2002) and modifying the formula of Wu et al. (2002), the adaptive capacity index (API) of people against each of these four major groups/dimensions of livelihood insecurity is computed. Therefore, ACI is the arithmetic mean of the adaptive capacity scores against respective impacts, which constitute each of the major four groups/dimensions of livelihood insecurity. Mathematically it can be expressed as

$$I_a = \frac{\sum V_i}{n}.$$

Here, I_a is the ACI (adaptive capacity index) of the respondents against each of the major four dimensions of livelihood insecurity; V_i is the absolute value of response that indicates the level of adaptive capacity against a particular impact that causes livelihood insecure; n is the number of impacts that constitute a major group/ dimension among the identified four. The key statistics of each of the four adaptive capacity indices are presented in Table 5.

Each of these four adaptive capacity indices is used as dependent variable in ANOVA (analysis of variance) procedure to identify the factors that cause differences in people's adaptive capacity against livelihood insecurity. These are discussed in some details in the respective sections.

Hypotheses Testing to Identify the Determinants of Adaptive Capacity

Earlier from literature review it was hypothesized that in the changing context of climate, the coastal people's adaptive capacity against livelihood insecurity would be largely determined by demographic and socioeconomic aspects, past adaptive behavioral aspects, access to climate/weather information and knowledge products, and physical environmental (i.e., spatial/locational) aspects. How these four groups of factors influence the respondent's adaptive capacities are determined by employing ANOVA (analysis of variance) technique. These four groups of factors are used as independent variable and each of the four adaptive capacity indices is used as dependent variable in ANOVA procedure. Earlier, to make simple and understandable to nonspecialist readers all independent variables were dichotomized either treating the mid value (average/median) as cutoff point or following the binary coding procedure as the case applicable (for details, see Hardy and Bryman eds. 2004). Therefore, ultimately all the independent variables have two levels (dichotomous variable) which are shown in the respective tables (Tables 2, 7, 8, 9, and 10). Normally for variables having two levels, "independent sample *t* test" procedure is followed. However as multiple (four) independent sample t tests would enhance the probability (about 20 %) of occurrence of type I error, multiple ANOVAs or MANOVA (multivariate analysis of variance) is considered a better statistical technique to employ for this analysis (Field 2005). Partial correlation analysis reveals that there exists very limited correlation (all correlation coefficients are $\leq .40$) among the four dependent variables, i.e., adaptive capacity indices. Therefore, multiple ANOVA technique better suits than MANOVA for these hypotheses testing (Field 2005; Hair et al. 2006). Accordingly, four separate ANOVAs are done instead of doing a single MANOVA. In the following couple of sections, these are presented in some details.

Before employing multiple ANOVAs, the normality of data (dependent variables) is checked which is one of the preconditions of ANOVA application. The result shows that skewness for each dependent variable is less than ± 1 which means data are normal for all the dependent variables (see Table 5). Another precondition of ANOVA is homogeneity of variance (Bryman and Cramer 2001). Levene's test of homogeneity of variance shows that the assumption of homogeneity of variance is not violated because $p > .05$ (Table 6). Therefore multiple (four) ANOVAs are done. Finally, to determine the exact nature of differences in dependent variables (adaptive capacity indices) for each independent variable the parameter estimates was computed in each ANOVA. The post hoc test – univariate pair-wise comparison – was avoided as each independent variable ultimately has two levels. Results of each hypothesis test are presented in Tables 7, 8, 9, and 10.

Hypothesis 1: Demographic and Socioeconomic Factors Determine the Adaptive Capacity Against Livelihood Insecurity

Levene's test statistics shows that assumption of homogeneity of equal variance is not violated as all p values are greater than 0.05 (Table 6); therefore, the models are valid. The models show that demographic and socioeconomic factors determine the adaptive capacity against different groups of livelihood insecurity with varying

Table 6 Levene's test statistics in ANOVA for all four dependent variables

Dependent variable (adaptive capacity index)	F value	Df1.	Df2.	Sig.
Severe constraints in agriculture farming and allied activities	1.26	263	21	0.273
Severe damage of physical and socioeconomic infrastructures	0.575	263	21	0.975
Severe constraints in fishing (mostly offshore) related activities	1.37	263	21	0.200
Severe crisis in freshwater supply and public health risk	0.743	263	21	0.854

proportions. For instance adaptive capacity of 37 % ($R^2 = .37$), respondents against livelihood insecurity that results from severe constraints in agriculture farming and allied activities are determined by demographic and socioeconomic factors such as sex of respondents ($p = .005$), possession of farmland holding ($p = .000$), and membership of social group ($p = .09$) (Table 7). For about 46 % ($R^2 = .46$) respondents, adaptive capacity against livelihood insecurity that results from severe damage of physical and social-economic infrastructure are determined by demographic and socioeconomic factors such as education ($p = .057$), membership of social group ($p = .013$), possession of land holding ($p = .000$), and source of income ($p = .000$) (Table 8). Similarly, for 41 % ($R^2 = .41$) respondents, adaptive capacity against livelihood insecurity that results from severe constraint in fishing-related activities are determined by demographic and socioeconomic factors such as membership of social group ($p = .054$), possession of land holding ($p = .000$), and source of income ($p = .000$) (Table 9). Finally for 32 % ($R^2 = .32$) respondents, adaptive capacity against livelihood insecurity that results from severe crisis of freshwater and public health risk are determined by demographic and socioeconomic factors such as membership of social group ($p = .03$) and access to social capital (i.e., assistance from relatives) (Table 10).

Parameter estimates further reveals that severe constraints in agriculture farming and allied activities affect families having own land 0.22 times more ($p = .000$) and families not belonging to any social groups 0.09 times more ($p = .093$). Conversely, female-headed households are affected 0.08 times less ($p = .005$) than male-headed households. This finding is a bit different than most qualitative research where female-headed families are portrayed as having less adaptive capacity (Cannon 2002; CARE 2003). Why female-headed families are more adaptive against severe constraints in agriculture farming and allied activities is unclear to this author; this requires further exploratory research. Similarly, severe damage of physical and socioeconomic infrastructure affects educated families ($p = .057$) and families not belonging to any social groups ($p = .013$) 0.09 and 0.21 times more, respectively. Landless families are 0.23 times more adaptive against the damages of physical and socioeconomic infrastructures ($p = .000$). Severe constraints in fishing-related activities affect 0.51 and 0.32 times more the families belonging to nonagricultural activities (i.e., fishing) ($p = .000$) and belonging to any social groups ($p = .054$), respectively. Similarly, landless families are 0.45 times less adaptive to the severe constraints in fishing-related activities. Families belonging to any social group ($p = .003$) and families having social capital (e.g., get assistance from relatives) ($p = .000$) are 0.38 and 0.54 times less affected by severe crisis of freshwater and public health risk. Therefore, the hypothesis is not rejected.

Hypothesis 2: Past Adaptive Behavior Determines the Adaptive Capacity Against Livelihood Insecurity

The models show that respondent's past adaptive behavioral factors determine the adaptive capacity against different groups of livelihood insecurity with a varying combinations (Tables 7, 8, 9, and 10). For instance, adaptive capacity against

Table 7 Parameter estimates in ANOVA to determine the influence of various factors on adaptive capacity against livelihood insecurity that results from severe constraints in agriculture farming and allied activities

Independent variables/parameters	B	Std. Error	t	Sig.
Intercept	1.974	0.287	6.889	0.000
Demographic and socioeconomic factors:				
Age (d): up to 35 is compared with 35 and above	−0.067	0.047	−1.426	0.155
Sex (d): female is compared with male	0.083***	0.029	2.859	0.005
Education (d): uneducated is compared with educated	−0.002	0.035	−0.070	0.944
Membership (d): no is compared with yes	−0.099*	0.059	−1.686	0.093
Farmland (d): landless is compared with or landholder	0.224***	0.043	5.192	0.000
Occupation (d): agriculture is compared with non-agriculture	0.048	0.041	1.174	0.241
Assistance of relative (d): no is compared with yes	−0.010	0.037	−0.277	0.782
Adaptive behavioral factors:				
Rainfall (d): no is compared with yes	−0.025	0.034	−0.736	0.463
Flood (d): no is compared with yes	0.030	0.037	0.809	0.419
Drought (d): no is compared with yes	0.018	0.032	0.572	0.568
Salinity (d): no is compared with yes	0.141***	0.034	4.113	0.000
Climate/weather informal factors:				
Radio (d): no is compared with yes	0.008	0.033	0.251	0.802
TV (d): no is compared with yes	−0.365***	0.147	−2.488	0.013
Newspaper (d): no is compared with yes	−.227***	0.090	−2.515	0.012
Peer contact (d): no is compared with yes	−0.050	0.032	−1.588	0.114
Official contact (d): no is compared with yes	0.019	0.054	0.341	0.734
Adherence to information (d): no is compared with yes	−0.036	0.033	−1.091	0.276
Physical environmental factors:				
Distance from shoreline (d): up to 10 km is compared with above 10 km	−0.050	0.032	−1.580	0.115
Distance of shelter (d): up to 2 km is compared with above 2 km	−0.054	0.038	−1.405	0.161
Accessibility of shelter (d): no is compared with yes	−0.024	0.033	−0.720	0.472
Change of settlement (d): no is compared with yes	0.016	0.066	0.246	0.806
F value: 7.34 ($p = 0.000$); $R^2 = 0.37$				

Note: Dependent variable: adaptive capacity against livelihood insecurity that results from severe constraints in agriculture farming and allied activities.
*significant at 0.10; **significant at 0.05; ***significant at 0.01

livelihood insecurity that results from severe constraints in agriculture farming and allied activities are determined by past adaptive behavioral factors such as adaptation against salinity intrusion ($p = .000$). Respondents who have past experience of recurrent adaptation against salinity intrusion are 0.18 times more adaptive against livelihood insecurity that results from severe constraints in agriculture and allied activities (Table 7). Similarly, adaptive capacity against livelihood insecurity that results from severe damage of physical and socioeconomic infrastructures are

Table 8 Parameter estimates in ANOVA to determine the influence of various factors on adaptive capacity against livelihood insecurity that results from severe damage of physical and socioeconomic infrastructures

Independent variables/parameters	B	Std. Error	t	Sig.
Intercept	1.974	0.287	6.889	0.000
Demographic and socioeconomic factors:				
Age (d): up to 35 is compared with 35 and above	0.097	0.061	1.579	0.116
Sex (d): female is compared with male	0.005	0.038	0.137	0.891
Education (d): uneducated is compared with educated	0.087*	0.046	1.915	0.057
Membership (d): no is compared with yes	−0.192***	0.077	−2.498	0.013
Farmland (d): landless is compared with or landholder	0.232***	0.057	4.107	0.000
Occupation (d): agriculture is compared with non-agriculture	−0.421***	0.053	−7.867	0.000
Assistance of relative (d): no is compared with yes	−0.054	0.049	−1.098	0.273
Adaptive behavioral factors:				
Rainfall (d): no is compared with yes	−0.014	0.044	−0.319	0.750
Flood (d): no is compared with yes	0.082*	0.049	1.660	0.098
Drought (d): no is compared with yes	0.033	0.041	0.797	0.426
Salinity (d): no is compared with yes	0.076*	0.045	1.697	0.091
Climate/weather informal factors:				
Radio (d): no is compared with yes	−0.016	0.043	−0.377	0.706
TV (d): no is compared with yes	−0.044	0.192	−0.231	0.818
Newspaper (d): no is compared with yes	−0.075	0.118	−0.635	0.526
Peer contact (d): no is compared with yes	−0.023	0.041	−0.559	0.576
Official contact (d): no is compared with yes	0.024	0.071	0.332	0.740
Adherence to information (d): no is compared with yes	0.063	0.043	1.457	0.146
Physical environmental factors:				
Distance from shoreline (d): up to 10 km is compared with above 10 km	−0.070*	0.042	−1.673	0.096
Distance of shelter (d): up to 2 km is compared with above 2 km	−0.023	0.050	−0.459	0.647
Accessibility of shelter (d): no is compared with yes	0.179***	0.043	4.132	0.000
Change of settlement (d): no is compared with yes	0.024	0.087	0.274	0.784
F value: 10.84 (p = 0.000); R^2 = 0.46				

Note: Dependent variable: adaptive capacity against livelihood insecurity that results from severe damage of physical and socioeconomic infrastructures.
*significant at 0.10; **significant at 0.05; ***significant at 0.01

determined by past adaptive behavioral factors such as adaptation against flooding (p = .098) and salinity intrusion (p = .091). Respondents who have past experience of recurrent adaptation against flooding and salinity intrusion are 0.082 and 0.076 times more adaptive against livelihood insecurity that results from severe

Table 9 Parameter estimates in ANOVA to determine the influence of various factors on adaptive capacity against livelihood insecurity that results from severe constraints in fishing (mostly offshore) related activities

Independent variables/parameters	B	Std. Error	t	Sig.
Intercept	1.992	0.624	3.192	0.002
Demographic and socioeconomic factors:				
Age (d): up to 35 is compared with 35 and above	−0.140	0.134	−1.047	0.296
Sex (d): female is compared with male	0.006	0.083	0.072	0.943
Education (d): uneducated is compared with educated	−0.112	0.099	−1.127	0.261
Membership (d): no is compared with yes	0.324**	0.167	1.936	0.054
Farmland (d): landless is compared with or landholder	−0.450***	0.123	−3.655	0.000
Occupation (d): agriculture is compared with non-agriculture	0.513***	0.116	4.402	0.000
Assistance of relative (d): no is compared with yes	0.115	0.107	1.081	0.281
Adaptive behavioral factors:				
Rainfall (d): no is compared with yes	0.280***	0.096	2.901	0.004
Flood (d): no is compared with yes	−0.220**	0.107	−2.059	0.040
Drought (d): no is compared with yes	−0.170*	0.090	−1.888	0.060
Salinity (d): no is compared with yes	−0.284***	0.098	−2.910	0.004
Climate/weather informal factors:				
Radio (d): no is compared with yes	0.144	0.093	1.546	0.123
TV (d): no is compared with yes	0.051	0.419	0.121	0.903
Newspaper (d): no is compared with yes	0.164	0.258	0.637	0.524
Peer contact (d): no is compared with yes	0.029	0.090	0.321	0.749
Official contact (d): no is compared with yes	−0.088	0.155	−0.564	0.573
Adherence to information (d): no is compared with yes	0.162*	0.094	1.722	0.086
Physical environmental factors:				
Distance from shoreline (d): up to 10 km is compared with above 10 km	−0.139	0.091	−1.535	0.126
Distance of shelter (d): up to 2 km is compared with above 2 km	0.187*	0.109	1.709	0.089
Accessibility of shelter (d): no is compared with yes	0.051	0.094	0.546	0.586
Change of settlement (d): no is compared with yes	−0.044	0.189	−0.231	0.818
F value: 8.85 ($p = 0.000$); $R^2 = 0.41$				

Note: Dependent variable: adaptive capacity against livelihood insecurity that results from severe constraints in fishing (mostly offshore) related activities.
*significant at 0.10; **significant at 0.05; ***significant at 0.01

damages of physical and socioeconomic infrastructures (Table 8). Adaptive capacity against livelihood insecurity that results from severe constraints in fishing-related activities are determined by past adaptive behavioral factors such as adaptation against rainfall ($p = .004$), flooding ($p = .04$), drought ($p = .06$), and

Table 10 Parameter estimates in ANOVA to determine the influence of various factors on adaptive capacity against livelihood insecurity that results from severe crisis in freshwater supply and public health risk

Independent variables/parameters	B	Std. Error	t	Sig.
Intercept	0.977	0.475	2.056	0.041
Demographic and socioeconomic factors:				
Age (d): up to 35 is compared with 35 and above	0.099	0.102	0.971	0.332
Sex (d): female is compared with male	0.084	0.063	1.328	0.185
Education (d): uneducated is compared with educated	−0.120	0.076	−1.592	0.113
Membership (d): no is compared with yes	0.384***	0.127	3.012	0.003
Farmland (d): landless is compared with or landholder	−0.052	0.094	−0.556	0.579
Occupation (d): agriculture is compared with non-agriculture	0.138	0.089	1.557	0.121
Assistance of relative (d): no is compared with yes	0.538***	0.081	6.620	0.000
Adaptive behavioral factors:				
Rainfall (d): no is compared with yes	0.184***	0.073	2.503	0.013
Flood (d): no is compared with yes	0.077	0.081	0.941	0.347
Drought (d): no is compared with yes	−0.012	0.069	−0.180	0.858
Salinity (d): no is compared with yes	0.007	0.074	0.092	0.927
Climate/weather informal factors:				
Radio (d): no is compared with yes	0.059	0.071	0.826	0.409
TV (d): no is compared with yes	−0.062	0.319	−0.193	0.847
Newspaper (d): no is compared with yes	0.354*	0.196	1.803	0.072
Peer contact (d): no is compared with yes	0.002	0.069	0.029	0.977
Official contact (d): no is compared with yes	−0.215*	0.118	−1.816	0.070
Adherence to information (d): no is compared with yes	−0.014	0.071	−0.195	0.846
Physical environmental factors:				
Distance from shoreline (d): up to 10 km is compared with above 10 km	0.032	0.069	0.463	0.644
Distance of shelter (d): up to 2 km is compared with above 2 km	0.140*	0.083	1.685	0.093
Accessibility of shelter (d): no is compared with yes	−0.097	0.072	−1.360	0.175
Change of settlement (d): no is compared with yes	0.101	0.144	0.699	0.485
F value: 5.77 (p = 0.000); $R^2 = 0.32$				

Note: Dependent variable: adaptive capacity against livelihood insecurity that results from severe crisis in freshwater supply and public health risk.
*significant at 0.10; **significant at 0.05; ***significant at 0.01

salinity intrusion ($p = .004$). Respondents who have past experience of recurrent adaptation against flooding, drought, and salinity intrusion are 0.22, 0.17, and 0.28 times more adaptive against livelihood insecurity that results from severe constraints in fishing-related activities (Table 9). However, it is unclear why people having recurrent experience of adaptation against rainfall are less adaptive to severe constraints in fishing-related activities. Finally, adaptive capacity against drought (e.g., freshwater crisis) and public health risk are determined by adaptive behavioral factors such as torrential rainfall ($p = .013$). Respondents having recurrent experience of adapting to torrential rainfall are 0.184 times more impacted by freshwater crisis and public health risk (Table 10). Therefore, the hypothesis is not rejected.

Hypothesis 3: Access to Climate/Weather Information and Knowledge Products Determines Adaptive Capacity Against Livelihood Insecurity

The models show that respondent's use of climate/weather information and knowledge products determines the adaptive capacity against different groups of livelihood insecurity with varying combinations (Tables 7, 8, 9, and 10). For instance, adaptive capacity against livelihood insecurity that results from severe constraints in agriculture farming and allied activities are determined by respondent's use of climate/weather information and knowledge products such as television ($p = .013$) and newspaper ($p = .012$). Respondents who use television and newspaper on a regular basis as a source of climate/weather information and knowledge products are 0.37 and 0.23 times more adaptive against livelihood insecurity that results from severe constraints in agriculture and allied activities (Table 7). Similarly, adaptive capacity against livelihood insecurity that results from severe constraints in fishing-related activities are determined by respondent's adherence to climate/weather information and knowledge products ($p = .086$). For instance, respondents who always try to follow the climate/weather information and knowledge products are 0.16 times more likely to be adaptive to severe constraints in fishing-related activities (Table 9). Finally, adaptive capacity against livelihood insecurity that results from severe crisis of freshwater and public health risk are determined by respondents use of climate/weather information and knowledge products such as newspaper (p = .072) and official sources ($p = .070$). Respondents who use newspaper and official sources (by contacting local officials) on a regular basis are 0.35 and 0.21 times more adaptive against livelihood insecurity that results from severe crisis in freshwater and public health risk (Table 10). However, uses of climate/weather information and knowledge products do not significantly influence the respondent's adaptive capacity against livelihood insecurity that results from severe damage of physical and socioeconomic infrastructures (Table 8).

To all surprise, it has been observed that no significant differences in adaptive capacities are observed among frequent radio users and nonusers. This finding does not confirm many other findings such as the ones of Kurita et al. (2006), Collins and Kapucu (2008). This research lacks in sufficient empirical evidences to substantiate this unusual finding. Further exploratory research may bring out the latent causes. Similarly, contrary to general expectation it is found that adherence to climate information make only little differences in adaptive capacity of the respondents. Those who always follow weather information are rather worse off while adapting against loss of employment in offshore activities. It is probably because, those who care about weather information hardly go out for off shore/deep sea fishing; therefore, they loss too many earning days throughout the rainy season (June to October) when most of the gusty wind and cyclonic events take place. Finally it can be argued that despite very casual influence of some of the climate/weather information sources, by and large access to climate/weather information and knowledge products cause differences in respondents' adaptive capacity against the impacts of hydrometeorological events on their livelihood security. Thus, the hypothesis is not rejected.

Hypothesis 4: Spatial and Locational (i.e., Physical Environmental) Factors Determine the Adaptive Capacity Against Livelihood Insecurity The models show that physical environmental factors determine the adaptive capacity against different groups of livelihood insecurity with varying combinations (Tables 7, 8, 9, and 10). For instance, adaptive capacity against livelihood insecurity that results from severe damage of physical and socioeconomic infrastructures are determined by physical environmental factors, such as distance from the shoreline ($p = .096$) and access to safe shelters ($p = .000$). Respondents who have been living within 10 km from shoreline are .07 times less adaptive to severe damage of physical and socioeconomic infrastructures than people who have been living more than 10 km away from the shoreline. Similarly, respondents who have good accessibility to safe shelters are 0.18 times less likely to be affected by severe damage of physical and socioeconomic infrastructures (Table 8).

Similarly, adaptive capacity against livelihood insecurity that results from severe constraints in fishing-related activities are determined by physical environmental factors such as distance of safe shelters from home ($p = .089$). Respondents who have claimed that the nearest safe shelter is less than 2 km away are 0.19 times more likely to be adaptive to livelihood insecurity that results from severe constraints in fishing-related activities (Table 9). Finally, adaptive capacity against livelihood insecurity that results from severe crisis of freshwater and public health risk are determined by physical environmental factors, such as distance of safe shelters from home ($p = .093$). Respondents who have claimed that the nearest safe shelter is less than 2 km away are 0.14 times more likely to be adaptive to livelihood insecurity that results from severe crisis of freshwater and public health risk (Table 10). It is probably because in most cases construction of safe shelters are accompanied by construction of freshwater ponds for use in emergencies as well as in normal time. However, physical environmental factors do not have statistically significant influence on respondent's adaptive capacity against livelihood insecurity that results from severe constraints in agricultural farming and allied activities. Therefore, the hypothesis is not rejected.

Overall findings suggest that highest number of nine factors determine the adaptive capacity of people against the livelihood insecurity that results from severe constraints in fishing-related activities. Among these nine factors, three are related to demographic and socioeconomic aspects; four factors are related to adaptation behaviors. One factor from each of climate/weather information/knowledge products and physical environmental category significantly influence the adaptive capacity against the livelihood insecurity results from severe constraints in fishing-related activities. As a whole, adaptive behavioral factors have the highest influence followed by demographic and socioeconomic factors. Livelihood insecurity that results from severe damage in physical and socioeconomic infrastructures is significantly determined by eight factors. Among these eight factors, four factors are related to the demographic and socioeconomic aspects of people. Two factors are related to people's adaptation behaviors. Another two factors are linked to the physical environment where the livelihood of people operates. Highest number of two physical environmental factors determine people's adaptive capacity against the impacts that result from severe damage in physical and socioeconomic infrastructures. Climate/weather information and knowledge products-related factors do not have statistically significant

Table 11 Summary of factors influencing various dimensions of livelihood insecurity

Whether the listed factors influence livelihood insecurity	LISD-1	LISD-2	LISD-3	LISD-4
Demographic and socioeconomic:				
Respondent's age				
Respondent's sex	√			
Respondent's education		√		
Respondent's occupation		√	√	
Family's landholding	√	√	√	
Membership of social group	√	√	√	√
Social capitals				√
Adaptive behavioral factors:				
Adaptation against rainfall			√	√
Adaptation against flood		√	√	
Adaptation against drought			√	
Adaptation against salinity	√	√	√	
Climate/weather information:				
Radio				
Television	√			
Newspaper	√			√
Peer network				
Official sources				√
Adherence to information			√	
Physical environmental factors:				
Distance from the shoreline		√		
Distance from the safe shelters			√	√
Accessibility to safe shelter		√		
Change of settlement				

Note: LISD-1: Livelihood insecurity results from severe constraints in agriculture; LISD-2: Livelihood insecurity results from severe damage in physical and socioeconomic infrastructures; LISD-3: Livelihood insecurity results from severe constraints in fishing related activities; LISD-4: Livelihood insecurity results from severe crisis of freshwater and public health risk.

influence on this group of adaptive capacity. Adaptive capacity against the impacts of livelihood insecurity that results from severe constraints in agriculture and allied activities is primarily determined by three demographic and socioeconomic factors. Physical environmental factors do not have any statistically significant influence on this adaptive capacity. Finally, the adaptive capacity against the livelihood insecurity that results from severe crisis of freshwater and public health risk is determined by six factors. Among these factors, two are related to demography and socioeconomic aspects and another two are related to use of climate/weather information products. Both adaptive behavioral and physical environmental factors have limited influence on this adaptive capacity. In sum, adaptive behavioral factors are the strongest determinants of people's adaptive capacity against the livelihood insecurity that results from severe constraints in fishing-related activities. Conversely, demographic and socioeconomic factors are the strongest determinants of adaptive capacity against the livelihood insecurity that results from severe damage in physical and socioeconomic infrastructures. Physical environmental factors have highest influence on adaptive capacity against the livelihood insecurity that results from severe damage in physical and socioeconomic infrastructures as well (Table 11).

Concluding Remarks

Increasing numbers of literature stress the importance of identification of factors that determine the adaptive capacity of people against the impacts of natural disasters. In the changing context of climate as both the frequency and the magnitude of some of the hydrometeorological events are projected to increase this call for a fresh look at the impacts of these events on livelihood security of the coastal people. This chapter first established the ground of amplification of various hydrometeorological disastrous events in coastal Bangladesh. It then identifies the likely threat of various hydrometeorological events on the livelihood security of natural resource-dependent coastal community in Bangladesh taking Kalapara Upazila (subdistrict) as the case study. Employing the PCA analysis from a long list of sources/causes of livelihood insecurity, four major dimensions of insecurity are identified. Therefore, the livelihood insecurity against which adaptive capacity need to be enhanced are (a) severe constraints in agriculture farming and allied activities; (b) severe damage of physical and socioeconomic infrastructures; (c) severe constraints in fishing (mostly offshore) related activities; and (d) severe crisis in freshwater supply and public health risk. At this point, the question arises how to intervene to enhance these four dimensions of adaptive capacity of peoples. It is highly unlikely that adaptive capacity of every one need to be enhanced in the same way. Hence, it is important to determine the characteristics that are associated with different dimensions of adaptive capacity. The multiple ANOVA techniques were employed to determine the influences of four groups of variables, namely, demographic and socioeconomic, past adaptive behavioral, climate/weather information/knowledge products, and physical environmental (spatial/locational) aspects on four dimensions of adaptive capacity.

The findings are robust. Among the demographic and socioeconomic factors, sex, education, occupation, farmland holding, membership status (of social institution), and assistance from neighbor/relative have the strongest influence on differential adaptive capacity in general. The influence of other demographic and socioeconomic factors is not statistically significant. Similarly, among the past adaptive behavioral factors, except the freshwater crisis, all other variables, namely, flood, rainfall, and salinity intrusion have strong influence in making difference in adaptive capacity. Likewise, among the climate/weather information/knowledge products, almost all have limited influence on various dimensions of adaptive capacity. However, contrary to expectation no statistically significant influence of radio on adaptive capacity is identified. This finding does not follow most literatures on the burgeoning role of information communication media on adaptive capacity. Therefore, this finding has to be triangulated with more in-depth study before making any conclusion about the role of information channels on adaptive capacity. This seems to be a weakness of this research as well. On the positive side, it can be argued that this research opens up a new avenue of further exploratory research. Similarly, all the physical environmental (spatial/locational) factors have limited influence on differential adaptive capacity of coastal people. Finally, it could be argued that while all the four major group of factors are important determinants of adaptive capacity against hydrometeorological disastrous events in coastal Bangladesh, the past adaptive behavior against flood, rainfall, salinity intrusion, and the few others socioeconomic factors, such as occupational engagement, land holding, and educational attainment are the key drivers of peoples adaptive capacity. Considering the heavy influence of most of the adaptive behavioral factors it can be said that the past experience of adaptation probably the cause of the winning the battle of the resource poor coastal people of Bangladesh against the various hydrometeorological disasters throughout the history. This finding stresses the importance of nurturing of local/traditional/indigenous knowledge of adaptation alongside initiation of programs for livelihood vulnerability reduction. Finally, it is concluded that rather than launching very generic program for adaptive capacity building of the coastal inhabitants in general, specific program may be initiated for specific group of natural resource-dependent coastal people whose livelihood are vulnerable to specific impacts of various hydrometeorological disastrous events. This finding can help policy makers and planners alike in identifying people in need of specific adaptive capacity enhancement program.

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