Chapter 9
Climate Change-Induced Livelihood Vulnerability and Adaptation of St. Martin's Island's Community, Bangladesh

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Abstract Bangladesh, amongst the countries most vulnerable to climatic impacts, is facing a significant impact on the livelihood of the community, especially in the coastal areas, where subsistence mostly depends on the natural resources. This study analyzes the livelihood vulnerability caused by climatic hazards in St. Martin's Island, Bangladesh, with reference to different well-being groups and their adaptation strategies. Both primary and secondary data were used. The primary data were collected from three well-being groups (well-off/rich, medium, and poor groups) of the community using key informant interviews, vulnerability matrices, and focus group discussions. The major climatic hazards identified include storms, cyclones, rainfall, salinity intrusion, and tidal water increase, which significantly affect the priority livelihood activities such as tourism business, agricultural practices, fishery practices, and other occupations. Cyclones momentously affect all three groups of people, despite their economic differences. Tidal water increase, on the other hand, affects mostly the poor and medium groups of people. Heavy rainfall causes damage mostly to the poor group. Interestingly, salinity intrusion has profound effects on the rich and medium groups of people compared with the poor group. Collectively, the rich (score: 8.25) and medium (score: 8.25) groups of people have a higher level of vulnerability due to major hazards than the poor group (score: 7.50), although the

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variation is not statistically significant (p value = 0.953). To cope with the impacts, the islanders are following short-term traditional adaptation strategies, i.e., changing crop variety, changing fishing patterns, selling more livestock, and selling corals, handmade ornaments, dry fish, and mollusks. However, to live with the climatic impacts in the longer-term and maintaining sustainable livelihoods, long-term, proactive and effective adaptation strategies need to be taken, e.g., enhancing cooperation among the community people, improving infrastructure, incorporating modern fishing technology, and producing new as well as diversified livelihood activities, amongst others.

Keywords Climate change · Livelihood · Vulnerability · Adaptation · St. Martin's Island · Bangladesh

9.1 Introduction

The subsistent development and future survival of mankind are being affected by global climate change (Tao et al. 2011), a broadly discussed issue that exacerbates the frequency and intensity of natural disaster (Kabir 2014) such as floods, tropical cyclones, salinity intrusion, tidal water surge, droughts, and heat-waves (IPCC 2014). These disasters bring about a devastating effect on a nation's agriculture, fisheries, water supply, food resources, health, and shelter (CFE-DM 2017). Bangladesh, a country with the seventh ranking in the Global Climate Risk Index among 170 countries, is among the most vulnerable to climate change (Rawlani and Sovacool 2011; Adem et al. 2017; Eckstein et al. 2019). The geographical location, low-lying topography and funnel-shaped coast expose the land to cyclones, tidal surges and seasonal flooding (Ali 1999; Rahman et al. 2011) and cause damage to lives and properties. In addition, a large population base, poor institutional development, and widespread poverty are making Bangladesh more vulnerable to climate variability and change (World Bank 2000). Coastal areas of the country are mostly exposed to these disasters. In Bangladesh, approximately 44 million people live in the coastal area, which made the situation worse, as some disasters such as cyclones are likely to hit in the coastal regions only (Mallick et al. 2017). About two-thirds of Bangladesh lies within 5 m above sea level with a high population density (Agrawal and Perrin 2009) whereby a 1-m increase in sea level will immerse 18% of the total land area, affecting 11% of the total population (Huq et al. 1995; Islam 2002; Alam 2003; Islam et al. 2014b; Ahammed et al. 2016). The predicted increase in sea level in Bangladesh is ten times more rapid than the global average, which is putting the country and its coastal areas at a four times higher risk (CFE-DM 2017) and can initiate permanent inundation, drainage congestion, salinity intrusion, and frequent storm surge inundation (Mohal et al. 2006).

From the last decade, vulnerability, adaptation, and adaptive capacity have emerged as the key concepts in illustrating the social implications of climate change (Füssel and Klein 2006). Since the publication of the IPCC fourth assessment report (2007), vulnerability and adaptation have gained the attention of numerous

researchers throughout the world (Balasubramanian et al. 2007; Below et al. 2012; Gbetibouo et al. 2010; Iglesias et al. 2011; Malone and Brenkert 2008). This emphasizes the need to carry out research studies on climate change to understand the impacts, vulnerability, and adaptation. According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability can be defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC 2001). It is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2001), whereby adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate the potential damage from it, to take advantage of its opportunities, or to cope with its consequences (IPCC 2007).

Coastal districts of Bangladesh are facing an expanding range of stresses and traumas, the scale of which now poses a warning to the resilience of both humans and environmental coastal systems, and are possibly to be aggravated by climate change (IPCC 2007; Islam et al. 2014a). Major climatic hazards such as storms, cyclones, land erosion, salinity intrusion, tidal water increase, sea-level rise, and heavy rainfall invade the coastal regions of Bangladesh (Islam et al. 2014a, b). Cyclones and tidal water increases have frequently invaded these regions, annihilating lives and properties (Alam and Collins 2010). Approximately 5.5% of the world's tropical cyclones hit the Bay of Bengal (Ali 1996) and the frequency of severe cyclones is one in every 3 years (GoB 2009), which critically destroys lives and property. Salinity intrusion and tidal water increases have long-term social and economic impacts (IPCC 2007). The natural resource-dependent livelihood practices such as agriculture and fisheries are facing severe impacts due to these climatic hazards (Alam et al. 2013). The common perception is that poor income group communities are the most vulnerable to climate change-induced hazards, as they have less capacity to adapt to the adverse environmental conditions (IPCC 2001; Islam et al. 2014c). However, this phenomenon may not be applicable everywhere. It may change over time, place, and in a particular situation in any community considering their access to resources, knowledge, and information. Therefore, for better understanding and effective policy development, local-level study of vulnerability and adaptive strategies for all well-being groups is a prerequisite.

St. Martin's Island, the only coral island of Bangladesh, is situated in the Bay of Bengal. The community's dependence on natural resources expose them to climatic hazards (IPCC 2007; Paavola and Adger 2002; Mosse 1994). Besides, the panoramic landscapes, clear seawater, and natural treasures of coral colonies have made this island an enchanting tourist spot (Rani et al. 2020) with the convenience of tourism-related livelihoods. Historically, there have been various research studies on St. Martin's Island from food security (Feeroz 2009) to policy development (Islam 2001). Besides, the island's diversified biodiversity i.e., coral reef, seaweeds, fish, and shellfish (Alam et al. 2015; Haider 2008; Tomascik 1997; Mollah 1997) as well as their potential threats (Moudud 2010; Hasan 2009) have been a vast hotspot of research. But despite being the most exposed and most vulnerable coastal area of Bangladesh owing to climatic hazards, and despite the potential threat to the livelihood of the

community due to the dependency on natural resources, research on the livelihood vulnerability of St. Martin's Island's community and how they adapt in such vulnerable circumstances has been disregarded among the researchers (Islam 2002; Alam 2003; Islam et al. 2014b; Ahammed et al. 2016). To understand the community's evidentiary condition and to implement sustainable adaptation practices we need to know the community level vulnerability and how they cope with the adverse situation. For this reason, this study was aimed at exploring how climate change is affecting the livelihoods of local communities, thus determining the vulnerability of different well-being groups and how they are trying to cope with and adapt to the climate hazards.

9.2 Materials and Methods

9.2.1 Study Area

St. Martin's Island is the southernmost union of Bangladesh with a total area of 835 acres, which lies 3.6 m above the mean sea level (Chowdhury 2012). The population of this island is only 6703, with a total of 1169 households (BBS 2011), where 90% of them consist of fishermen (Haider 2008). Myanmar's Arakan coast resides about 10 km away from the eastern side of the island; the southern and western sides are bounded by open sea and the only mainland edge, the Teknaf coast of Bangladesh, lies about 9.8 km north of the island (Hossain 2001) (Fig. 9.1).

9.2.2 Methodology

9.2.2.1 Data Collection

Both primary and secondary data were collected for this study during the period October 2017 to February 2018. To collect primary data, this study used key informant interviews (KIIs), climate vulnerability and capacity analysis (CVCA), and focus group discussions (FGDs).

A total of 12 KIIs were conducted to make up the three well-being groups of the sample people of St. Martin's Island, based on their income, food sufficiency, land ownership, and educational qualifications (Mosse 1994) (Table 9.1). According to the KII findings, the island contains approximately 30–50 rich households, 300–500 medium-rich households, and the remaining 800–1000 were poor households.

This study adopted CARE's CVCA method to explore the climatic consequences with the sense of well-being vulnerability and adaptation strategies of St. Martin's Island's community. This method provides a framework for analyzing vulnerability and adaptive capacity to climate change at the community level by combining local knowledge with scientific data to yield greater understanding about the local impacts of climate change (Daze et al. 2009). The CVCA process is different from other

Fig. 9.1 Map of St. Martin's Island on the map of Bangladesh. (Source: Banglapedia 2014)

forms of participatory methods because of its focus on climate change (how climate change will affect the lives and livelihoods of target populations) and its emphasis on multi-stakeholder analysis, collaborative learning, and dialog. It focuses on communities as well as examining enabling environments.

Among several participatory tools of CVCA, there are, for example, hazard mapping, seasonal calendars, historical timeline of livelihood activities, vulnerability matrix, and stakeholder analysis; vulnerability matrix was used in this study to

Table 9.1 Criteria for the categorization of the three well-being groups of St. Martin's Island's people

Criteria applied	Well-off/rich group	Medium group	Poor group
Food sufficiency and storage	Food sufficiency throughout the year and food storage for 1 year or more	Food sufficiency throughout the year and food storage for 6 months or less	Food sufficiency for 6 months or less
Land/boat/trawler	Have large area of irrigated and non-irrigated land, also boat and trawler	Limited boat and land	No irrigated land or no developed boats
Education and employment	Children admitted to schools and family has a large business	Children admitted to schools and at least one member per family has a job/has small business	Children admitted to schools but no job/business, do different forms of labor
Income	High income, around BDT15,000–20,000 per month and no loan	Medium income, around BDT5000–10,000 per month	Very low income, around BDT1000 per month; taken out a loan

Table 9.2 Impact scoring criteria for determining vulnerability

Impact scores	Criteria
3 (significant impact)	People's houses are destroyed. They have to live under the open sky until their house is repaired. Their coconut tree garden is also destroyed. The educational institution remains shut down for a long time. People have to starve because of lack of food
2 (medium impact)	People's houses are damaged. They have to suffer a lot until their house is repaired. Their coconut tree garden is also damaged. The educational institution remains shut down for a certain period. People suffer from lack of food
1 (low impact)	People's houses and coconut tree gardens are damaged. It takes time to repair them. Education system is hampered for some time. People cannot concentrate on their business because they are busy repairing their houses
0 (no impact)	No impact at all

determine the hazards with the most serious impacts on important livelihood resources and their vulnerability as well as to identify adaptation strategies used by the communities to address the identified hazards (Rawlani and Sovacool 2011; Adem et al. 2017). A total of three CVCAs were conducted each for a well-being group of 8–10 participants. During a CVCA, at first, the most important livelihood resources were identified and the priority resources were listed vertically. Then, the greatest hazards to the community's livelihood were perceived and the significant hazards were set horizontally. The final step was to put the score within a range of 0–3 to determine vulnerability (Table 9.2). During the process of building consensus for each score, the participants were encouraged to discuss the reasons for each score, related vulnerability, and adaptation strategies. The climate change-related impacts, adaptation, and vulnerability were prompted.

In addition, three FGDs, each containing 8–10 preselected household heads of different categories (well-being groups) were carried out to discuss the important issues in detail and triangulate the CVCA and KII data. For the FGDs a checklist was prepared beforehand seeking information about the perception of communities regarding climate change, impacts of climatic hazards, extreme climatic events, and response strategies. In addition, to cross-check the primary data, participant observation and secondary data were collected from various books, journals, and other published literature. Meteorological data of the last 20 years (1997–2007) from Teknaf station were collected from Bangladesh Meteorological Department (BMD) to compare and underpin the spatial and temporal variations in temperature and rainfall with the observed impacts.

9.2.3 Data Analysis

Content analysis was used to analyze the field data collected for FGDs, KIIs, and the discussion part of the CVCA matrices. A list of climate hazards and livelihood resources was prepared and then significant hazard and livelihood resources were itemized in the vulnerability matrix table to be scored from 0 to 3 (3 = significant impact, 2 = medium impact, 1 = low impact, 0 = no impact) by the respondents and the total scores were calculated. Scores obtained from the vulnerability matrix table were delineated in charts and graphs using MS Excel to better understand the results. Finally, analysis of variance (ANOVA) F test was executed to compare how the vulnerability varied among the three well-being groups owing to the impact of major hazards.

9.3 Results and Discussion

9.3.1 Impacts of Climate Change on Livelihood

St. Martin's Island has tropical sunny weather with an average dry bulb temperature fluctuating from almost 25.5 to 26.45 °C. The highest annual maximum temperature ever, 38.1 °C, was recorded here in the year 2000. Average precipitation in this island ranges from 3200 to 5500 mm. The climatic variables significantly affect the occurrence of natural hazards such as storms, cyclones, weather fluctuations, and seasonal environmental stresses such as rainfall, salinity intrusion, and tidal water increase that affect the livelihood resources of the community. The livelihood of the community of this island is predominantly dependent on the natural resources i.e., fish, coconut, coral, and other natural amenities (Rawlani and Sovacool 2011; Adem et al. 2017). Fishing is the main source of income for most of the people on the island, which covers 90% of the total community (Haider 2008). In addition, hotel/

cottage and resorts, restaurant businesses, coral and shell collection, fish drying, small shop, tourism business, algae collection, coconut selling and agricultural practices, are also important livelihood resources. Among these, fishing, fish drying, and agricultural practices related to coconut selling are the most common livelihood options throughout the year, although coconut and dry fish selling, shell extraction, tourist van-pulling, shop-keeping, and hotel and motel services only run during the peak tourist season from November to April (Nafi and Ahmed 2017).

The major climatic hazards, i.e., storms, cyclones, heavy rainfall, salinity intrusion, and tidal water increase the impact on the principal livelihood resources in various ways. Cyclones and tidal surges, which are considered the world's foremost climatic hazards, have frequently destroyed lives and properties (Alam and Collins 2010). As the island is only accessible by local mechanized wooden boat (tourist vessels are only seasonally available), the usual communication with the mainland is cut off under disastrous circumstances; thus, the conventional food supply becomes entangled and shatters the supply–demand chain of the island, leaving a crisis of basic needs, namely, food, water, health, sanitation, and transportation. Lack of environmental health knowledge among the affected people creates the most important problem of water and sanitation in the post-disaster period (Alam and Collins 2010), mostly among the poor and middle-income group people. The CVCA discussion reveals that agricultural practices on the St. Martin's Island are reducing rapidly because of salinity intrusion, excessive population pressure, and increasing construction activities. Salinity intrusion also affects livestock rearing by reducing local vegetation and grass production (Rawlani and Sovacool 2011; Adem et al. 2017). Fishing activity also stops under hazardous environmental conditions such as storms, cyclones, and heavy rainfall. Hence, only a few months during monsoon and the tourist season are the local poor community able to feed themselves by securing substantiated income, mainly by selling fish, coconuts, dry fishes, and pulling vans.

9.3.2 Differential Vulnerability of Well-Being Groups

To identify the vulnerability of three well-being groups of communities of St. Martin's Island this study has used cyclone, tidal water increase, heavy rainfall, and salinity intrusion as major climatic hazards. Prioritized livelihood resources and activities were tourism business (e.g., hotels, cottages or resorts, small or big shops), fishing by using boats/trawlers, agricultural practices, i.e., crops and coconut gardens, and other jobs. Each hazard was scored according to the significant impacts on the livelihood resources and activities. The people of the community have given their vulnerability score on the basis of their destruction and losses due to the hazards. Tables 9.3, 9.4, and 9.5 represent the vulnerability matrices of well-off, medium, and poor well-being groups respectively.

The results from Tables 9.3, 9.4, and 9.5 show that cyclones have a significant impact on all three well-being groups despite their economic distinction, as they severely damage and destroy the homesteads and livelihoods of the people (Mallick

Table 9.3 Vulnerability matrix for the well-off/rich well-being group of people of St. Martin's Island

Major livelihood resources and activities	Major hazards				
	Cyclone	Heavy rainfall	Tidal water increase	Salinity intrusion	Total vulnerability score
Tourism business/shop	3	3	3	0	9
Agricultural practices	3	3	3	3	12
Fishing (boat/trawler)	2	2	2	0	6
Job/education	3	2	1	0	6
Total score	11	10	9	3	

Table 9.4 Vulnerability matrix for the medium well-being group of people of St. Martin's Island

Major livelihood resources and activities	Major hazards				
	Cyclone	Heavy rainfall	Tidal water increase	Salinity intrusion	Total vulnerability score
Tourism business/shop	3	2	3	0	8
Agricultural practices	2	3	3	3	11
Fishing (boat/trawler)	3	2	2	0	7
Job/education	3	2	2	0	7
Total score	11	9	10	3	

Table 9.5 Vulnerability matrix for the poor well-being group of people of St. Martin's Island

Major livelihood resources and activities	Major hazards				
	Cyclone	Heavy rainfall	Tidal water increase	Salinity intrusion	Total vulnerability score
Tourism business/shop	2	2	3	0	7
Agricultural practices	3	2	3	0	11
Fishing (boat/trawler)	3	2	2	1	8
Job/education	3	2	2	0	7
Total score	11	8	10	1	

et al. 2017). Heavy rainfall, at the same time, has a profound impact on the well-off group (as it mainly affects the agricultural land and tourism business) followed by the medium and poor groups of people. On the other hand, tidal water increases usually affect the medium and poor groups of people, mostly because of the structure and position of their household, which become inundated during flooding situations and they need to take shelter in a safe place. Sometimes, poor people build their temporary house by using polythene and plastic, whereas the middle group of people use bamboo and wood. They eat less than they require and some have no food to eat. The study says that approximately 54% of people of this island do not get sufficient food at the market owing to disruption of the food supply from the mainland after the disaster (Feeroz 2009). Interestingly, salinity intrusion has a

significant impact on the well-off and medium-income groups of people as salinity mainly affects the agricultural lands, which are mainly owned by these two groups of people. Thus, in most climatic hazards, both well-off and medium groups of people are more affected than the poor group of people.

The priority livelihood resources of the people of this island are tourism business (e.g., hotels/resorts, food hotels, and small shops), agricultural practices (i.e., cultivation of lands and coconut gardens), fishery activities (fishing in the sea using boats or trawlers, fish drying) and other jobs or educational services. All these livelihood options are mostly dependent on the natural resources of the island; therefore, climatic hazards can easily affect the livelihood of all income groups of people. The tourism business, for example, is mainly dependent on the aesthetic beauty of this island. In any natural disturbance such as a storm or a cyclone, the island becomes separated from the mainland, interrupting the tourism business and affecting dependent people as no tourists can come onto the island. This study has found that, in the case of the tourism business and agricultural practices, climatic hazards mostly affect the rich group of people followed by the medium and poor well-being groups (see Tables 9.3, 9.4, and 9.5) as the rich group of people have most of the tourism-related business and most own agricultural land and coconut gardens. Disturbance in fishery activities, e.g., fishing in the sea using a small boat or working on a trawler as a wage earner mostly affect the poor well-being group, as their livelihood is often dependent on these, followed by the medium and rich groups of people. At the same time, inconvenience in the job and other sectors due to climatic hazards also simultaneously affects the medium and poor groups of people. Thus, from the CVCA score it is evident that the rich group of people has the greatest vulnerability in the case of the tourism business and agricultural practices; the poor group of people has the highest vulnerability in fishery activities and the job sector, whereas the medium group are only highly vulnerable in the job sector.

Following the ANOVA *F* test (Table 9.6) it is perceptible that the combined impact of major hazards has the highest impact on the rich (score: 8.25, standard

Table 9.6 Comparison of the vulnerability scores of the three well-being groups of people on St. Martin's Island due to major climatic hazards along with standard error (SE), 95% confidence interval (CI), and *p* value of the ANOVA *F* test

		Vulnerability scores for well-being groups			*p* value (ANOVA *F* test)
		Rich/well-off	Medium	Poor	
Major hazards	Cyclone	11	11	11	0.953
	Heavy rainfall	10	9	8	
	Tidal water surge	9	10	10	
	Salinity intrusion	3	3	1	
	Total score	33	33	30	
	Mean	8.25	8.25	7.50	
	SE	1.80	1.80	2.26	
	95% CI for mean	(2.53, 13.97)	(2.53, 13.97)	(0.32, 14.68)	

Table 9.7 Some studied proactive and reactive adaptation practices adopted by the three well-being groups of people of St. Martin's Island

Well-being status	Proactive adaptations	Reactive adaptations
Well-off	Change fishing and cropping pattern, purchase land, lend money, access new business options	Keep storage of fish and crops, cash savings
Medium	Change business patterns, find different skill-based work, livelihood diversification	Keep storage of fish and crops, cash savings, selling products on the market
Poor	Change work pattern, sale of property	Sell corals, mollusks, echinoderms, handmade ornaments, and dry fish to the tourists

error [SE] = 1.80, 95% confidence interval [CI]: 2.53 to 13.97) and medium (score: 8.25, SE = 1.80, 95% CI: 2.53 to 13.97) well-being groups than on the poor (score: 7.50, SE = 2.26, 95% CI: 0.32 to 14.68) group of people, although this variation is not statistically significant (p value = 0.953). Although it is conceivable that climate change-related natural disasters damage the livelihood of poor people by making them more vulnerable (Kabir et al. 2016), in this study we found that the rich and middle-income groups of people are also correspondingly vulnerable. Even the well-off group of people faces difficulties in resolving potential vulnerability.

9.3.3 Adaptation Strategies

Despite the impacts posed by different climatic hazards, communities of St. Martin's Island try to adapt by diversifying their livelihood resources. Communities adopt both proactive and reactive adaptation practices based on their capacity (Table 9.7). But in most of the cases, these adaptation practices are short term and traditional, such as diversification of livelihoods, changing techniques and patterns in farming and fishing, adopting supplementary livelihood options.

Table 9.7 clearly illustrates that poor households are unable to adopt some adaptation options such as changing crop variety, changing fishing pattern, and saving more livestock owing to their lack of resources and cash. In the tourist season, they change their work options such as selling corals, handmade ornaments, dry fish, and mollusks, but at other times they have fewer options and most of them are reactive rather than proactive. On the other hand, the well-off households save cash, purchase land, store food, and lend money to the poor with high interest. Also, most of the well-off households and some medium households explore new fishing and agriculture technology, new crop varieties, new business paths, and diversify their livelihood options. Adaptation strategies by rural communities are mostly autonomous and reactive rather than strategic (Smit et al. 2000), which are in most cases inefficient and could be unsuccessful (IPCC 2007). Evaluation of adaptation options can be based on criteria such as costs, benefits, urgency, efficiency, and implementation

ability (Smit and Wandel 2006); thus, the poor households have limited access to long-term effective proactive adaptation measures owing to lack of resources and low-income strategy. They have the greatest vulnerability in contrast to the well-off households, with enough resource ownership and better financial access. This statement is also supported by another statement by Reardon and Taylor (1996): rich households are expected to have more flexibility in adapting to climate change because they can afford more expensive strategies. The study has revealed that all the adaptation practices identified by the households are mainly traditional practices based on their local knowledge and experience in response to climate hazards. A similar result was also found in a study by Alam (2017) where respondents applied their perception and long-term knowledge in adapting to climate change. In general, adaptation practices adopted in the countryside are mostly related to crop diversification, irrigation, water management, and lending money (IPCC 2007; Gentle and Maraseni 2012). These short-term traditional adaptation strategies might be helpful in the current situation, but with the additional burden of climate change, they might not be able to cope in the future.

9.3.4 Reducing Impacts and Increasing Adaptations

Increasing the competency of individuals or groups to adapt to changes by building adaptive capacity and transforming that competency into practice are the two factors in implementing adaptation (Adger et al. 2005). Improved risk management, increasing knowledge, and development of technology can be involved in an adaptation strategy (West and Gawith 2005). But it should be continuous and reflect social norms and processes (Adger et al. 2005). On small islands, supplying incessant power facilities, increasing tourism facilities and activity, and enhancing services related to the coastal resources can increase adaptation (Nurse et al. 2014). As most of the adaptation practices adopted by the St. Martin's Island community are short term, for effective and sustainable adaptation, long-term, proactive, and integrated adaptation measures on social, economic, technological, institutional, and infrastructural dimensions are truly needed.

9.4 Conclusions

As one of the most vulnerable countries in the world, the livelihoods of the coastal areas of Bangladesh are being heavily impacted because of major natural and climatic hazards. With the study it was intended to explore the vulnerability of different well-being groups of St. Martin's Island community in Bangladesh to climatic hazards by using vulnerability matrices, FGDs, and KIIs. It identified four major hazards, namely, cyclones, heavy rainfall, salinity intrusion, and tidal water increase, which affect nature-dependent major livelihood resources and activities, i.e., tourism businesses, agricultural practices, fishery practices, and other occupations. In

spite of having economic disparity, cyclones affect all three well-being groups, whereas poor and medium-income groups of people are mostly affected by tidal water increases. Interestingly, although heavy rainfall affects the poor group most, salinity intrusion affects rich and medium-income groups of people more. It was found that the rich and medium groups of people have a higher level of vulnerability to major hazards than the poor group, although the variation is not statistically significant (p value = 0.953). All groups struggle to adapt under changing environmental conditions by adopting short-term traditional adaptation strategies such as the diversification of livelihoods, changing crop varieties, selling more livestock, change fishing patterns, and storing foods. However, to ensure effective adaptation and sustainable livelihoods of the community, long-term, proactive adaptations by the governmental and nongovernmental bodies are needed, for example, by:

(a) Enhancing co-operation: as most of the people on the island are fishermen, to build cooperation among them (despite their economic differences), the community's association with microfinancing facilities can be built to incorporate savings accounts and increase access to credit by providing emergency loan schemes.
(b) Ensuring basic needs: as there is insufficient fulfilment of basic needs during and after disasters, ensuring a continuous supply of food, water, and health services from the mainland during these periods will increase the adaptation capacity of the community.
(c) Improving infrastructure and incorporating modern technology: improving infrastructural facilities such as solar power supply for everyone and improving communication with the mainland all the year round will augment the tourism business; increase the livelihood capacity of all income groups of people, thereby increasing their adaptation. In addition, technological advancement of fishing boats and trawlers can increase the catch by facilitating deep-sea fishing.
(d) Producing new livelihood opportunities: as the poor well-being group of people have fewer opportunities to diversify their livelihoods, some additional income-generating opportunities, namely, producing value-added fish products, and hand crafting (by both women and men), can be created outside of the tourist season. In addition, introducing seaweed culture and crab culture may have a profound impact on the livelihoods of the island's people.

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