

**Vulnerability and Adaptation of Fishing Communities to the Impacts  
of Climate Variability and Change: Insights from Coastal Bangladesh**

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## PhD Publications

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All the above articles constitute an important part of my thesis. I am lead author on these articles as they represent the publications generated from PhD studies. Consequently, I use my own collected data, empirical results and analysis. The articles were co-authored with my supervisors whose role was in the recommendation of revisions and edits to these articles.

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## **Abstract**

Climate variability and change are predicted to impact on coastal and marine small-scale fisheries and dependent communities. They have been adapted to the normal range of climate variability and its impacts, but additional adaptation will be required to address the increased impacts of climate change. Migration is regarded as one strategy to adapt to these impacts but debates surround its successfulness. Fishing communities can adapt in many ways and migration is one example. However, limits and barriers can prevent adaptation being successful or reduce vulnerability. Studies on vulnerability, adaptation and limits and barriers to adaptation are therefore preconditions for the fishing communities to develop effective adaptation strategies to face climate variability and change. Despite considerable studies on the impact of climate change on aquatic ecosystems and fish stocks, the macro scale fishery-dependent economies and their people, and on vulnerability and adaptation in agricultural communities, there has been insufficient examination of the vulnerability and adaptation of small-scale fishing communities to climate variability and change. This thesis therefore assesses the vulnerability and adaptation to the impacts of climate variability and change, in three small-scale coastal fishing communities in Bangladesh. Using a mixed method approach, particular focus is given to the assessment of livelihood vulnerability, the investigation of the outcomes of climate induced migration, and the exploration of limits of and barriers to adaptation. Results highlight that the level of livelihood vulnerability not only differs between communities but also between different household groups within a community, depending on their level of exposure, sensitivity and adaptive capacity. Exposure to floods and cyclones; sensitivity (such as dependence on small-scale marine fisheries for livelihoods); and lack of adaptive capacity in terms of physical, natural and financial capital and diverse livelihood strategies construe livelihood vulnerability in different ways depending on the context. Results show that the most exposed community is not necessarily the most sensitive or least able to adapt because livelihood vulnerability is a result of combined but unequal influences of bio-physical and socio-economic characteristics of communities and households. Within a fishing community, where households are similarly exposed, higher sensitivity and lower adaptive capacity combine to create higher vulnerability. Migration may be a viable strategy to respond to climate variability and change. Results show that migration has generated several positive outcomes for households that resettled. The resettled

households are now less exposed to floods, sea level rise and land erosion than those who stayed behind. They have also more livelihood assets and better access to them. They enjoy higher incomes, better health, better access to water supply, health and educational services, technology and markets than the households who remained in their original settlement. The thesis also establishes that fishing communities face multiple limits and barriers to adaptation of fishing activities to cyclones, however. Limits include physical characteristics of climate and sea, such as higher frequency and duration of cyclones, and hidden sandbars. Barriers include technologically poor boats, inaccurate weather forecasts, poor radio signals, lack of access to credit, low incomes, underestimation of cyclone occurrence, coercion of fishermen by the boat owners and captains, lack of education, skills and livelihood alternatives, unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets. These local and wider scale factors interact in complex ways and constrain completion of fishing trips, coping with cyclones at sea, safe return of boats from sea, timely responses to cyclones and livelihood diversification. Overall, this thesis contributes empirical evidence to current debates in the literature on climate change by enhancing an understanding of the characteristics and determinants of livelihood vulnerability, migration as an adaptation strategy and limits and barriers to the adaptation of fishing communities to climate variability and change. The findings of this thesis form the basis for further detailed research into the vulnerability and adaptation of small-scale fishing communities to climate variability and change. Based on the above findings, this thesis also provides some suggestions for reducing vulnerability and for developing effective adaptation strategies.

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## **List of Acronyms and Abbreviations**

ANOVA	Analysis of Variance
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
COP	Conference of Parties
ENSO	El Niño–Southern Oscillation
FGD	Focus Group Discussion
GDP	Gross Domestic Product
HACCP	Hazard Analysis Critical Control Point
IPCC	Intergovernmental Panel on Climate Change
NAPA	National Adaptation Programme of Action
NGO	Non-Governmental Organisation
PCA	Principal Component Analysis
PRA	Participatory Rural Appraisal
SLA	Sustainable Livelihood Approach
SPSS	Statistical Package for Social Sciences
TK	Taka
UNFCCC	United Nations Framework Convention on Climate Change

## **Chapter 1 – Introduction**

This chapter outlines the research motivation, aim and objectives, and structure of this research. The research motivation section (1.1) briefly introduces the importance, gaps and possible outcomes of the research on vulnerability and adaptation of fishing communities to climate variability and change. Section 1.2 outlines the aim and objectives, evolved from a combined academic and empirical challenge, portrayed in this research motivation section and in the literature review (Chapter 2). Finally, section 1.3 outlines the structure of this thesis.

### **1.1 Research Motivation**

Climate variability used to be a normal phenomenon in the Earth's history but over the last few decades climate has been changing faster and is predicted to do so even more in coming decades due to global warming (IPCC, 2007b). This faster climate change has been predicted to impact on both natural and human systems in a complex and unprecedented way (IPCC, 2007a). The fisheries sector, which supports livelihoods of 660–820 million people (FAO, 2012), is considered amongst the worst affected by climate change (IPCC, 2007a; Perry et al., 2009). Climate change is an additional pressure on fisheries systems which already experience other stresses such as over fishing, loss of habitat, pollution and disturbance (Brander, 2006; Coulthard, 2009). In particular, small-scale fishing communities in developing countries, which constitute 90% fishery-dependent people (FAO, 2012), will face complex and localised impacts, as predicted by the Intergovernmental Panel on Climate Change (IPCC) with high confidence (IPCC, 2007a). These impacts can range from changes in ecosystems and fish stocks (IPCC, 2007a; Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010) to damage in fishery methods, and land-based property and infrastructure (Westlund et al., 2007; FAO, 2008). These have the potential to make fishing communities and their livelihoods more vulnerable, but they are only occasionally investigated in the context of developing countries or investigated in other sectors such as agriculture. A detailed study on how fishing communities are vulnerable to past and current climate impacts can provide important insights to address the enhanced level of future impacts or reduce vulnerability for them.

To address the impacts of climate change, adaptation is widely recognised as an important response strategy along with mitigation (Fankhauser, 1996; Smith, 1996; Adger et al., 2007). However, due to lag times in the climate and biophysical systems, the positive impacts of current mitigation efforts will not necessarily be noticeable until around 2050 (IPCC, 2007b). The current level of greenhouse gases will continue to change the climate in the next few decades (IPCC, 2007b). Therefore, adaptation is regarded as inevitable and necessary to tackle the additional shocks and stresses due to climate change (Pielke et al., 2007; Stern, 2007). Whilst societies, including fishing communities, have traditionally adapted to the normal range of climatic variation using different strategies, this level of adaptation is not distributed homogeneously around the world (Perry et al., 2010). Climate change is predicted to pose impacts and vulnerability often outside the range of experience, for which additional adaptation will be needed (Adger et al., 2003), especially for fishing communities (Allison et al., 2005; FAO, 2008). As such, fishing communities deserve greater attention within climate change adaptation debates because they face compounding climate change impacts and non-climatic pressures (Coulthard, 2009).

Human migration is regarded as one of the strategies to cope with or adapt to the impacts of climate change. This strategy has brought much attention in recent years as it is predicted that millions of people, many of whom are from fishing communities, are likely to be displaced due to the impacts of climate change (Myers, 2002; Nicholls et al., 2011). However, there is an on-going debate in academic and policy arenas about the successfulness of climate-induced migration. Migration may be short-term (temporary/seasonal) or long-term (permanent), short-distance (internal) or long-distance (international), and forced (reactive) or voluntary (adaptive). While a growing body of literature considers different drivers (McLeman and Smit, 2006; Black et al., 2011a; Black et al., 2011b; GOS, 2011; McLeman, 2011; Piguet et al., 2011) and types of migration (Paavola, 2008; Piguet et al., 2011), only a few of them examine the likely consequences of migration (Paavola, 2008; Mortreux and Barnett, 2009; Black et al., 2011b; GOS, 2011; Barnett and O'Neill, 2012). None of them have used evidence-based data to conclude the outcomes of migration and many studies have asked for more empirical studies on this issue to support public policy (e.g., IPCC, 2007a; Stern, 2007; GOS, 2011). Studies on the outcomes of past and present climate-induced migration can therefore provide important insights for developing strategies to cope with and adapt to



climate change. Especially, comparing a fishing community that migrates permanently due to climatic reasons, leaving a portion behind, provides an opportunity to compare the two communities and assess the successfulness of migration.

Fishing communities can adapt in many ways, migration is just one example. Adaptation efforts are impeded in many ways, however. Limits (largely insurmountable constraints) and barriers (often malleable constraints) can constrain people's ability to identify, assess and manage risks in a way that maximises their wellbeing and facilitates adaptation to climate variability and change (IPCC, 2007a; Adger et al., 2009b; Moser and Ekstrom, 2010; IPCC, 2012). Fishing communities may not be an exception in this respect (Morgan, 2011). Many of these limits and barriers are interrelated and combine to constrain adaptation (Adger et al., 2007; Jones and Boyd, 2011). But there is a lack of evidence on limits and barriers to adaptation and interactions between them, especially from a developing country perspective. Assessing these limits and barriers would help find suitable means of overcoming them to enable the adaptation of fishing communities to present day climate variability and future climate change.

Bangladesh is regarded as one of the most vulnerable countries to the impacts of climate change (IPCC, 2007a; Met Office, 2011; World Bank, 2013a), despite its significant economic strides over the past four decades (World Bank, 2013b). Its fisheries sector, regarded amongst the most vulnerable to climate change in the world (Allison et al., 2009b), supports the livelihoods of about 7 million fishers directly and contributes 4.43% to GDP and 2.73% to export earnings (DoF, 2012). Most (93%) of the marine fishing is small-scale in nature, supporting livelihoods of over half a million fishers and their household members (ibid). The climate of Bangladesh has changed over the past decades and predictions are that it will continue to change even more in the future, resulting in considerable negative impacts especially in the coastal areas (Met Office, 2011). From 1980 to 2000, a total of 250,000 deaths were associated with tropical cyclones around the world, of which 60% occurred in coastal Bangladesh (IPCC, 2007a). One of the most devastating cyclones and associated storm-surge-induced floods killed 300,000 people in coastal Bangladesh in 1970 (IPCC, 2007a) many of whom were from fishing communities. Thus, the coastal fishing communities in Bangladesh are particularly interesting cases for the study of vulnerability and

adaptation to climate variability and change. The findings of such a study could also contribute to an understanding of these issues in other parts of the world with similar environmental, socio-economic and livelihood conditions.

In summary, despite considerable studies on the impact of climate change on aquatic ecosystems and fish populations, on macro scale fishery-dependent economies and their people, and on vulnerability and adaptation in agricultural communities, there has not yet been sufficient examination of the vulnerability and adaptation of small-scale fishing communities to climate variability and change. This thesis aims to contribute to an increased understanding of these issues and, in particular, of the situation facing Bangladesh. Overall, based on empirical evidence this thesis contributes to current debates on climate change by enhancing an understanding of the characteristics and determinants of livelihood vulnerability, migration as an adaptation strategy and the limits and barriers to adaptation of fishing communities to climate variability and change.

## **1.2 Research Aim and Objectives**

The aim of this research is to assess the vulnerability and adaptation of three Bangladeshi coastal small-scale fishing communities to the impacts of climate variability and change. To achieve this aim, the specific objectives are to:

- 1) to assess the vulnerability of fishery-based livelihoods to the impacts of climate variability and change in two fishing communities and their households;
- 2) to examine how climate-induced permanent migration has impacted vulnerability and adaptation of a fishing community by comparing with the residual of its original community, in order to shed light on the viability of migration as a strategy to address climate change; and
- 3) to identify and characterise limits and barriers to adaptation of fishing activities to cyclones and examine interactions between them in two fishing communities.

## **1.3 Thesis Structure**

The thesis is divided into eight chapters. Following this introductory chapter, Chapter 2 provides a general literature review for the research and explains the key terms used in aim and objectives such as climate variability, climate change, impacts, vulnerability,

small-scale fisheries, livelihood and adaptation. The sustainable livelihood approach and how it fits into this research are discussed. The chapter then goes on to critically examine the existing literature related to the thesis' aim and objectives and identifies gaps and weaknesses in the literature.

Chapter 3 describes the case study sites and methodology. It explains the methodological approaches that this study follows and provides a detailed description of, and justification for, study in Bangladesh and the three case study contexts. The chapter further describes the methods employed for data collection and analysis.

The following three chapters – Chapters 4, 5 and 6 – are the results of this research. Chapter 4 assesses livelihood vulnerability to the impacts of climate variability and change in two fishing communities and different household groups within each community by calculating sub-indices and indices using a composite index approach. This chapter also examines livelihood vulnerability qualitatively focussing on these sub-indices and indices. Chapter 5 examines the outcomes of climate-induced permanent human migration by comparing a migrant community, which has been identified as less vulnerable in Chapter 4, with its original counterpart. It uses historical data to compare climate exposures and explain the migration process, and current data to compare livelihood outcomes in the face of climate variability and change. Chapter 6 identifies and characterises the limits and barriers to adaptation of fishing activities (identified as a main livelihood activity in Chapters 4 and 5) to cyclones (identified, in Chapter 4, as the main climatic shock during fishing). Chapter 6 also examines the interactions amongst limits and barriers.

Chapter 7 integrates the insights from Chapters 4, 5 and 6 and provides a general discussion. This chapter is mainly devoted to explaining the contributions of this research. It highlights how each research objective has been achieved followed by a synthesis that came out while integrating the empirical chapters. It also explores the scaling-up and transferability of the findings of this research.

Chapter 8 is the concluding chapter of this thesis. It summarises the contributions, provides practical implications, states limitations and suggests future research.

## **Chapter 2 – Literature Review**

This chapter provides a general review of the literature on climate variability and change, its impacts, vulnerability, adaptation, livelihoods and fishing communities in order to outline state-of-art, gaps and weaknesses, and to identify possible areas of contribution for this thesis. More focussed reviews of literature related to each objective are later presented in each empirical chapter (Chapters 4, 5 and 6). Section 2.1 outlines future climate variability and change and its overall impacts. Section 2.2 outlines the concepts of vulnerability and adaptation to climate variability and change. Section 2.3 describes fishing communities and their livelihoods through a sustainable livelihood approach. Section 2.4 discusses how the sustainable livelihood approach can be used in climate vulnerability and adaptation research. Section 2.5 discusses how climate variability and change can impact on fishing communities and their livelihoods. Section 2.6 critically reviews the assessment of vulnerability, especially the composite index approach. Section 2.7 reviews how fishing communities adapt to climate variability and change with particular emphasis on migration as an adaptation strategy, and limits and barriers to adaptation. Section 2.8 concludes by summarising this chapter and identifies the research gaps that this thesis addresses.

### **2.1 Climate Variability and Change**

A growing body of literature has documented climate variability and change in the context of global warming. Climate variability refers to “variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events” (IPCC, 2007a, p. 872). Variability in climate had been regarded as natural internal processes within the climate system (internal variability) but over the past few decades anthropogenic external forcing (external variability) has compounded this variability in climate (IPCC, 2007a). Climate change refers to any change in climate over time due to natural or anthropogenic reasons (IPCC, 2007a). Climate change differs from climate variability in the sense that the former is “a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period, typically decades or longer” (IPCC, 2012, p. 5).

Global warming is predicted to impact on natural and human systems in various ways such as increase in temperature, changes in precipitation, increase in flooding, changes in cyclones, increase in drought, rise in sea level and changes in El Niño–Southern Oscillation (ENSO) (IPCC, 2007b). The global surface air temperature is predicted to increase with all scenarios, even if the concentrations of all greenhouse gases and aerosols are kept constant (IPCC, 2007b; Goodess, 2013). Global mean precipitation is predicted to increase, with an increase in tropical regions but a decrease in the subtropics (IPCC, 2007b). More precipitation will cause more flooding but, in areas where mean precipitation will decrease, precipitation intensity will increase which will bring longer periods between rainfall events indicating a greater risk of drought in those regions (IPCC, 2007b). Some models predict an increase in the intensity of tropical cyclones (see Goodess, 2013 for a review); however, there is still uncertainty whether the frequency of cyclones will change (IPCC, 2007b). Under climate change the frequency of cyclones may decrease (Oouchi et al., 2006; Bengtsson et al., 2007; Zhao et al., 2009) or increase (Sugi et al., 2002; McDonald et al., 2005). Deglaciation of polar ice sheets has also been projected which will bring major changes in coastlines and inundation of low-lying areas (IPCC, 2007b). Sea level may rise 18 – 59cm (IPCC, 2007b) or even higher (29 – 84cm) (Bamber and Aspinall, 2013) by 2100. ENSO originates in the tropical Pacific region and affects extreme weather events (such as cyclones and flooding), aquatic and terrestrial ecosystems, agriculture and freshwater supplies worldwide (Collins et al., 2010). Models predict changes in behaviour of ENSO due to global warming, although there is insufficient agreement of model projections (IPCC, 2012).

Together, climate variability and change have been creating unprecedented impacts on natural and human systems, and are predicted to do more so in future, *ceteris paribus*. These impacts are classified as “potential impacts (all impacts that may occur given a projected change in climate, without considering adaptation) and residual impacts (the impacts of climate change that would occur after adaptation)” (IPCC, 2007a, p. 876). Generally, the term impact means potential impact in this study. Hulme et al. (1999) suggest that the differences in impacts due to climate change and those due to climate variability will not be detectable. These impacts are predicted to lead to vulnerability in natural and human systems such as in fishing communities. In response to these

impacts, adaptation is, and will likely be increasingly necessary. The concepts of vulnerability and adaptation will now be explored.

## 2.2 Vulnerability and Adaptation

### 2.2.1 Vulnerability

Originally, the concept of vulnerability was rooted in the study of natural hazards (Hewitt, 1983). Nowadays vulnerability is a central concept in a variety of research contexts including natural hazards and disaster management, ecology, public health, poverty and development, rural livelihoods and famine, sustainability science, land change, and climate impacts and adaptation (Füssel, 2009). Vulnerability is defined in different ways in the environmental change literature (Table 1).

Table 1. Definitions of vulnerability.

<i>Definitions</i>	<i>Sources</i>
“The likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards place with the social profile of communities.”	Cutter (1996, p. 532)
“The exposure of individuals or collective groups to livelihood stress as a result of the impacts of such environmental change.”	Adger (1999, p. 249)
“The ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and wellbeing.”	Kelly and Adger (2000, p. 328)
“The characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of natural hazards”.	Wisner et al. (2004, p. 11)
“The exposure of groups or individuals to stress as a result of climate variability and change”.	Allison et al. (2005, p. 3)
“The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes”.	IPCC (2007a, p. 883)
“The propensity or predisposition to be adversely affected”.	IPCC (IPCC, 2012, p. 5)

In global change and climate change research, vulnerability is an integrative measure of the threats to a system (Cutter et al., 2000; IPCC, 2001). Climate change vulnerability study combines natural and social science perspectives. In the natural sciences, there is a tendency to apply a physical-flows view which focuses on the flow of matter and energy between system components; while in the social sciences there is a tendency to apply an actor system view, which emphasises the flow of information and the relationship between different factors that determine social decision-making (Füssel and

Klein, 2006). Combining the natural and social science perspectives IPCC defines vulnerability to climate change (which this study uses) as: “the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC, 2007a, p. 883).

“Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity” (IPCC, 2007a, p. 883). In this definition the components exposure and sensitivity create potential impacts and increase vulnerability, whilst adaptive capacity decreases it (Figure 1).

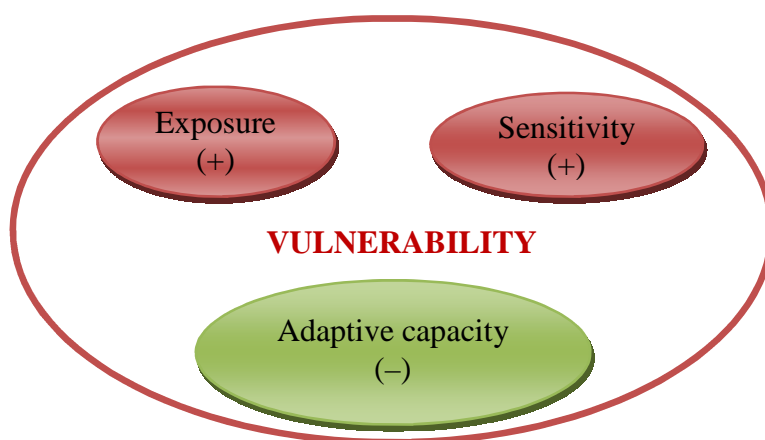


Figure 1. The concept of vulnerability (drawn according to the concept of IPCC, 2007a, p. 883); (+) sign means increased level of vulnerability and (-) sign means decreased level of vulnerability.

Exposure is “the nature and degree to which a system is exposed to significant climatic variations” (IPCC, 2001, p. 987). It is anticipated that exposure to different shocks and stresses such as rise in temperature and sea level, cyclones, floods, land erosion and droughts will be intensified due to climate change (outlined earlier in section 2.1). Repeated exposure can result in the loss or destruction of people’s resources, adaptive capacity and resilience leading to greater vulnerability and preventing their quick recovery (Ford et al., 2006). Although shocks and stresses are often used interchangeably to denote climatic exposure (e.g., IPCC, 2012), for this study extreme events such as cyclones and floods are termed as shocks, whilst slow onset phenomena such as rise in temperature and sea level are termed as stresses. They are also often termed as climatic hazards if there is a threat or potential for adverse effects (Smith, 1996; Wisner et al., 2004). A hazard becomes a disaster when people are severely affected or costs are incurred. Disaster is the “severe alterations in the normal

functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects...” (IPCC, 2012, p. 5). Disaster risk is “the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery” (IPCC, 2012, p. 5). Sensitivity is “the degree to which a system is affected, either adversely or beneficially, by climate variability or change” (IPCC, 2007a, p. 881). Adaptive capacity is “the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, or to cope with the consequences” (IPCC, 2001, p. 982). Adaptive capacity is referred to as the preconditions to enable adaptation to change (Smit and Pilifosova, 2001; Nelson et al., 2007). Adaptive capacity can be enhanced by practical means of coping with changes and uncertainties in climate, including variability and extremes (Smit and Pilifosova, 2001, p. 879). In this sense, enhancement of adaptive capacity reduces vulnerabilities, increases adaptation and promotes sustainable development (Goklany, 1995; Burton, 1997; Cohen et al., 1998).

### **2.2.2 Adaptation**

The term adaptation is interpreted in different ways. In ecology, adaptation refers to changes by which an organism or species becomes fitted to its environment (Lawrence, 1995; Abercrombie et al., 1997); whilst in social sciences, adaptation refers to adjustments by individuals and the collective behaviour of socioeconomic systems (Denevan, 1983; Hardesty, 1983). See Table 2 for more definitions of adaptation.



Table 2. Definitions of adaptation in the domain of climate change.

<i>Definitions of adaptation</i>	<i>Sources</i>
“Adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts”.	Smit and Pilifosova (2001, p. 881)
“Adaptive actions are those responses or actions taken to enhance the resilience of vulnerable systems, thereby reducing damages to human and natural systems from climate change and variability”.	Scheraga and Grambsch (1998, p. 85)
“The ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderate harm or takes advantage of any positive opportunities that the climate may afford”.	IUCN et al. (2003, p. 5)
“Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”.	IPCC (2007a, p. 869)

The above definitions differ from one another. The key differences are how definitions relate to the question “who or what adapts?” and answer the question “adaptation to what and how?” For example, IUCN et al. (2003, p. 5) do not define adaptation as a process or an adjustment of a system but as the ability of a system to respond. This type of definition is generally used to define adaptive capacity rather than adaptation itself (Füssel and Klein, 2006, p. 319). This study considers the definition of adaptation as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2007a, p. 869). This definition is widely used (such as Adger et al., 2005a; Smit and Wandel, 2006) and includes both building adaptive capacity and implementing adaptation decisions. Adaptive capacity can increase the ability of individuals, communities, governments or organisations to adapt to changes, whilst adaptation can transform that capacity into action (Daw et al., 2009). This definition of adaptation focuses not only on technical adaptation measures but also on social, economic and institutional responses.

The concept of adaptation is closely linked to that of coping. Many of the concepts on coping arise from food security literature. Coping is defined as “the methods used by households to survive when confronted with unanticipated livelihood failure” (Ellis, 2000, p. 62). Coping strategies are short-term or temporary responses to external shocks and stresses (which this study uses) (De Haan, 2000, p. 348), which may undermine long-term capacity (Eriksen et al., 2005). Adaptation, on the other hand, is regarded as a

long-term adjustment in a system, as defined above. Coping mechanisms can be developed into more permanent adaptation strategies which in turn can be considered as normal livelihood strategies (De Haan, 2000). Brouwer et al. (2007) consider that within climate change literature, coping strategies and adaptation are often used interchangeably and sometimes intermixed, such as adaptive coping mechanisms.

Adaptation is also linked to the concept of disaster risk reduction and resilience. Disaster risk reduction is “the strategic and instrumental measures employed for anticipating future disaster risk, reducing existing exposure, hazard, or vulnerability, and improving resilience” (IPCC, 2012, p. 34). This includes reducing the vulnerability of people, livelihoods and assets, and ensuring sustainable management of environment (IPCC, 2012). Resilience is “the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change” (IPCC, 2007a, p. 880). Holling (1973, p. 17) defines resilience as the “ability of a system to absorb changes of state variables, driving variables, and parameters and still persist”. A further concept is that within the context of socio-economic resilience, disturbance creates new regimes where opportunities for renewal come about (Holling et al., 2002).

The resilience approach views adaptations as important processes which improve system resilience to a range of shocks (Folke, 2006; Nelson et al., 2007), either by building resilience to prevent collapse of a system or by recovering a system once a shock has caused a collapse (Adger et al., 2009a). As such, the purpose of adaptation within climate change debate is often seen as a mechanism to reduce vulnerability or to enhance resilience to climate variability and change (Smit and Pilifosova, 2001).

Adaptation can also contribute to the development process (Apuuli et al., 2000). The linkages between adaptation and development, especially sustainable development, are understood (Scoones, 1998; Bebbington, 1999; Ellis, 2000; Brown, 2011; Eriksen and Brown, 2011). For instance, enhancement of adaptive capacity includes similar requirements (such as through improvement of people’s resources and access to them) as promotion of sustainable development (Smit and Pilifosova, 2003). A growing body of literature emphasises the importance of mainstreaming adaptation within wider (sustainable) development objectives (OECD, 2005; Huq et al., 2006; Mitchell and

Tanner, 2006; Yohe et al., 2007; Stringer et al., 2009; Brown, 2011). However, caution should be maintained as some literature argues that some current adaptation strategies to climate variability are not sustainable; they may undermine long-term resilience or even result in maladaptation (Osbahr et al., 2010; Brown, 2011; Eriksen et al., 2011).

### 2.2.2.1 Types of adaptation

Adaptation can be categorised in different ways (Smit et al., 1999) (Table 3). Processes and forms of adaptation are dependent on “who or what adapts?” and “adaptation to what?” (Smit et al., 1999). For example, in unmanaged natural systems, adaptations are autonomous and reactive while in public agencies adaptations are usually planned and may be anticipatory (Smit et al., 1999).

Table 3. Types of adaptation (Smit et al., 1999, p. 208).

<i>General Differentiating Concept or Attribute</i>	<i>Examples of Terms Used</i>	
Purposefulness	Autonomous Spontaneous Automatic Natural Passive	Planned Purposeful Intentional Policy Active Strategic
Timing	Anticipatory Proactive Ex ante	Responsive Reactive Ex post
Temporal Scope	Short term Tactical Instantaneous Contingency Routine	Long term Strategic Cumulative
Spatial Scope	Localised	Widespread
Function/Effects	Retreat – accommodate - protect Prevent – tolerate – spread – change – restore	
Form	Structural – legal – institutional – regulatory – financial – technological	
Performance	Cost – effectiveness – efficiency – implementability – equity	

Based on purposefulness, a common division of adaptation is made between autonomous and planned adaptations. Autonomous or spontaneous adaptation is the adaptation “that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems” (IPCC, 2001, p. 982). Whilst planned adaptation is “the result of a

deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state” (IPCC, 2001, p. 982).

Based on timing, adaptation can be categorised into: anticipatory and reactive. Anticipatory adaptation takes place before the impacts of climate change are observed, while reactive adaptation takes places after the impacts of climate change are observed (IPCC, 2001, p. 982). There might also be another category – concomitant or simultaneous – which occur at the same time as climate impacts. Anticipatory adaptation is also termed as “proactive” or “ex ante”, whilst reactive adaptation is also termed as “responsive” or “ex post” responses (Smit et al., 1999).

Adaptation can also be classified as private and public. Private adaptation is a response by an individual or a firm to an environmental change for its own benefit (Mendelsohn, 2000). An extension of this definition is: private adaptation is initiated and implemented by individuals, households or private companies, while public adaptation is initiated and implemented by governments at all levels (IPCC, 2001).

Based on failure or success, adaptation is classified as maladaptation or successful/effective/sustainable adaptation. Maladaptation is the “action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups” (Barnett and O'Neill, 2010, p. 211). For example, the increased level of flooding due to climate change may be tackled by the agriculture sector taking adaptive strategies such as construction of more flood control, drainage and irrigation schemes. However, these structures may create negative consequences for fisheries. Studies of such schemes in Bangladesh found that fish production can be 50% lower inside flood control schemes compared to outside mainly because of diminished recruitment of migratory fish (Halls et al., 1998; Halls et al., 2008). Osbahr et al. (2010) found that adaptation by individuals may have negative spill-over effects at the community level. Therefore, an action that is successful for one may be classed as unsuccessful by another. Successful or sustainable adaptations are those measures that reduce vulnerability and promote long-term resilience in a changing climate (O'Brien and Leichenko, 2007). The success of an

adaptation strategy depends on how that action meets the objectives of adaptation, the scale of implementation and the criteria used to evaluate it (Adger et al., 2005a, p. 78).

### **2.3 Fishing Communities and Their Livelihoods**

Globally, fisheries support the livelihoods of about 660–820 million people, and supply 154 million tonnes of fish and 16.6% of animal protein intake for the world's populations (FAO, 2012). Employment in the fisheries sector has continued to grow (between 1990 and 2010) faster than employment in agriculture (FAO, 2012). Fish and fish products are highly traded items, with an export value of US\$102 billion (in value terms), contributing significantly to gross domestic product (GDP), food security and poverty alleviation (FAO, 2012). Fishing is very important for the people dependent on it. It is not just a livelihood activity but a way of life which determines social identity and relationships (Coulthard et al., 2011). Besides direct dependency, fisheries provide numerous jobs in pre- and post-fishing activities (also termed as ancillary activities) such as processing, packaging, marketing and distribution, manufacturing of fish-processing equipment, net and gear making, ice production and supply, boat construction and maintenance, research and administration (FAO, 2012). Small-scale fisheries are located in developing countries and support livelihoods of more than 90 percent of the world's capture fishers (FAO, 2012). They are increasingly fishing for commercial purposes and export, rather than being only a subsistence activity (Westlund et al., 2007). The focus of this thesis is on small-scale (or artisanal) coastal and marine fisheries.

Marine small-scale fishery-dependent people usually live near the shore, often in a community “that is substantially dependent on, or substantially engaged in, the harvest or processing of fishery resources to meet social and economic needs” (OECD, 2001: glossary of statistical terms). Thus a fishing community includes people who are directly involved in fishing (such as boat captains and crews) as well as those who are involved in pre and post-harvest fishing processes (such as gear and boat makers, processors and primary fish traders). The boat captains and crews are termed as “fisherfolk” or “fishers” (FAO, Undated). People depend on fisheries on a full-time, part-time or occasional basis. While for the full-time group, fisheries are the sole source

of their livelihoods, for part-time and occasional groups, fisheries form part of their diversified livelihood strategy (Allison and Ellis, 2001; Coulthard, 2008).

The concept of livelihood has received much attention over the last few decades in order to conceptualise and analyse people's means of living. Although numerous organisations in the world such as donors, NGOs and domestic governments have been working on livelihoods, most adopt (sometimes with a little modification) the definition of livelihood and sustainable livelihood as: "a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short- and long-term" (Chambers and Conway, 1992, p. 6).

### **2.3.1 Sustainable livelihoods approach**

Over the last few decades, livelihood approaches (Scoones, 1998; DFID, 1999; Ellis, 2000) have been gaining increasing importance and are used as one of the fundamental analytical tools (and concepts) to support poverty reduction and rural development in many countries. The sustainable livelihood approach (SLA) (Scoones, 1998; DFID, 1999) has been particularly widely used. The SLA is based on six underlying principles: people-centred, responsive and participatory, multi-level, conducted in partnership, sustainable and dynamic (Ashley and Carney, 1999; DFID, 1999).

Based on the sustainable livelihood framework (Figure 2) a fishery-based livelihood encompasses the individual or household assets, the activities and strategies in which they are engaged, and the processes that mediate access to assets, activities and strategies to generate livelihood outcomes. These are discussed below.

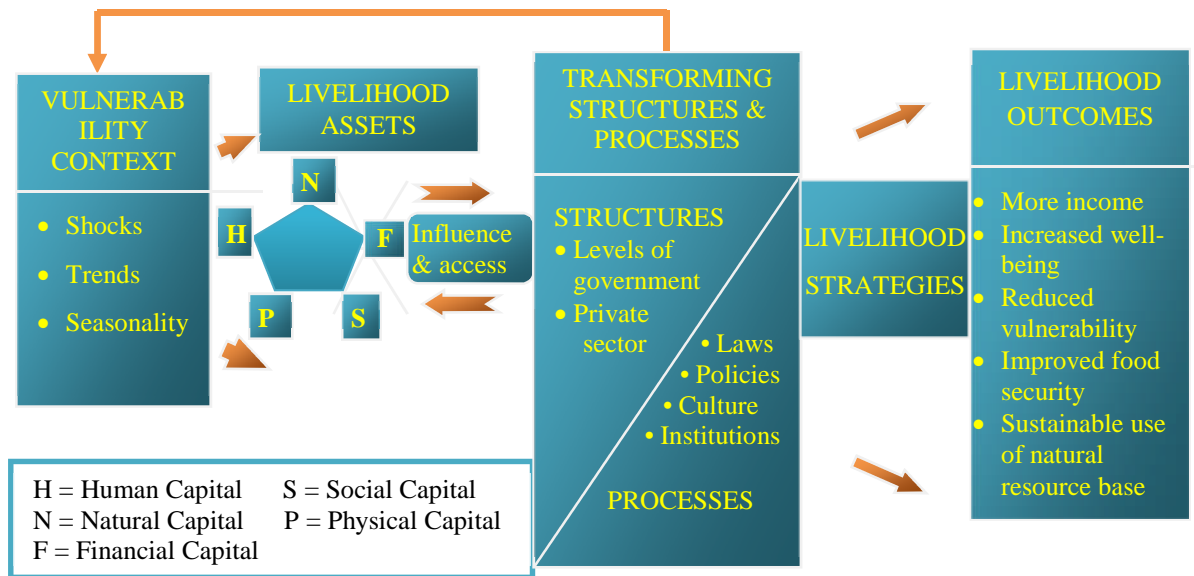


Figure 2. Sustainable livelihood framework (adapted from DFID, 1999).

### 2.3.1.1 Livelihood assets

The livelihood assets of fishery-dependent people can be grouped into five categories known as five capital assets: natural, physical, human, financial and social capital (Figure 3). These capital assets are also termed as the “livelihood platform” or “building blocks of livelihood” (DFID, 1999) and form the fundamental basis of adaptive capacity for fishery-dependent people (Daw et al., 2009; Badjeck et al., 2010). The term ‘capital’ used here does not always refer to capital stocks in the economic literature where capital is the product of investment which yields a flow of benefits over time (DFID, 1999).

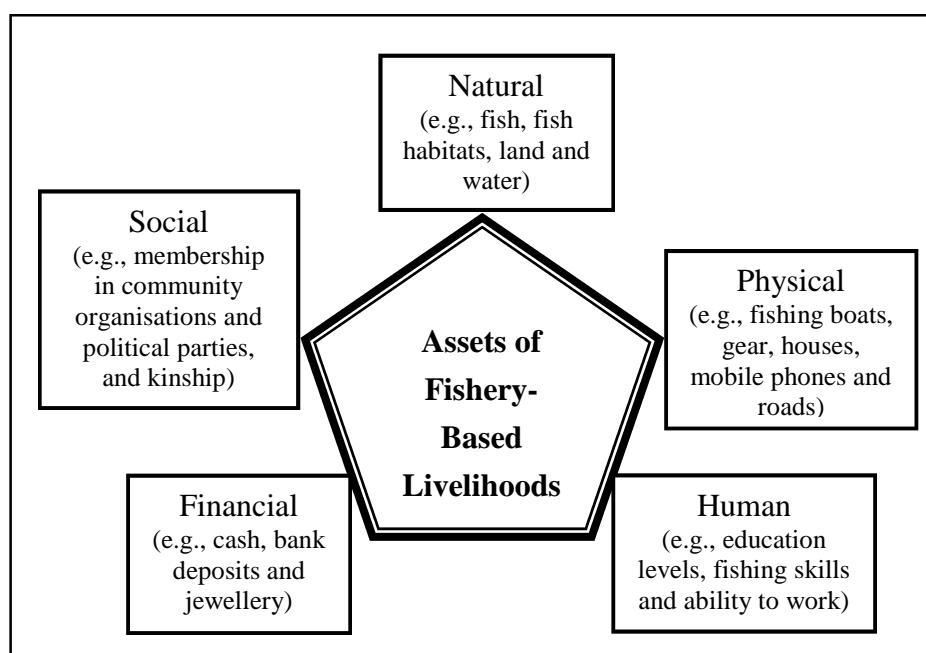


Figure 3. Livelihood capital assets of a fishing community (adapted from DFID, 1999; Satia, 2004; Townsley, 2004).

Natural capital is the natural resources from which benefits flow to fishery-dependent people. These include fisheries resources such as fish stock and aquatic habitats as well as the non-fisheries resources in which they can also be dependent such as agricultural land and freshwater for drinking and agriculture (Satia, 2004; Townsley, 2004).

Physical capital includes physical infrastructure and tools or equipment used to support livelihoods. These include fisheries resources such as fish landing centres, gear stores, ice plants, boats, engines, nets, processing equipment, as well as non-fisheries resources such as roads, dams, houses, schools, markets, hospitals, water supply systems and cyclone shelters (raised concrete structures that protect from wind and flood) (Allison and Ellis, 2001; Satia, 2004; Townsley, 2004). Fishing communities are often poorly served by roads and other infrastructure, and social services (FAO, 2005). Access to education and health services is of particular concern (Westlund et al., 2007; Iwasaki et al., 2009). Small-scale fishers are in a weak marketing position in areas with limited storage, processing and transport facilities (Westlund et al., 2007).

Human capital includes knowledge, skills and health. These include education levels, fishing skills and physical ability to work (Satia, 2004; Townsley, 2004). Human capital is essential to effectively using the other four types of capital (Satia, 2004).



Financial capital includes the financial resources that people use to achieve their livelihood objectives (DFID, 1999). These include available stocks such as cash, bank deposits or liquid assets (such as livestock and jewellery) and regular inflows of money such as remittances (DFID, 1999). Small-scale fishing communities in developing countries are often characterised as the “poorest of the poor” due to their low levels of income (see Béné, 2003 for a review). In many coastal communities, access to credit and insurance is restricted (De Silva and Yamao, 2007; Westlund et al., 2007). For example, Mills et al. (2011) found lack of access to credit in two fishing communities in sub-Saharan Africa. Fishery-dependent households are often unable to raise formal bank loans due to lack of collateral (De Silva and Yamao, 2007). Informal sources of credit, typically with high rates of interest and unfavourable terms and conditions, are often the only available sources of credit to them (Tietze and Villareal, 2003). Thus lack of credit especially during fisheries’ crises is a key problem for the fishing communities in developing countries (Perry et al., 2009).

However, the view of “poorest of the poor” has been disputed in some research (Allison et al., 2006; Allison and Horemans, 2006). Fishers are not necessarily the poorest in terms of income but may be amongst the most vulnerable groups due to their high exposure to certain natural or economic shocks and disasters or health-related issues (Allison et al., 2006). Even for the boat owners and fish traders who may be among the wealthier members of a community, income from fishing is uncertain (Westlund et al., 2007).

Social capital is social resource such as networks and relationships which people use to achieve livelihood objectives (DFID, 1999). Some forms of social capital are more formal such as membership in fisherfolk community organisations and political parties, whilst others are more informal such as kinship and trading linkages (Satia, 2004; Townsley, 2004). Social capital enables people to build collective actions and act together more effectively to pursue shared objectives (Resnick, 2001). The poorest are often highly reliant on the social capital around them for their survival, particularly in the absence of access to other livelihood capital assets. Social support networks and local bonding relationships are important for helping households and communities build resilience and response better to the impacts of climatic shocks and stresses (e.g., Adger, 2003; Thomas et al., 2007). For example, Townsley (2004) found that in poorer

communities around the Bay of Bengal, social capital can be of critical importance to people's livelihoods and resilience.

Different groups within a fishing community may have different quantities of, or access to, livelihood assets and may be classified into different wealth categories (Westlund et al., 2007). These different types of livelihood assets may be combined creatively and innovatively to create more livelihood opportunities in a particular area (Scoones, 1998).

#### *2.3.1.2 Livelihood strategies*

Livelihood strategies are the range and combination of activities and choices that people make in order to achieve livelihood outcomes (DFID, 1999). In the context of rural agricultural livelihoods, three broad clusters of livelihood strategies are identified: agricultural intensification/extensification, livelihood diversification and migration (Scoones, 1998). In a fishery-based livelihood system the stakeholders often engage in more than one livelihood activity (Allison and Ellis, 2001; Satia, 2004; Coulthard, 2008). A household may engage in fishing, fish processing and trade, producing and selling garden produce, wage labouring (Satia, 2004), and agriculture. There are several reasons for diversified livelihood activity: uncertainty of income from fishing, unpredictable fluctuation of fish stock, spreading the risk across more than one income sources, to overcome uneven use of assets and to develop a safety net during widespread uncertainties (Allison and Ellis, 2001; Westlund et al., 2007). Migratory fisherfolk may leave their homes for a long period of time and travel to other regions for fishing leaving their families behind (Satia, 2004). Therefore fishery-based livelihood strategies are dynamic whereby fisheries' stakeholders combine activities to meet their various needs. This process shows how important different livelihood assets are and how they are sequenced and combined in the pursuit of different livelihood strategies (Scoones, 1998).

#### *2.3.1.3 Factors affecting livelihood assets and strategies*

Many factors affect fishery-based livelihoods. Using the concepts from general livelihood literature (e.g., DFID, 1999; Ellis, 2000), these factors can be classified into two broad categories: the vulnerability context and the transforming structures and processes (Figure 4).

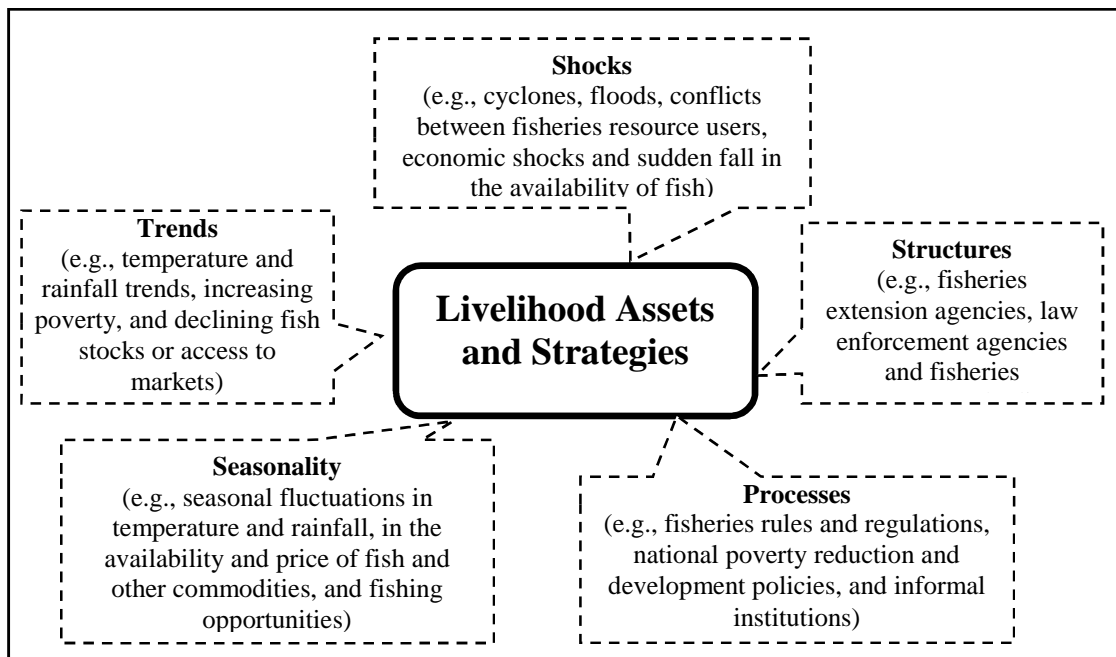


Figure 4. Factors affecting livelihood assets and strategies of a fishing community (adapted from DFID, 1999; Allison and Ellis, 2001; Satia, 2004).

The vulnerability context – classified as trends, shocks and seasonality – has a direct impact upon livelihood assets, strategies and outcomes (DFID, 1999; Ellis, 2000) and therefore can influence fishery-based livelihood vulnerability and adaptation (Daw et al., 2009; Badjeck et al., 2010). Shocks such as cyclone, flood, conflict between resource users (large-scale versus small-scale fishing), economic shocks and sudden fall in the availability of fish can affect fishery-dependent people directly. Particularly, their assets such as boats and gear are more exposed to climatic shocks and hence more easily lost than land-based property (Westlund et al., 2007). The shocks can also force people to sell their important livelihood assets (such as boats) prematurely as part of coping strategies. Trends such as changes in temperature and rainfall, increasing poverty, declining fish stocks or access to markets due to climate change can have long-term effects on livelihood strategies. In particular, they have an important influence on rates of economic or other return to chosen livelihood strategies (DFID, 1999). Seasonal fluctuations such as changes in the temperature and rainfall, availability and price of fish and other commodities, and fishing opportunities can also affect greatly the livelihoods of fisheries dependent people. This is particularly the case for the small-scale fishers who have limited market power (Westlund et al., 2007). Structures and processes can play a significant role in managing the vulnerability context in order to help people become more resilient or create opportunities especially for the poorest (DFID, 1999).

Structures and processes include organisations, institutions, policies and legislation (DFID, 1999). They frame the livelihoods of fishing communities by determining access to various types of livelihood assets and strategies (DFID, 1999). Access is defined as “the opportunity in practice to use a resource or service or to obtain information, material, technology, employment, food or income” (Chambers and Conway, 1992, p. 8). These determine the terms of exchange between different types of assets (DFID, 1999) and therefore affect livelihood strategies and outcomes. Particularly, the ways individuals, households and communities are able to access different assets and resources play a role in determining their vulnerability and ability to cope with and adapt to stress (including climatic stress) (Kelly and Adger, 2000). Hence, in order to understand the livelihood vulnerability and adaptation of fishing communities, it is important to investigate how different structures such as fisheries’ management bodies and NGOs, in conjunction with processes such as rules and regulations, affect fishery-based livelihoods. In remote coastal rural areas an absence of appropriate fisheries structures (such as fisheries extension agencies, law enforcement agencies and fisheries management bodies) could essentially be one of the major constraints in developing livelihood strategies, adaptation and development. This absence could ultimately make people vulnerable especially during adverse environmental, social and economic conditions.

In everyday use we mean institutions as organisations but in the livelihood, sociological and anthropological literature (also in this study) institutions include the rules, norms and values that shape our behaviour (DFID, 1999). Sometimes institutions are also known as the “rules of the game”, “standard operating practices”, “routines, conventions and customs” or “the way things are done”. Institutions can be: 1) formal (e.g. laws that govern fishing licences, market transactions or civil rights) or informal (e.g. social customs and conventions); 2) created (e.g. as a result of deliberate political or policy decisions) or may evolve over time; and 3) present at local, organisational, national, and international levels (DFID, 1999). Institutions are part of a process of social negotiation, rather than fixed ‘objects’ or ‘bounded social systems’ (Scoones, 1998). Institutions can restrict the choice of livelihood strategies for some people; on the other hand, they can open up opportunities for others (Scoones, 1998). Informal institutions such as social relations can determine who has access to fishing opportunities (Allison and Ellis,

2001). Policies result in the development of new legislation and provide a framework for the actions of the public sector (DFID, 1999). They principally include fisheries sector policies but may include a diversity of other policy areas that relate to fishing communities such as poverty reduction, rural development, and education and health policies.

#### *2.3.1.4 Livelihood outcomes*

Livelihood outcomes are the outputs of livelihood strategies (DFID, 1999). Different authors have distinguished the indicators for livelihood outcomes in slightly different ways, depending on the focus of a particular study. Scoones (1998) categorises five key outcome indicators which can be used to assess the achievement of livelihoods for people. These are the creation of working days, poverty reduction, wellbeing and capabilities, livelihood adaptation, vulnerability and resilience, and the sustainability of the natural resource base. For a fisheries livelihood system these indicators can be effectively used to assess the livelihoods of dependent people. However, sometimes there can be conflict between different outcomes and trade-offs may be necessary. Achieving the livelihood outcomes should be done without sacrificing sustainability. For example, fishers should not be allowed to increase the catch in the short-term to the point where biodiversity is severely affected (Satia, 2004).

## **2.4 Use of Livelihoods Concept in Climate Change Vulnerability and Adaptation Research**

The six principles of the SLA (section 2.3) offer a wide range of uses. The SLA is a powerful tool in analysing the situation, context and process of livelihood. It contributes towards providing a wider approach to peoples' livelihoods (Chambers and Conway, 1992) and creates opportunities for considering factors that influence livelihoods, interactions between those factors, and sustainability of livelihoods (Mukherjee et al., 2002). The SLA can be utilised in various ways, depending on the goal of a particular study or programme. Ashley and Carney (1999) consider the SLA as a means of thinking about the objectives, scope and priorities for development, in order to enhance progress in poverty elimination. Farrington et al. (1999) find the use of the SLA as a 'process' tool particularly in development practice, to enable participants in

development programmes identify the main constraints and opportunities for development intervention.

In the studies of climate variability and change, the concept of livelihoods is used to understand the impact of seasonal climate forecasts in the villages of Lesotho (Ziervogel and Calder, 2003), impacts of hurricane on the rural poor of Honduras (Morris et al., 2002), social vulnerability in the rural agrarian societies of Vietnam (Adger, 1999) and inter-village vulnerability in China (Knutsson and Ostwald, 2006). The concept is also employed to identify livelihood responses in Tanzania (Paavola, 2008) and develop a livelihood vulnerability index in Mozambique (Hahn et al., 2009).

In the field of fisheries the SLA can be used to assess the livelihoods, management and development of policy of small-scale fishery-dependent people (Allison and Ellis, 2001; Allison and Horemans, 2006; Ferrol-Schulte et al., 2013). Allison and Ellis (2001) recognise the importance of the livelihoods approach by identifying its capacity to capture the seasonal and cyclical complexity of livelihood strategies. Ferrol-Schulte et al. (2013) found the SLA suitable specifically for livelihood assessment of tropical coastal and marine fishing communities, and appreciate it as a tool for studying context-specific dynamic social–ecological vulnerability.

For this study, the SLA is used as an approach to study vulnerability and adaptation of fishing communities to climate variability and change. This has been possible because the concept of sustainable livelihood is intimately linked with the concept of livelihood vulnerability and adaptation. The definition of sustainable livelihood (section 2.3) has emphasised the coping and recovery from stresses and shocks such as storms and floods. Stresses and shocks make a livelihood vulnerable, whereas adaptation helps coping and recovery or adjustments to the livelihood through multiple response strategies. In this sense the sustainability of livelihoods can be enhanced by adaptation or reducing vulnerability (Chambers and Conway, 1992; Scoones, 1998).

The concept “capability” in SLA (section 2.3) refers to being able to perform certain basic functions so that a person is capable of being (i.e., to be adequately nourished, free of illness etc.) and doing (i.e., to develop skills and experience, to exercise choices etc.) (Sen, 1984). This concept of capability, developed in entitlement literature, has been

imported to livelihoods literature (sometimes with a little modification) by many authors such as Chambers and Conway (1992) and Scoones (1998). The core of the entitlement approach is that people starve not only due to insufficient supply of food but also due to lack of command over or access to food. Within the general concept of entitlement, there is a subset of livelihood capabilities which include ability to cope with stress and shocks and utilise livelihood opportunities (Chambers and Conway, 1992). Thus the concept of capability in livelihood and sustainable livelihood literature has strong linkages with coping capacity, adaptive capacity and adaptation in the climate change literature.

There are differences in the concept of vulnerability between climate change (e.g., IPCC) and livelihood literature (e.g., SLA). In the livelihood literature, vulnerability (more specifically “vulnerability context”) refers to mainly external stressors to livelihood which are more closely associated with only one of the three components – exposure – in vulnerability to climate change literature. The transforming structures and processes, and livelihood assets of the livelihood literature are more closely associated with the other two components – sensitivity and adaptive capacity – in the vulnerability to climate change literature. This study assesses the livelihood vulnerability using the concept in climate change literature but uses livelihood literature (SLA) to explain this concept and guide the data collection process.

Thus, in a fishery-based livelihood system the SLA can be used to explore the social and economic impacts and vulnerability of fishery-dependent households and communities to climate change (Badjeck et al., 2010, p. 3). The SLA will also be useful in helping to investigate different adaptation strategies taken by people to secure their livelihood from climatic shocks and stresses, particularly in low income countries (Allison and Ellis, 2001).

However, the SLA is not totally without criticism. For example, SLA is claimed as dynamic (Ashley and Carney, 1999). However, the capacity of SLA to tackle all dimensions of dynamisms such as temporal, spatial, cultural and societal changes has not been well described. Fraser (2007) found that SLA may only provide a snapshot of households’ conditions at a particular point in time and may not consider temporal dynamics. DFID (1999) recognises that the true dynamism of livelihoods has not been

included in the sustainable livelihood framework, but it can be reflected in process and modes of analysis. DFID (1999) also identifies it as an important area for monitoring and learning. In addition, the SLA is sometimes criticised for its lack of explicitness on power and political relations, including those dealing with human rights (Foresti et al., 2007). Ferrol-Schulte et al. (2013) consider that like other participatory social analysis tools, the SLA suffers from response bias and that the SLA may not be able to ensure representative sampling in a heterogeneous community. Ferrol-Schulte et al. (2013) however further consider that these limitations do not undermine the value of holistic approaches to interventions in coastal and marine social-ecological systems. Thus the SLA is found useful for this study. It has been integrated with other approaches and tools to overcome the criticisms where necessary. For example, to ensure representative sampling, random sampling technique and cluster analysis have been used (see sections 3.3.1 and 3.4.1.1). The SLA has also been integrated with climate change vulnerability and adaptation literature and tools to frame the assessment of vulnerability and adaptation.

## **2.5 Impacts of Climate Variability and Change on Fishing Communities and Livelihoods**

### **2.5.1 Impacts on coastal systems**

The coastal and marine systems are amongst the most ecologically and socio-economically important in the world. These systems are threatened by several factors such as pollution, mismanagement and coastal zone modifications. Over the past few years a strong consensus has emerged that anthropogenic global climate change has resulted/will result in negative consequences for this system (Table 4) (IPCC, 2007a). These have the potential to make coastal fishing communities vulnerable notably by impacting on their livelihoods due to scarcity or absence of adaptation.



Table 4. Main climate drivers for coastal systems, and their main physical and ecosystem effects in the context of climate change (adapted from Nicholls et al., 2007).

<i>Climate driver</i>	<i>Main physical and ecosystem effects on coastal systems</i>
CO <sub>2</sub> concentration	Increased CO <sub>2</sub> fertilisation, and decreased seawater pH (or ocean acidification) negatively impacting coral reefs and other pH sensitive organisms
Sea surface temperature	Increased stratification/changed circulation, reduced incidence of sea ice at higher latitudes, increased coral bleaching and mortality, pole-ward species migration, and increased algal blooms
Sea level	Inundation, flood and storm damage, erosion, saltwater intrusion, rising water tables/impeded drainage, and wetland loss (and change)
Cyclone intensity	Increased extreme water levels and wave heights, episodic erosion, cyclone damage, risk of flooding and defence failure
Cyclone frequency	Altered surges and cyclone waves, and hence risk of cyclone damage and flooding
Wave climate	Altered wave conditions including swell, altered patterns of erosion and accretion, and re-orientation of beach plan form
Run-off	Altered flood risk in coastal lowlands, water quality/salinity, fluvial sediment supply, circulation and nutrient supply

## **2.5.2 Impacts on livelihood assets**

Livelihood assets, the building blocks of livelihoods, are regarded as important elements for adaptive capacity that facilitate adaptation to climate change (see sections 2.3 and 2.4). These assets can be impacted by climate variability and change as discussed below:

### *2.5.2.1 Impacts on natural capital*

Most studies on likely impacts of climate variability and change on fisheries have focussed on changes in marine ecosystems, and fish population distribution and abundance. Most of them are on a global or regional scale. As such, it is challenging to predict the specific impacts of climate change on a particular marine ecosystem and fish population (Grafton, 2010). Given the multiple non-climate pressures on fisheries (such as overfishing and pollution), it is also difficult to differentiate impacts from climate change on marine ecosystems (Coulthard, 2009). Nonetheless, Perry et al. (2009) notice that the effect of climate change has already extended from aquatic ecosystems to dependent people in some areas.

Changes in water temperature, precipitation, wind velocity, wave action, sea level, dissolved oxygen concentration and pH can bring about significant ecological and biological changes to aquatic ecosystems and fish populations (IPCC, 2007a; Cheung et

al., 2009; Brander, 2010; Drinkwater et al., 2010). The changing environmental conditions can impact on oceans, estuaries, coral reefs, mangroves and sea grass beds, generating complex and inter-related impacts (Brander, 2007) on the distribution, productivity and species composition of fish (FAO, 2008). For example, coral reefs are at risk from increased water temperatures and acidification (Hoegh-Guldberg et al., 2007), which may threaten the productivity of these fisheries. Mangroves and seagrass beds that provide breeding and nursery grounds for aquatic species may be impacted by sea level rise (Nicholls et al., 2007).

Sub-optimal environmental conditions can decrease foraging, growth and fecundity, alter metamorphosis, and affect endocrine homeostasis and migratory behaviour of aquatic species (Mukherjee, 2008). The rising ocean acidity due to increases in dissolved carbon dioxide can make it more difficult for marine species such as shrimps, oysters or corals to form their shells (Gattuso et al., 2013). Increase in sea surface temperature can trigger toxic marine algal blooms (such as dinoflagellates) that can cause red tides (Patz, 2000).

While most of the impacts of climate change on aquatic ecosystem and fish are overwhelmingly negative (IPCC, 2007a), a few positive impacts have also been reported, such as increased nutrient production in high latitude (Brander, 2010), seasonal increase in growth of rainbow trout (Morgan et al., 2001) and reduced cold-water mortalities of some aquatic animals (IPCC, 2007a). Due to changes in species distribution, whilst some fishers will experience a decrease in their target species, others could experience an increase in landings of commercially important species (Daw et al., 2009).

Sea level rise may result in the erosion of coastal fishing communities' land used for homestead areas, ancillary activities, infrastructure, social services and non-fisheries activities (Nicholls et al., 2007). Their non-fisheries assets such as agriculture production can also be negatively impacted by variations in temperature and rainfall and drought, in various parts of the world, particularly in Africa (Lobell et al., 2008; Thornton et al., 2011).

#### *2.5.2.2 Impacts on physical capital*

Sea-level rise, cyclones, floods and land erosion may impact on the physical capital of households or of entire communities, leading not only to decreased harvesting capacity and fisheries ancillary activities but also to disrupted public infrastructure and services. Cyclones and floods can destroy or severely damage assets and infrastructure such as fish landing sites, boats and gear (Jallow et al., 1999; Westlund et al., 2007; FAO, 2008). For example, in 1998 Hurricane Gilbert destroyed 90% of traps and 5% of boats of Jamaican fishers resulting in a loss of revenue and high cost of repairs (Aiken et al., 1992).

Extreme events can also damage post-harvest and transport facilities, impacting on fish processing, marketing and trade. For instance, in 1998, Peruvian rural fishing communities were unable to access their usual markets due to disruption of road communications by heavy rain (Broad et al., 1999). This is particularly problematic for small-scale fishers in developing countries who usually have only limited market power (Westlund et al., 2007). Extreme events may further damage other physical assets such as housing and community infrastructure, for example, hospitals, schools and sewage system (Westlund et al., 2007). These can result in displacement and resettlement of households (Badjeck et al., 2010).

#### *2.5.2.3 Impacts on social capital*

Climate change may bring up conflict between resource users (Badjeck et al., 2010), which may harm the social relationship, cohesion, trust, solidarity and informal institutions amongst households both within and between fishing communities. Changes in abundance and distribution of fish stocks due to climate change could lead to conflicts over property rights and resource access (Daw et al., 2009; Badjeck et al., 2010). For example, in Southern Africa, climate change may result in increasing frequencies of droughts which may lead to greater variability in lake levels and river flows, resulting in greater spatial and temporal variability of fish landings (Conway et al., 2005). To respond to this variability in landings, fishers may have to become more mobile and show opportunistic behaviour which on the one hand may increase the strain on resource access and management systems (Badjeck et al., 2010). Increased extreme weather events may disrupt social networks by killing relatives and friends (Westlund et

al., 2007). For instance, in 1991 the cyclone *Gorki* killed 150,000 people across coastal Bangladesh, resulting in the deaths of relatives and friends of many households across the Bay. The displacement and resettlement of households due to land erosion and destruction of physical assets may cut support from some relatives and friends.

#### *2.5.2.4 Impacts on financial capital*

Any impacts of climate variability and change on other capital assets can have financial consequences. Damage to physical capital such as infrastructure, and fishing boats and gear will incur financial loss. Displacement and resettlement of households will involve extra cost. Changes in the abundance and distribution of fish stock can affect both total revenues and net revenues (when harvesting costs are deducted), which can result in greater costs in managing and accessing the fish stock (Badjeck et al., 2010). Climate variability and change is frequently cited as a consequence for declining stock abundance and catches, and subsequent reductions to net revenue (Mahon, 2002; Roessig et al., 2004). For example, changes in the distribution of fish stock due to climate change are likely to require changes in the harvesting strategies that may require changes in travel time and associated fuel consumption, which may affect fishing costs (Mahon, 2002). Closure or reduction of fisheries related activities during adverse weather conditions may incur loss of revenues (Nagy et al., 2006). Changes in distribution of some species may, on the other hand, increase landings and revenues for some fishers. For example, the landings of shrimp and octopus increased in northern Peru during El Niño years (Daw et al., 2009).

Fishing communities and households already have a lack of access to credit (see section 2.3.1.1), which could be exacerbated in the context of enhanced climatic disturbances. For example, damage to physical capital due to climate change, mentioned above, may reduce the collateral of households and limit their capacity to pursue credit.

#### *2.5.2.5 Impacts on human capital*

Loss of life can be the most dangerous impact of increased extreme events which can affect the economic and social activities of other household members (Westlund et al., 2007). Physical injuries are often associated with climatic shocks and stresses which can reduce the physical ability of fishers to pursue their livelihoods (Badjeck et al., 2010).

Climatic stresses can be associated with the spread of diseases such as malaria and dengue fever (Kovats et al., 2003). Particularly, malaria is highly sensitive to El Niño in South America, Asia and Africa, where the majority of small-scale fishers live (Patz and Kovats, 2002; Allison et al., 2009b). The toxic red tides due to increased sea surface temperature can cause diarrheal and paralytic diseases linked to shellfish poisoning (Patz, 2000).

Impacts of climate variability and change on other capital assets can further risk human capital of fishing communities. Sea level rise and higher levels of land erosion, cyclones and flooding can damage educational institutions and health facilities, limiting access to them. Loss of financial capital may further limit this access. A poor education and health status combined with increased exposure to health hazards can reduce the capacity of community members to pursue livelihood activities.

### **2.5.3 Impacts on transforming structures and processes**

There may not be any direct impact of climate change on fisheries related transforming structures and processes except damage to physical capital of organisations due to extreme events or land erosion. However, climate change may prompt many other sectors adopting institutions and policies which may significantly affect the fisheries sector and may compound the effects of direct climate impacts on fish production and dependent livelihoods (Badjeck et al., 2010). Changes in species distribution due to climate change may bring up trans boundary conflict and may pose new challenges to the way boundaries are defined and access rights for fisheries resources agreed (Badjeck et al., 2010).

### **2.5.4 Impacts on livelihood strategies and outcomes**

Small-scale fishing is a high-risk activity (Coulthard, 2009; MRAG, Undated) and safety at sea is often substandard (Westlund et al., 2007). Worsening cyclones and damages to physical capital such as boats and gear may make fishing activities further risky (FAO, 2008; Daw et al., 2009). Small-scale fishing that is based on traditional knowledge of local weather and current systems may be disrupted by changes in weather patterns due to climate change (Daw et al., 2009).

Changes in the abundance and distribution of fish stock would require more management of fishing activities. Impacts on fish stock and fishing activities can in turn have an effect on fisheries ancillary activities. Ancillary activities such as boats and gear making may be reduced due to lesser demand in the event of reduced fishing due to unfavourable weather conditions. Reduced fishing may reduce employment and nutritional intake in the fishing communities and beyond. Decreased catches may increase the risk of malnutrition or under-nutrition for communities highly dependent on fish for a source of protein (Ogutu-Ohwayo et al., 1997), particularly in Asian and sub-Saharan African countries with higher dependency on fish based protein (Allison et al., 2009b). Reduced fish catch means a reduced supply of fish for processing which may result in market instability. Fish processing, especially open sun fish drying can be affected by changes in temperature and rainfall, and may require additional technology, cost and management.

These impacts of climate variability and change on fishery-based assets, strategies, institutions, policies and outcomes have the potential to make fishing communities vulnerable by affecting their adaptive capacity, adaptation and resilience. Assessment of vulnerability to climate change is explored next.

## **2.6 Assessment of Vulnerability**

Climate vulnerability assessments have focussed largely on agricultural production (Fischer et al., 2005; Parry et al., 2005; Schmidhuber and Tubiello, 2007; Tubiello et al., 2007; Antwi-Agyei et al., 2012b) and food security (Fraser, 2007; Thornton et al., 2011; Antwi-Agyei et al., 2012a). Most studies on climate variability and change and fisheries have focussed on documenting trends and fluctuations in fish abundance and distribution (Cushing, 1982; Glantz and Feingold, 1992; Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010). Most of these studies have targeted large-scale industrial fisheries particularly in relation to oceanic regime changes and the major pelagic fish stocks of upwelling zones (Klyashtorin, 2001; Yáñez et al., 2001; Gutierrez et al., 2007). At the national level these studies have concentrated mainly on fluctuation of stocks, for example, in the inland fisheries of Malawi (Sarch and Allison, 2000; Allison et al., 2001) and in tsunami-ravaged Sri Lanka (De Silva and Yamao, 2007). There are a number of studies that have investigated the impact of climate change on the

vulnerability and adaptive capacity of the fisheries sector and dependent communities at the macro scale (e.g., national) (McClanahan et al., 2008; Allison et al., 2009b). But macro scale study cannot provide specific findings applicable to the local or community scale (Hahn et al., 2009). There are only a limited number of recent studies which have focussed on impacts, vulnerability and adaptation to environmental (including climate) variability and change at the local level of fishery system (e.g., Coulthard, 2008; Badjeck et al., 2010). Hence there is a lack of understanding in this system which has prevented the development of effective adaptation strategies (FAO, 2008). There are agriculture-based livelihood vulnerability assessment to climate change studies at the local level (e.g., Vincent, 2007; Eakin and Bojórquez-Tapia, 2008; Paavola, 2008; Antwi-Agyei et al., 2012a). But vulnerability of agriculture-based livelihoods can be different from those that are fishery-based due to the differential characteristics of each system. For example, in contrast to agricultural production, small-scale fishing depends on wild populations, whose variability depends mainly on environmental processes and effects of environmental change cannot be quickly observed on these populations (FAO, 2008).

The assessment of vulnerability to climate variability and change is also facing some methodological challenges. A range of frameworks have been proposed to assess the vulnerability of socio-ecological systems at different scales (Brooks, 2003; Füssel, 2005; Adger, 2006; Eakin and Luers, 2006; Janssen et al., 2006; Fraser, 2007; Reed et al., 2013). New frameworks emerge constantly and differ according to specific circumstances and criteria. Some of the criteria for vulnerability assessment include the need to draw upon a varied and flexible knowledge base; to address multiple and interacting stresses; to allow for differential adaptive capacity; and to be both prospective and historical (Schröter et al., 2005). A specific focus has been given to the analysis of current vulnerability informed by historical perspectives (Adger, 1996). In order to find ways to reduce people's vulnerability and enhance their capacity to face natural hazards, attention has also been given to community participation, local contexts and everyday life (Anderson and Woodrow, 1989; Maskrey, 1989; Delica-Willison and Willison, 2004).

Regarding the determinants of livelihood vulnerability, different strands of literature have used quite different sets of indicators. Findings also vary considerably particularly

when concluding the key determinants. A reduction in vulnerability can often be achieved by increasing the adaptive capacity of people. But identification of adaptive capacity is context-specific and varies from community to community, among social groups and individuals, and over time (Smit and Wandel, 2006; Adger et al., 2007). There are individuals and groups within all societies whose capacity to adapt is not sufficient (Adger et al., 2007). For example, due to insufficient adaptive capacity the poor or migrant fishers are often considered more vulnerable (Béné, 2009). Carter et al. (2007) suggest that there may be an asset threshold level below which households are caught in an asset poverty trap and therefore they can become extremely vulnerable. Since climate change will impact different social and ecological systems in different ways, it is necessary to conduct more studies to prioritise determinants and to measure levels of vulnerability in fishery systems.

Despite its importance, determining the degree of livelihood vulnerability at the local level is very difficult (Eakin and Luers, 2006). This is because livelihood vulnerability is multidimensional and is influenced by a range of indicators of differential importance (Eakin and Bojórquez-Tapia, 2008). Quantitative methods enhance the scope of generalisation of findings but are less flexible than qualitative methods (Hay, 2005). A combination of quantitative and qualitative methods (often termed as mixed methods) is becoming popular for social research because combining both methods can give rich insights into the phenomena studied (Rocheleau, 1995; Bryman and Bell, 2007). The composite index approach (also known as indicator approach) (e.g., Moss et al., 2001) has gained attention in recent years to analyse climate change vulnerability. This approach is a useful tool to guide policy formulation (Niemeijer, 2002; Eakin and Bojórquez-Tapia, 2008). However, this approach has some limitations (Eriksen and Kelly, 2007; Barnett et al., 2008; Füssel, 2009), such as its lack of general agreement on how to measure vulnerability, for example, selecting indicators and the process of index construction. Eriksen and Kelly (2007) are particularly concerned about selection, standardization and weighting of indicators. To address these challenges, this study follows an integrated quantitative-qualitative approach of vulnerability assessment, detailed in section 4.3.



## **2.7 Adaptation in Fishing Communities to Climate Variability and Change**

Section 2.5 shows that climate change can have multiple impacts on fishing communities, household members and their livelihoods, which lie outside the realm of present day experience and which might limit the effectiveness of past adaptive strategies (FAO, 2008). Although fishing communities in the developing world have adapted to a normal range of climate variability throughout history, additional adaptation will be needed to face climate change impacts and reduce vulnerability (Allison et al., 2005; FAO, 2008). It is also no longer always possible for fishing communities to fall back on historical adaptive strategies due to increasing populations, reduced fish catch rates and the presence of limits and barriers (Allison et al., 2005).

To face the challenge of climate change, fishing communities need to adapt to cyclones, floods, variations in temperature and rainfall, sea level rise, El Niño, drought and land erosion, and their impacts. In addition to reducing exposures to these shocks and stresses, adaptation of fishing communities would need adjustment within livelihood assets, strategies (fishing, pre-harvest activities such as boats making, financing; post-harvest activities such as processing and marketing) and transforming structures and processes. These adaptations may be adopted by the fishing communities themselves or by outsiders such as national governments.

As already mentioned, coastal small-scale fishing communities in developing countries have been adapting to climate variability. Examining these adaptations in detail can provide essential insights for developing sustainable adaptation strategies to address climate change. To understand the potential for adaptation to future climate change, several studies have emphasised the need to first investigate current and past adaptation strategies to climate change or variability and what has constrained or facilitated those adaptations (Basher, 1999; Kelly and Adger, 2000; Smit et al., 2000; Adger et al., 2003; Conway, 2005; Eriksen et al., 2005). Specifically, examining current and past adaptations will provide greater insights into the social aspects of adaptation, the constraints on adaptation and the processes of adaptation (Adger, 2003; Ford et al., 2006). This approach involves the use of detailed case studies of past and current responses and constraints to responses to climate stresses and shocks (Adger et al., 2003). This type of study can not only provide insights into estimating future

adjustments but can also help to address current problems of sustainable development as well as help avoid maladaptation (Smithers and Smit, 1997; AfDB et al., 2003).

Literature shows that past adaptation strategies to climate variability in fishing communities are dominated by diversification or flexible livelihoods and migration. A diversified fishery-based livelihood can adapt to change better (Allison et al., 2007; Turner et al., 2007; McClanahan et al., 2008). Diversification of livelihoods to address climate variability has occurred outside and inside fisheries, where the households are involved in several income generating activities (Turner et al., 2007; Allison et al., 2009a). Diversification has also occurred as a means to address the non-climatic stresses in small-scale fisheries (Allison and Ellis, 2001; van Oostenbrugge et al., 2004) such as in the face of resource fluctuations (Coulthard, 2008).

Migration among fishers has occurred in response to climate-mediated fluctuations in fish abundance (Daw et al., 2009). In this type of migration the fishers usually only migrate for a short period leaving their families behind. This type of migration is considered a part of livelihood diversification (Wouterse and Taylor, 2008). However, a lot of other fishers might also have migrated in the past or may migrate permanently in future (either forcefully or voluntarily) with their households to adapt to climate impacts. Climate change has been predicted to displace more and more coastal people including fishing communities (Döös, 1994; Myers and Kent, 1995; Hugo, 1996; Magadza, 2000; Meze-Hausken, 2000; Myers, 2002). For example, rise in sea level may displace up to 187 million people (up to 2.4% of global population) by 2100 (Nicholls et al., 2011). Hence, it is important to assess whether migration can be a viable adaptation strategy for them. This is an emerging research agenda in the field of climate change adaptation (e.g., Action Aid, 2007; Stern, 2007; Warner et al., 2009). Recognising the importance of this, human migration and displacement have recently been entered into the UNFCCC (United Nations Framework Convention on Climate Change) climate negotiations (Warner, 2012). Warner (2012) has noticed that at COP16 (UNFCCC 16th Conference of Parties), parties accepted the draft text containing a paragraph (14(f)) on migration and displacement. Paragraph 14(f) reads as follows: "Measures to enhance understanding, coordination and cooperation with regard to climate change induced displacement, migration and planned relocation...". Black et al. (2013a) have identified migration and extreme environmental events as new agendas for global change research. Black et al. (2011b) emphasised the need to conduct research on

migration in relation to global environmental change, particularly the importance of identifying the positive and negative outcomes of environmental change-induced migration. However, there is scarcity of research on this issue both in the field of fisheries and outside it.

The literature suggests that many studies have investigated drivers of climate-induced migration (e.g., McLeman and Smit, 2006; Black et al., 2011a; Black et al., 2011b; GOS, 2011; McLeman, 2011; Piguet et al., 2011) but few studies have assessed how climate-induced migration has influenced livelihoods and vulnerability of migrants in comparison to non-migrants. Climate-induced migration may have positive or negative consequences for migrants (GOS, 2011). Migration may help reduce vulnerability or enhance adaptation to climate variability and change. Migration may reduce exposure to climatic shocks and stresses for the people (Warner et al., 2008). It may also help diversify livelihoods and risks and to build resilience against environmental threats to livelihoods (Paavola, 2008; Black et al., 2011b). Migration can also create access to new livelihood assets and activities to generate incomes (Koczberski and Curry, 2005; Paavola, 2008).

On the other hand, migration may also lead to increased vulnerability, poor livelihood outcomes or maladaptation (Reuveny, 2007). Migrants frequently face landlessness, un- or under-employment, homelessness, marginalization, food insecurity, reduced access to common-pool resources and ill health, if they migrate involuntarily (Cernea, 1997). People may also lose their lifestyle, culture and identity as a result of migration (Mortreux and Barnett, 2009). Thus there are debates in the literature as to whether climate-induced migration can be a viable strategy to adapt to climate change. A detailed and more focussed literature review has been provided on this later in section 5.2.

In addition to the above adaptation strategies, several preliminary adaptation options or strategies have been proposed to address the impacts of future climate change in fisheries (FAO, 2008; Daw et al., 2009; Badjeck et al., 2010), some of which have been outlined in Table 5. However, adaptation strategies may not be so simplistic: they may be successful or maladaptive and there may be multiple limits and barriers to be addressed. For example, in Table 5, “increase in effort or fishing power” has been

proposed to address the reduced fisheries productivity and yields due to climate change. However, this strategy can be destructive to the ecosystem and deplete resources at an accelerated rate and, as such, can be unsustainable or maladaptive (Jiddawi and Öhman, 2002; Daw et al., 2009; Cinner, 2011).

Table 5. Adaptation to address the impacts of future climate change on fisheries (adapted from Daw et al., 2009).

<i>Impact on fisheries</i>	<i>Potential adaptation measures</i>
Reduced fisheries productivity and yields	Access higher value markets Increase effort or fishing power
Increased variability of yield	Diversify livelihood portfolio Insurance schemes Precautionary management for resilient ecosystems Implementation of integrated and adaptive management
Change in distribution of fisheries	Private research and development and investments in technologies to predict migration routes and availability of commercial fish stocks
Reduced profitability	Reduce costs to increase efficiency Diversify livelihoods Exit the fishery for other livelihoods/investments
Increased risks associated with fishing	Private insurance of capital equipment Adjustments in insurance markets Insurance underwriting Weather warning system Investment in improved vessel stability/safety Compensation for impacts
Trade and market shocks	Diversification of markets and products Information services for anticipation of price and market shocks

Increased risk associated with fishing activities is often considered a consequence of climate change (e.g., Daw et al., 2009) and adaptation strategies have preliminary been proposed to reduce this risk (see Table 5). However, a detailed understanding of how fishers adapt to climate shocks and stresses during fishing and how they are constrained to accomplish adaptation are preconditions to develop sustainable adaptation strategies. More generally, in order to facilitate adaptation and ensure resilience for communities, there is a need to identify and address key constraints of adaptation in the face of a changing climate (Jones and Boyd, 2011).

Going beyond the fisheries sector and considering the response to climate change in different sectors, Adger et al. (2007) noticed that most studies of specific adaptation plans and actions argue that the constraints to adaptation may be both limits and barriers. These limits are faced when thresholds or tipping points associated with the systems are exceeded (IPCC, 2012).

Limits and barriers to adaptation can be natural, technological, economic, social or formal institutional; they can stop, delay or divert the adaptation process (Moser and Ekstrom, 2010). Studies on limits and barriers to adaptation have been an area of growing interest in recent years (see section 6.2 for a full review), as a result, a growing body of studies, albeit small, have emerged that specifically target the presence and nature of limits and barriers to adaptation and how society can address them (Grothmann and Patt, 2005; IPCC, 2007a; Moser et al., 2008; Patt and Schröter, 2008; Adger et al., 2009a; Adger et al., 2009b; Jantarasami et al., 2010; Moser and Ekstrom, 2010; Nielsen and Reenberg, 2010; Jones and Boyd, 2011; Morgan, 2011; Productivity Commission, 2011; IPCC, 2012). These studies on limits and barriers to adaptation to climate change have been published in biological, agronomic, economic, sociological, psychological, and urban planning literature. These studies have often focussed on single limits or barriers; hence, how they interact has not been properly investigated. A number of studies have developed theoretical frameworks for limits and barriers (e.g., Adger et al., 2009a; Moser and Ekstrom, 2010). More empirical studies are needed to aid adaptation decision-making. Most of the studies published to date focus on agricultural communities (e.g., Jones and Boyd, 2011; Oxfam, 2011) but none have examined limits and barriers to adaptation in small-scale fisheries systems in developing countries.

## **2.8 Conclusion**

This chapter first explains the key terms in the thesis' aim and objectives such as climate variability, climate change, impact, vulnerability, adaptation, fishing communities and livelihoods. It then explores how SLA can be used in climate change vulnerability and adaptation studies. This follows a critical review on impacts, vulnerability and adaptation related to climate variability and change, particularly in fishing communities, households and their livelihoods. This review identifies that

vulnerability and adaptation to climate variability and change are important research areas, especially at the local scale of small-scale fishery systems in developing countries. Most studies on climate variability and change, and fisheries, have focussed on documenting trends and fluctuations in fish abundance and distribution, and its impact on the marine ecosystem (Cushing, 1982; Glantz and Feingold, 1992; Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010). They focus mainly on large-scale industrial fisheries. Some of the studies have investigated the impact of climate change on the vulnerability and adaptive capacity of the fisheries sector and dependent communities at the macro scale (e.g., national) (McClanahan et al., 2008; Allison et al., 2009b). But macro scale study cannot provide specific findings applicable to the local or community level (Hahn et al., 2009). There are agriculture-based vulnerability and adaptation assessments to climate change at the local level (e.g., Vincent, 2007; Eakin and Bojórquez-Tapia, 2008; Paavola, 2008; Sallu et al., 2010; Antwi-Agyei et al., 2012a), which are different from fishery-based ones. There is a lack of understanding of vulnerability and adaptation to climate variability and change in fishery systems as only a limited number of studies have focussed on these (e.g., Coulthard, 2008; Badjeck et al., 2010), which has prevented the development of effective adaptation strategies (FAO, 2008). This study aims to contribute to this.

The review also shows that assessment of vulnerability is facing some challenges including methods of vulnerability assessment, and determinants and characteristics of vulnerability especially at the local scale of fisheries systems. Objective 1 of this thesis seeks to contribute here.

The review also indicates that many studies have investigated drivers of climate-induced migration in coastal (including fishing) and other communities. Few of them have examined how climate-induced migration has impacted on livelihoods, vulnerability and adaptation of migrants, based on views and perceptions, rather than on empirical evidence. Moreover, none of them examined climate-induced migration from coastal fishing communities. This research contributes to this part of the scholarship (Objective 2).

The review further identifies that empirical studies on limits and barriers to adaptation to climate change have been published in biological, agronomic, economic,

sociological, psychological, and urban planning literature. Few studies have focussed on the limits and barriers to adaptation and interaction among them in fisheries sector. This study also seeks to contribute to this part of the scholarship (Objective 3).

## **Chapter 3 – Research Design and Methodology**

This chapter describes the research design and methodological process employed to fulfil the thesis aim and objectives set out in Chapter 1. This chapter is structured into five sections. Section 3.1 documents the methodological approaches. Section 3.2 describes the study contexts and justifies the selection of study sites. Section 3.3 describes the methods of data collection. Section 3.4 describes the methods of data analysis. Finally, section 3.5 concludes this chapter.

### **3.1 Methodological Approaches**

The literature review in the previous chapter has opened up several methodological approaches for vulnerability and adaptation analysis of fishery-dependent people. Within environmental change and adaptation research, bottom-up approaches and local scale studies have been receiving growing importance to complement the top-down approaches (Wilbanks and Kates, 1999; Fraser et al., 2006; Ziervogel et al., 2006; Ford et al., 2010; Twyman et al., 2011). Bottom-up case studies also help validate data at smaller resolutions (Fraser et al., 2006). The SLA is useful in this regard: the researcher can focus on local level studies while at the same time recognising the influence of wider factors on local level processes. With the SLA, the researcher has the flexibility to engage with a combination of quantitative and qualitative methods: livelihood surveys, case studies, in-depth interviews, group exercises and so on. In order to investigate the ways in which fishing communities and their households are vulnerable and adapted to climate variability and change, a household- and community-centered case study approach, framed by SLA, is used.

#### **3.1.1 Case-study approach**

The case study approach focuses on understanding the dynamics present within the case(s) (Eisenhardt, 1989). This approach, designed by Yin (1981; 1984) and further advanced by others (e.g., Eisenhardt, 1989), is widely used in social research. In the current research, the case study approach has enabled a detailed and in-depth investigation and analysis of the research objectives. It has offered more accurate and detailed information compared with larger scale studies, and provided the opportunity



to study social processes and relationships in greater depth and also to understand both how and why things happened (Yin, 1984; Eisenhardt, 1989). It has also provided an opportunity to combine various data collection methods such as archives, interviews, and questionnaires (Eisenhardt, 1989) of qualitative and/or quantitative in nature (Yin, 1984).

Case-study research also allows flexibility in data collection and analysis which helps revise data collection tools and research objective(s) (Eisenhardt, 1989). For this study, at the early stage of qualitative data collection, a preliminary report on “insights from qualitative data” was produced. In this way interesting themes and patterns in the data were explored and data collection tools were revised to focus on interesting issues. A research objective (Objective 3) was also revised at this stage. This overlapping of data analysis with data collection enabled flexible data collection, while at the same time allowing a head start in data analysis (Eisenhardt, 1989).

Case-studies should be carefully chosen so as to collect rich enough data to test objectives and expand theory. Case studies can involve either single or multiple cases and various levels/scales of analysis (Yin, 1984). The use of multiple case studies (see section 3.2.2 for selection of cases) has made this research more compelling, and the overall study is therefore more robust (Herriott and Firestone, 1983). Multiple cases allowed replication of findings that increased validity and generalizability (Eisenhardt, 1989).

Scale of analysis is a critical factor when investigating livelihood vulnerability and adaptation as they may vary depending on whether the analysis is at an individual, household, community, regional or national level (Adger et al., 2005a). Local scale (community and households) is the main focus in this study because major decisions about vulnerability and adaptation to climate change are undertaken at this scale (Thomas et al., 2007).

However there are some weaknesses in case-study research. For example, the intensive use of empirical evidence can yield overly complex theory, and building theory from cases may result in narrow and idiosyncratic theory (Eisenhardt, 1989). Use of multiple cases and a mixed-method approach in this study, which combines qualitative and

quantitative data collection and analysis, has helped overcome these weaknesses (Kelle, 2005). For example, quantitative methods have enhanced the scope of generalisation of findings, while qualitative methods have allowed flexibility (Hay, 2005). Use of this mixed method approach has also allowed the development of rich insights into the phenomena studied (Rocheleau, 1995; Bryman and Bell, 2007).

## **3.2 Study Sites**

### **3.2.1 Bangladesh context**

Bangladesh is a sub-tropical developing country, bordered to the west, north and east by India, to the south-east by Myanmar, and to the south by the Bay of Bengal with a 480km long coastline (Figure 5). It has made considerable economic strides in the past two decades. It is on track to achieve the Millennium Development Goals of halving extreme poverty by 2015. Poverty among the population has declined from 57 percent in 1990 to 31.5 percent in 2010 (World Bank, 2013b). Average GDP growth over the last nine years was more than 6 percent (World Bank, 2013b). Population growth rate has also slowed down markedly from 2.9 percent in 1974 to 1.34 percent in 2011 (BBS, 2011a).

Nonetheless, Bangladesh is regarded as one of the most climate vulnerable countries in the world (IPCC, 2007a; Yu et al., 2010b; Maplecroft, 2011; Met Office, 2011; World Bank, 2013a). Its vulnerability is due not only to its physiographic and climatic conditions (will be described in the next sub-section 3.2.1.1) but also to its socioeconomic conditions (Table 6), poor infrastructure and high livelihood dependence on natural resources.

Table 6. Socio-economic conditions of Bangladesh.

<i>Socio-economic indicator</i>	<i>Value</i>	<i>Year</i>	<i>Source</i>
Total population (million)	154.70	2012	World Bank (2013b)
Population density (per km <sup>2</sup> )	979	2008	BBS (2009)
Population growth rate (% per year)	1.34	2011	BBS (2011a)
Total gross domestic product (billion US\$)	115.60	2012	World Bank (2013b)
Gross national income per capita (US\$)	840	2012	World Bank (2013b)
Poverty headcount ratio at national poverty line (% of population)	31.50	2010	World Bank (2013b)
Literacy rate for 7 years and above (%)	51.80	2011	BBS (2011b)
Life expectancy at birth (years)	69	2011	World Bank (2013b)
Malnourished children (%)	61	2008	BBS (2009)

In Bangladesh, climate variability and change has reversed much of the development, achieved in the past 20 years (ADB, 2009) and they are anticipated to harm future development (Rahman et al., 2007). From 1980 to 2000, a total of 250,000 deaths were associated with tropical cyclones around the world, of which 60% occurred in coastal Bangladesh (IPCC, 2007a). One of the most devastating cyclones and associated storm-surge-induced floods killed 300,000 people in coastal Bangladesh in 1970 (IPCC, 2007a). The number of deaths as a result of floods has considerably decreased over the past decades due to improved disaster preparedness and response strategies, and higher levels of households' adaptive capacity (Del Ninno et al., 2001; Del Ninno et al., 2003). However, a large number of coastal people are still at risk to climate change due to various reasons. For example, despite improvements in warning systems and the construction of cyclone shelters, there are high rates of non-evacuation during extreme weather events (Paul and Dutt, 2010).

At present climate change has become a growing development concern in Bangladesh due to the risk of vulnerability (ADB, 2009). For example, a sea level rise of 1m by the end of the century may reduce the country's GDP by 57 % (ADB, 2009). Considering the impacts and vulnerability, Bangladesh is considered as a 'climate change hotspot' (World Bank, 2013a).

### *3.2.1.1 Climate variability and change in Bangladesh*

According to the Met Office (2011), Bangladesh has experienced widespread warming (0.24°C per decade during the hot season of March to May and 0.19°C per decade during the cool season of December to February) and a small increase in total precipitation since 1960. This study also observed several temperature and precipitation extreme events in the last 5 decades. Although this study observed a long-term trend of temperature extremes, no evidence of a long term trend of precipitation extremes (i.e., continuous wet or dry days) was observed. Between the years 1985-2009 an increased rate of sea surface temperature (0.0086°C to 0.0191°C annually) was found in the Bay of Bengal (Chowdhury et al., 2012). Other studies (Mirza and Dixit, 1997; Khan et al., 2000; Mirza, 2002 ) found an increase in temperature of about 1°C in May and 0.5°C in November (from 1985 to 1998), and decadal rain anomalies above long term averages since the 1960s in Bangladesh. Shahid (2010) observed an increase in annual and pre-monsoon rainfall as 5.53 and 2.47 mm/year, respectively, over the period 1958-2007.

In coming decades, Bangladesh will experience a mixture of climate variability and change (some data are shown in Table 7). Greater variation in temperature and precipitation has been predicted compared to the past. General Circulation Models for Bangladesh predict a steady increase in temperature and precipitation (Agrawala et al., 2003a), with temperatures increasing both in winter and summer, but more so in winter. In contrast, precipitation is predicted to decrease in winter and much increase in summer (Agrawala et al., 2003a). The Met Office (2011) projects 3 – 3.5°C increase in temperature in Bangladesh, and 20% increase in precipitation in the north of the country and 5 – 10% increase in precipitation for the rest of the country by 2100 under A1B (higher) emissions scenario of IPCC.

Table 7. Future climate change scenarios for Bangladesh.

Year	Mean temperature change (°C) <sup>1</sup>			Mean precipitation change (%) <sup>1</sup>			Cyclone (% increase of wind speed) <sup>2</sup>	Sea level rise (cm) <sup>3</sup>	Flood (% increase of flooded area) <sup>4</sup>
	Annual	December, January, February	June, July, August	Annual	December, January, February	June, July, August			
<i>Baseline</i>				2278	33.7 mm	1343.7			
<i>Average</i>				mm		mm			
2030	+1.0	+1.1	+0.8	+ 3.8	- 1.2	+ 4.7		14	
2050	+1.4	+1.6	+1.1	+ 5.6	- 1.7	+ 6.8		32	
2100	+2.4	+2.7	+1.9	+ 9.7	- 3.0	+ 11.8	10 – 25	88	23 – 29

<sup>1</sup>Agrawala et al. (2003a); <sup>2</sup>Emanuel (1987); <sup>3</sup>MoEF (2005); <sup>4</sup>Mirza (2003).

About 7% of the global cyclonic storms are formed in the Bay of Bengal region which is considered a potentially energetic region for the development of cyclonic storms (Gray, 1968). Between the years 1985-2009 an increased frequency of cyclonic storms (5.48 annually) was experienced in the Bay of Bengal (Chowdhury et al., 2012). There is still considerable uncertainty regarding how cyclone frequency and intensity will be affected in future by climate change in Bangladesh (Met Office, 2011). Cyclone frequency may increase (McDonald et al., 2005; Sugi et al., 2009) or decrease (Bengtsson et al., 2007; Emanuel et al., 2008; Zhao et al., 2009) in the North Indian Ocean (home to the Bay of Bengal). Likewise, cyclone intensity may increase (Vecchi and Soden, 2007; Yu et al., 2010a) or decrease (Oouchi et al., 2006) or even remain unchanged (Emanuel et al., 2008) in this basin. A more recent study, specifically focussing on the Bay of Bengal, predicted an increasing frequency of 7.94 cyclonic storms per year by 2050 due to climate change (Chowdhury et al., 2012).

Along the Bangladeshi coast, the sea level has risen in the past and is predicted to rise further in the future. Sea level rise is influenced by astronomical, geological and climate change factors. Expansion of the ocean, due to the increased temperature and the melting of glaciers, small icecaps, the Greenland ice sheet and the Antarctic ice sheet, is the major climate related factor that could explain a rise in global mean sea level on a 100-year time scale (Warrick and Oerlemans, 1990). Yu et al. (2010b) observed that the sea level has risen along the Bangladeshi coast over the past 60 years. Depending on the coastal geomorphology it varied along the coastline. At Hiron point (western region) the rate of sea level rise was 5.6mm/year, whereas at the Chandpur station (central region)

on the Meghna River no change was observed. Although the sea level rose at most of the stations, only that at Hiron point was statistically significant. By 2030, 2050 and 2100, the sea levels along the Bangladeshi coasts may raise upto 14, 32, and 88cm, respectively (MoEF, 2005). In a review, Agrawala et al. (2003a) predicted the sea level rise in Bangladesh as 30cm – 1m by 2100 under different IPCC scenarios.

An increase in temperatures, sea level and the number of summer precipitation events and cyclones will result in higher intensity and frequency of storm surge induced floods in coastal Bangladesh. Of the total land area, 79% has less than 1m elevation that includes all the coastal areas (Rashid, 1991). With a global temperature rise of 2°C, the flooded area in Bangladesh will rise by at least 23-29% more than today (Mirza, 2003). The flooded area, flooding depth and surge intrusion length may be substantially larger under intensified surge conditions (Karim and Mimura, 2008). As Dasgupta et al. (2011) suggested, a 10% intensification of the storm surge combined with a 1m sea level rise could affect 23% of Bangladesh's total coastal land area.

Land erosion is a regular and recurring phenomenon in Bangladesh. However, in coastal areas, especially on small islands, the rate of erosion is higher. A comparison of Landsat imagery of 1972 and 1987 showed a total of 11 small Bangladeshi coastal islands (and/or chars) disappeared totally (Pramanik, 1988). Although this study does not specifically mention the number of islands that might have been accreted, it has found that during that period erosion was greater than accretion, resulting in a net loss of the number of islands. Of the total 50 islands in 1973 only 39 existed in 1987 (Pramanik, 1988). Under sea level rise and increased flooding, land erosion is predicted to intensify along Bangladeshi coasts if protection is not given (Ahmed et al., 2002). The climate change scenario is predicted to increase the volume of water in the Ganges-Brahmaputra-Meghna river system during the monsoon. This may also increase coastal land erosion (Agrawala et al., 2003b).

The coastal region of Bangladesh is susceptible to increasing salinity in groundwater as well as surface water resources. Referring to the available data of 2005, Yu et al. (2010b) found that about 12% land area of Bangladesh contains a salinity of more than 5ppt during the monsoon which goes up to 29% during the dry season. The sea level rise (Han et al., 1999) and increased storm-surge (Ahmed et al., 2002) are the two

reasons for this increased level of salinity. Thus, increased levels of sea and storm-surge will result in more intrusion of salinity in the coastal areas.

In addition to model based observations/predictions mentioned above, local elderly people in coastal Bangladesh observed a continuous shift in climatic patterns, timing of the onset of monsoon and the highest level of tidal levels (Rahman et al., 2007).

### *3.2.1.2 Coastal fishing communities in Bangladesh*

Bangladeshis have a long tradition of fishing and fish culture which contribute significantly to employment, income generation, export earnings and human nutrition. This sector supports livelihoods of about 7 million fishers directly and 12 million people indirectly and contributes 4.43% to GDP and 2.73% to export earnings (DoF, 2012). Most (93%) of the marine fishing is small-scale in nature and supports the livelihoods of over half a million fishers and their household members (DoF, 2012) living in 870 fishing communities (Aghazadeh, 1994). Although no recent data is available, the number of coastal fishing communities is frequently claimed as more than 2000 in the media. In addition, marine fisheries support the livelihoods of other households involved in ancillary activities such as fish processing, gear making and so on.

Several studies have found poor physical infrastructure in the coastal fishing villages of Bangladesh and most people live in poor socioeconomic conditions (BOBP, 1985; Ahmed, 2002; Hasan et al., 2004; Chowdhury, 2005; Ahmed et al., 2009; Akter et al., 2009). They have also found that most of the households cannot eat regularly, have little education, and have only moderate public health provision. Some get financial assistance from the government and international donors (Hasan et al., 2004). Local village leaders tend to make community decisions and resolve most family conflicts, although sometimes elected local government representatives such as the chairmen and members of “*union parisad*” (a local government unit) resolve conflicts (Ahmed et al., 2009). Women have less freedom both socially and economically than men (Ahmed et al., 2009). However, most of them can cast their votes during national and local government elections (Ahmed et al., 2009).

In the fisheries sector women are mainly involved in post-harvest, processing and marketing. It is estimated that about 30% of Bangladeshi women in rural coastal areas

are directly or indirectly engaged in small-scale fishing activities (Librero, 1987). Their specific activities include making and repairing fishing gear, sorting fingerlings (especially in coastal areas), catching shrimp/prawn post-larvae, fish processing, transportation, small-scale marketing (Ahmed et al., 2012). However, they are often excluded from fishing and from the institutions that manage fisheries (Sultana and Thompson, 2006).

Marine small-scale fishery-dependent people can be categorised into different groups (Table 8). Most of the fishers catch fish with boats and gear, although a small number of them do not have a boat and operate only with small (push/pull) nets near the shore. Four types of boats (small manual, small mechanised, medium mechanised and large mechanised) are normally used with different types of nets depending on the target species and fishing season. In Bangladesh, there are 21,097 total motorised fishing vessels of which 99.20% are less than 12m in length (FAO, 2012). Normally rich people, who can afford at least 400,000TK, own these boats (BOBP, 1985). In a boat, a group of 5 to 25 people work during a fishing operation that lasts between 12 hours and 20 days (Hasan et al., 2004). In a typical large boat, there is a captain (also called crew leader) and normal crew members (BOBP, 1985). The boat captain's income is two to three times higher than a normal crew member (Hasan et al., 2004).



Table 8. Classification of coastal and marine small-scale fisheries in Bangladesh (Source: BOBP, 1985; Hasan et al., 2004; Akter et al., 2009; DoF, 2009).

<i>Characteristics</i>	<i>Classifications</i>
Activity	Boat owning and renting (usually males) Fishing (as crew leader or captain) (only males) Fishing (as crew member) (only males) Shrimp post-larvae collecting (mainly females, elderly and children) Fish processing (both males and females) Fish trading (mainly males; some females) Boats and gear making and mending (both males and females)
Type of boats	Small Manual Boat Small Mechanised Boat Medium Mechanised Boat Large Mechanised Boat
Type of gear	Gill net Bag net Longline Trammel net Others
Scale of fishing	Full-time Part-time Occasional

There are two main fishing seasons: rainy and winter. In the rainy season (May to September) with rough seas, mainly hilsa shad fish (*Tenualosa ilisha*) (the most popular and the largest single species fishery of Bangladesh) are caught by gill nets on the far shore. Some other species such as bombay duck (*Herpodon nehereus*), pomfret (*Pampus spp*), ribbon fish (*Trichiurus savala*), flat fish and shrimps (*Penaeus spp*) are also caught during this season by using bag nets, longlines and trammel nets. In the winter season (November to March) the sea generally stays calm. During this season some of the above species of fishes are caught but shrimp post-larvae are also collected during this season by small manual boats with bag nets, and by push/pull nets without a boat. During the other two months of the year (April and October), the boats and nets are repaired and the fishers prepare for fishing (Hasan et al., 2004). There are three types of fishers depending on time involvement in fishing – full-time (9-12 months per annum), part-time (3-9 months per annum) and occasional (less than 3 months per annum). After landing, the fish are normally sold by auction in local fish landing centres or on the local market or directly to local fish processors. Fish marketing is controlled by a group of intermediaries known as "Aratdars" (commissioning agents) and

“*Mohajans*” (money lenders). The commissioning agents dominate the wholesale markets and have a chain of suppliers who regularly bring catches. These agents charge 3-6% commission and take 2-4 fish for every 80 fish sold (Rahman, 1994). The agents in turn provide advance money (*dadon*) to boat owners to make boats and nets. The boat owners are required to sell fish to the agents. After landing, fishermen tend to sell their fish as early as possible to these agents to avoid spoilage because of the inadequate cold storage facilities and unavailability of good quality ice (Ahmmed, 2007). There are around 6,500 fish markets scattered across the country of which 4,500 are small primary village markets (Rahman, 1994).

Seafood is processed and preserved in mainly two ways: freezing (includes chilling) and drying (includes salting followed by drying). There are 162 shrimp and fish processing (freezing) industries (DoF, 2012). Fish are frozen as whole (often beheaded and gutted) or as fillets or steaks, either by individual quick frozen or block frozen technique (Ahmmed, 2007). Fish that are exported overseas need to achieve international standards following international regulations such as the HACCP (Hazard Analysis Critical Control Point) procedure.

In Bangladesh, traditional sun drying is one of the most popular low cost methods of fish processing and preservation both for domestic consumption and export. Traditional sun drying is carried out in the open air using solar energy to evaporate the water from fish. This technique involves a longer drying period, no control over the operating variables, and a risk of infestation with insects, their eggs and larvae (Islam et al., 2007; Islam et al., 2008). To overcome these disadvantages a small quantity of fish is also dried by mechanical drier such as a solar tunnel drier where different variables such as temperature, relative humidity, air velocity and solar radiation are controlled (Bala and Mondol, 2001; Islam et al., 2007; Islam et al., 2008).

### *3.2.1.3 Coastal fishing communities and climate change in Bangladesh*

There are few studies available on climate change and the fisheries of Bangladesh. A national scale study found that the economy of Bangladesh will be amongst the most vulnerable to climate change impacts on fisheries by the 2050s (Allison et al., 2009b). The results from this type of study should however be used cautiously as it has used only a single climate change parameter (Met Office, 2011). The projected climate

change may directly impact on the fish stocks and the Bay of Bengal ecosystems, and on the livelihoods of the fishery-dependent people in Bangladesh. In general, the impacts of climate change between the Bangladeshi coastal small-scale fishing communities and those of other parts of the world may have some level of similarity as the nature of this fisheries system varies little across the world (discussed in section 2.5). Climate change may result in an increased level of fluctuation in fish production in Bangladesh (Ali, 1999; Ahmed et al., 2002). Cyclones and associated floods may exert tremendous impacts on fishing assets, infrastructure and ultimately on the livelihoods of fishing communities. Ahmed and Neelormi (2008) observed a reduction of fishing days during the monsoon of 2007 due to cyclonic sea condition. More frequent and intensified cyclones can further reduce fishing days. In coastal Bangladesh cyclones of very high intensity may occur in April and May, and between September and November (Met Office, 2011). Most of these months fall within the fishing seasons and consequently fishing activities may be impacted by intense cyclones. Traditional fish drying activity may also be impacted by increased temperature and variation in rainfall as well as by extreme climate and weather events. Sea level rise and land erosion may make the current living areas of fishing communities unsuitable and may result in their displacement or may leave them in a more vulnerable situation. As a whole they are likely to be exposed more to climate change impacts (Agrawala et al., 2003a).

The Government of Bangladesh is claimed to be one of the pioneers and key proactive policy formulators in the world in addressing the negative impact of climate change in Bangladesh (MoEF, 2012). Two main policy documents – the National Adaptation Programme of Action (NAPA) developed in 2005 (updated in 2009) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP) developed in 2008 are frequently referred to in support of this claim (MoEF, 2005; BCCSAP, 2008; MoEF, 2009). The BCCSAP builds on the NAPA. These documents provide overall policy and action guidance to address the impacts of climate change. The BCCSAP is the main basis of a ten year plan to address climate change over the next 20 – 25 years. The objective of BCCSAP is to increase the country's resilience to climate change, reduce the climate change risks to national development, and accelerate the development of the country following a low-carbon path. It also suggests an integrated approach to socio-economic development and the management of climate change issues. It has already received

funding from international donors and has itself funded the implementation of some of the strategies.

However, how these strategies have helped or would help the coastal fishing communities to address climate impacts is vague. The lack of policy for coastal fishing communities is due to the serious lack of understanding of the issues and implications of climate change amongst scientists, activists and planners (Rahman et al., 2007). The first version of NAPA had two policies directly relevant to fisheries; consisting only of policies linked to culture fisheries but there was no policy for coastal and marine capture fisheries on which millions depend. The updated version of NAPA and especially the BCCSAP included two medium and long term strategies and action plans for adaptation in the coastal and marine fisheries sector: 1) “Assess potential threats to fish spawning and growth of fish in the coastal zone and brackish water and develop appropriate adaptive measures and cultural practices”, 2) “Assess potential threats to the marine fish sector and develop adaptive measures”. This research has the potential to contribute to the 2<sup>nd</sup> strategy.

### **3.2.2 Selection of the fishing communities**

In order to achieve the aim and objectives of this research stated in Chapter 1, three coastal fishing communities (cases) were chosen in Bangladesh (Figure 5). The communities were not selected randomly but rather based on a well-defined theoretical focus which replicates or extends theory by filling conceptual categories (Yin, 1984; Eisenhardt, 1989).

Due to the lack of accessible and published local level information, it was challenging to select the fishing communities. The selection process comprised of several steps including a literature review and a reconnaissance study. Through a literature review two districts, Barguna and Cox’s Bazar, were selected from the entire coastal area of Bangladesh. These districts are more affected by climatic phenomena such as cyclones and tidal fluctuation than other coastal areas of Bangladesh (Agrawala et al., 2003a). During the reconnaissance study, key information on climate and the livelihoods of the fishing communities were gathered using key informant interviews and focus group discussions (FGDs) (see section 3.3 for details). Some of the local level documents (such as demographics and past extreme events data), which are not available online,

were also collected during that time. Three study sites were selected (Padma, Kutubdia Para and Kutubdia Island) (Figure 5). The main selection criteria were characteristics of the settlements, communities' level of dependence on marine fisheries, their livelihood characteristics and their exposure to past climatic shocks and stresses. The three communities are first described based on secondary and primary data (reconnaissance study data that were updated later during the main data collection), followed by more justifications of their selection for this study.

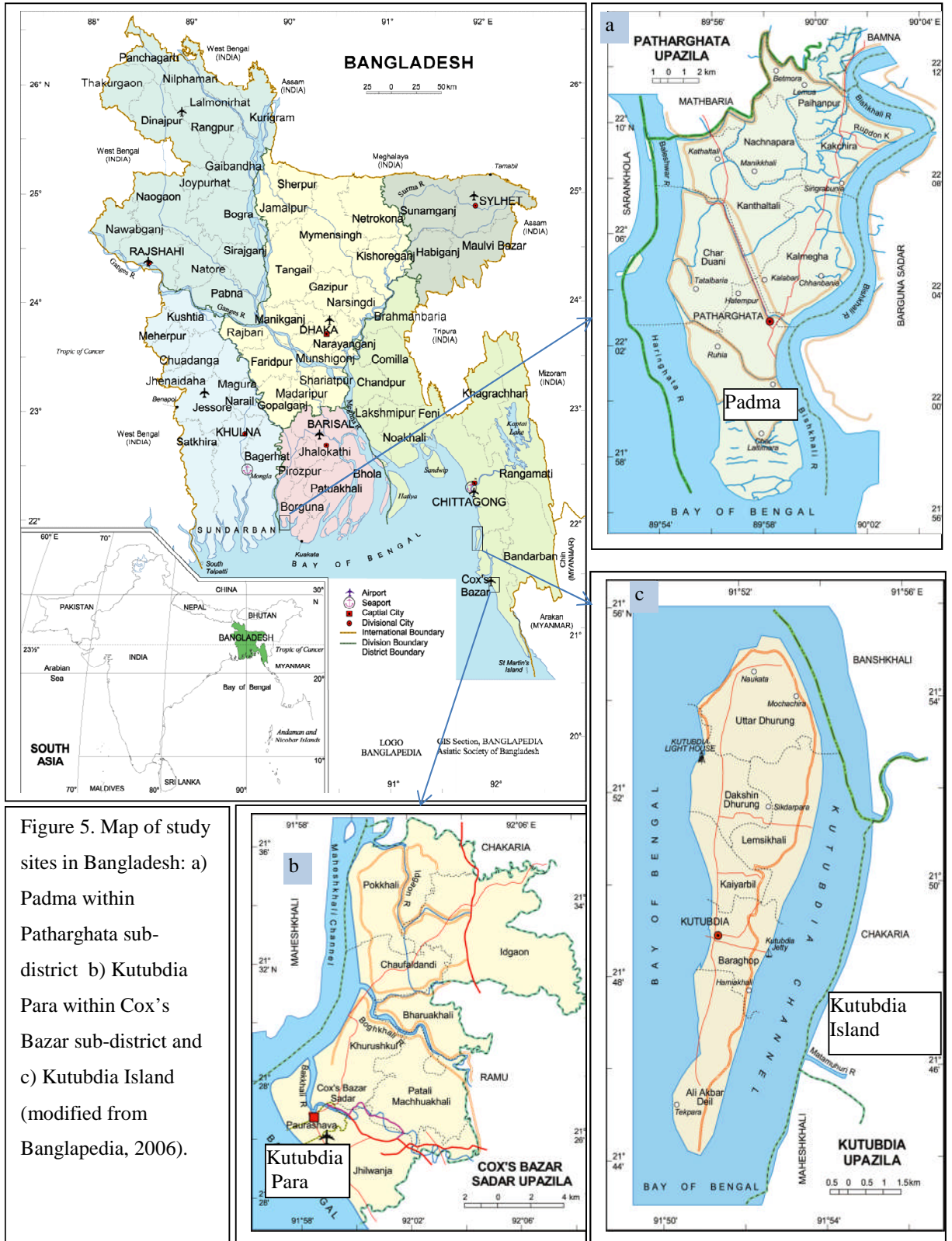


Figure 5. Map of study sites in Bangladesh: a) Padma within Patharghata sub-district b) Kutubdia Para within Cox's Bazar sub-district and c) Kutubdia Island (modified from Banglapedia, 2006).

### *3.2.2.1 Padma*

Padma is situated on the western coastal zone of Bangladesh along the coast of the Bay of Bengal in the district of Barguna (Figure 5). Table 9 summarises some of its information. The world's largest single chunk of mangrove forest 'the Sundarbans' is situated in this coastal region. Because of the presence of the mangrove forest, this zone is relatively stable in terms of soil erosion. Mangrove swamps, tidal flats, natural levees and tidal creeks are characteristics of this zone. Mangroves support feeding and breeding grounds for fish and shrimps enriching their bio-diversity. This area has silty loams or alluvium soil.

Padma's physical infrastructure is poor. Dirt roads become muddy during the rainy season and are dusty when it does not rain. Two cyclone shelters have a joint capacity for 3,000 people (based on reconnaissance study). One of the cyclone shelters serves as a primary school, the only formal educational institution in Padma. There is no hospital or clinic but two pharmacies dispense medicines. People with medical needs visit the sub-district health complex in Patharghata about 8km away. There is no access to the electricity grid or piped water supply. Filtered and alum-treated pond water of uncertain quality is used by households. The Patharghata municipality is a small town where most of the local government and non-government offices, educational institutions and health centres are situated. Therefore, the livelihoods of the inhabitants of Padma are partly influenced by Patharghata.

Padma is home to 4,204 people in 908 households. Most household heads are male with limited formal education. Most households (89%) directly depend on fisheries; small-scale fishing in the Bay of Bengal is their main livelihood activity (based on reconnaissance study). Some households are involved in other activities such as fish drying, fish trading, net making and/or mending, boat making and repairs, shrimp post-larvae collection, daily labouring, firewood selling, grocery shop keeping, cattle rearing, investing money in informal loan systems, motorcycle driving, fish culturing and agriculture (Table 9). The reconnaissance study data show that most men work as crews in small mechanised fishing boats. The first fishing season runs between July and October, although there are a few days within this period when fishing does not take place. The second season is between December and April. Most fishing is done during the first season. A crew of 3-18 people work during a fishing operation that lasts

between 6 hours and 15 days. Mainly three types of actors are directly linked to these activities – boat owners (investors), boat captains and fishermen (crews). A boat owner provides a boat and associated materials and appoints a captain who is responsible for running a fishing trip and appointing fishermen.

The reconnaissance study data also show that livelihoods in Padma have been influenced by climatic shocks and stresses. The most devastating climatic shock in the past 40 years was the super cyclone *Sidr* (wind speed: 230-270km/hour, surge height: 20-25 feet) in 2007. There was also a strong cyclone in the sea in 2005 and a flood caused by cyclone *Aila* in 2009. Each year 5-7 minor cyclones affect fishing activities. Padma lies between 0.9 to 2.1m above the mean sea level (Iftekhar and Islam, 2004) and does not have a protective dike around it. The sea level in this area has been rising by 2.9mm/year (CEGIS, 2006).



Table 9. Characteristics of the three study fishing communities.

<i>Characteristics</i>	<i>Padma</i>	<i>Kutubdia Para</i>	<i>Kutubdia Island</i>	<i>Source of data</i>
Location	On mainland; in the western region of the coastal zone	On mainland; in the eastern region of the coastal zone	An island in the eastern region of the coastal zone	Pramanik (1983)
History of settlement	Most people have been living here for more than 100 years	People have migrated here from Kutubdia Island two decades ago	Most people have been living in this village for long time. Many of their neighbours migrated to Kutubdia Para	Reconnaissance study (updated during main data collection)
Land elevation (above the mean sea level)	0.9 to 2.1m	Less than 1m	Less than 0.5m	Iftekhar and Islam (2004)
Proximity to town	8km from a local town	6km from a big tourist town	No town or tourist area nearby	Reconnaissance study (updated during main data collection)
Cyclone shelter	Two cyclone shelters present	No cyclone shelter present but many buildings present in nearby town	Few cyclone shelters present	Reconnaissance study (updated during main data collection)
Main livelihood activities	Fishing, fish processing, fish trading, shrimp post-larvae collecting, agriculture farming and labouring	Fish processing, fishing, fish trading, shrimp post-larvae collecting and labouring	Fish processing, fishing, salt producing, agriculture farming, fish trading, shrimp post-larvae collecting and labouring	Reconnaissance study (updated during main data collection)
Fishing area	Catch fish mainly from near shore areas and 'west of swatch of no ground' <sup>1</sup>	Catch fish mainly from near shore areas and 'south patches' <sup>1</sup>	Catch fish mainly from near shore areas and 'south patches' <sup>1</sup>	Reconnaissance study (updated during main data collection)
Cyclones and floods	Few major cyclones and floods in the past 40 years and some minor cyclones each year in the fishing area <sup>2</sup>	Few major cyclones and floods in the past 40 years but at different times than Padma and some minor cyclones each year in the fishing area <sup>2</sup>	Few major cyclones and floods in the past 40 years at the same time like Kutubdia Para and some minor cyclones each year in the fishing area <sup>2</sup>	Reconnaissance study (updated during main data collection)
Trend of sea level rise	2.9 mm/year	1.4 mm/year	2.1 mm/year	CEGIS (2006)
Soil erosion	Medium	Low	Very high	Pramanik (1983)

<sup>1</sup>Fishing grounds in the Bay of Bengal.

<sup>2</sup>Based on intensity, cyclones are different types (together also known as cyclonic disturbances). Major cyclones include severe cyclonic storm (48 – 63 knots), very severe cyclonic storm (64 – 119 knots) and super cyclonic storm ( $\geq 120$  knots), while minor cyclones include depression (17 – 27 knots), deep depression (28 – 33 knots) and cyclonic storm (34 – 47 knots) (WMO, 2012).

### 3.2.2.2 *Kutubdia Para*

Kutubdia Para is situated on the eastern coastal zone of Bangladesh along the coast of the Bay of Bengal in the district of Cox's Bazar (Figure 5). Table 9 outlines some of its information. It is 3km from Cox's Bazar airport and 6km from Cox's Bazar town. The soil characteristics of this zone are dominated by submerged sands and mudflats (Islam, 2001). The world's longest unbroken sandy sea beach, which is very important from the tourists' perspective, is located in this area. Many hotels, markets and industries are situated along the beach and in the nearby Cox's Bazar town where most of the government and non-government offices are also situated. Therefore, the livelihoods of the inhabitants of Kutubdia Para are partly influenced by this town and the beach.

Kutubdia Para is home to 12,815 people in 2,015 households. Most households are climate migrants from the Kutubdia Island in the same district. The village came into existence in 1986 as an isolated neighbourhood but it is now a ward in the district of Cox's Bazar. Most household heads are male with little formal education.

Livelihoods in Kutubdia Para depend on fishery-related activities such as fishing in the Bay of Bengal, fish drying, fish transportation and net mending (Table 9). The reconnaissance study data show that fishing and fish drying support the livelihoods of about 92% of the households. A few households depend on tailoring, groceries and daily labouring in building construction for their livelihoods.

The reconnaissance study data also show that fishing practices in Kutubdia Para are similar to those of Padma, except that the second fishing season is extended by two more months and more fish is caught in this season. Fish is dried by the traditional open air method and 80 % of this is done between November and February. The remaining 20% of fish are dried in September, October, March, April and May (extended drying period).

Kutubdia Para's physical infrastructure is either similar to or better than that of Padma. Half of its roads are made of brick and the other half are made of dirt. The quality of houses and access to health facilities and education are similar to Padma. Households have better access to temporary shelters which are in the nearby town to escape disasters and also to electricity and pure drinking water.

The reconnaissance study data further show that since settling in Kutubdia Para, households have experienced two major cyclones and associated floods in 1991 (named *Gorki*) and in 1997. They are also exposed to sea level rise, temperature and rainfall variations, and slight land erosion. As in Padma, each year 5-7 minor cyclones affect its fishing activities. Kutubdia Para is less than 1m above sea level (Iftekhar and Islam, 2004) and less than 1km away from the sea, and it has no protective dike around it.

### *3.2.2.3 Kutubdia Island*

Kutubdia Island is a sub-district of 50 km<sup>2</sup> with 119,899 people (22,403 households) (USO, 2011) in the district of Cox's Bazar (Figure 5). Table 9 summarises some of its information. People started living here more than 500 years ago. The island is separated from the mainland by the 3km wide Kutubdia Channel. Fishery-related activities are central to the livelihoods on the island which are facilitated by a sand bar (used as a fish drying field) and creeks (used for fishing boat landings). The households are also involved in other activities such as salt producing, agriculture, fish drying, shrimp post-larvae collecting, mollusc-shell collecting, aquaculture, daily labouring, cattle rearing and shop keeping (Table 9).

Households on Kutubdia Island are exposed to multiple climatic shocks and stresses which has ultimately led to the migration of some of its households. The island is less than 0.5m above the mean sea level (Iftekhar and Islam, 2004). The key informant interviews data (see section 3.3.5) show that since the 1960s, the rate of land erosion has increased substantially in the south-western part of the island known as Kuzier Tek. Locals consider that sea level rise, floods and changes in the direction of currents are the main reasons for accelerating land erosion. Increased water flow in the Ganges-Brahmaputra-Meghna river system over the past decades, due to increased ice melt in the Himalayas (Agrawala et al., 2003b), may also have exacerbated land erosion.

A traditional mud-made dike was built by the government to protect the settlement in Kuzier Tek. It proved unsuccessful and about 3000 households were displaced by land erosion, sea level rise and cyclonic-storm-induced flooding between 1960 and 1997 (based on key informant interviews). The displaced households first resettled nearby on land they or their relatives owned. The number of displaced households grew and most

resettled 4-5 times over time. When they had no land left in around 1970, some of the households moved behind a nearby government-owned dike with the hope of returning after accretion. However, accretion did not take place and further erosion displaced more households. With the assistance of relatives some of the households moved to other parts of the island.

The key informant interviews data (see section 3.3.5) also show that in 1984, the government relocated 80 of these households 60km south-east to the mainland. In 1986, a locally elected government representative (*Chairman of Union Parishad*) located a government-owned forest plot about 100km south-east of the island on the mainland, 6km from Cox's Bazar town and 3km from the Cox's Bazar airport. Heads of 15-25 households moved there the same year to take advantage of the new settlement which was well-suited for fishery-related livelihoods. Other household members followed, houses were built and the settlement was named Kutubdia Para. Within a year 500-600 households migrated to the new settlement. Another wave of migration happened in 1991 when Kuzier Tek was hit by the devastating cyclone *Gorki* and storm surges over 6.1m high associated with it. In 1997 Kuzier Tek was hit by another cyclone which resulted in further dislocation and resettlement to Kutubdia Para.

Two thirds of the households displaced from Kuzier Tek migrated to Kutubdia Para between 1986 and 1997. There has been little migration since 1997. More recently displaced households from Kuzier Tek have migrated elsewhere. The key informant interviews and focus group discussions data (see section 3.3) show that of the original 3500 households of Kuzier Tek only 11 remain there, 78 reside nearby on the island, 2000 reside in Kutubdia Para, and the rest have resettled elsewhere. The following paragraphs give details about why the three fishing communities chosen for the study were selected.

Padma and Kutubdia Para have been studied to meet Objectives 1 and 3 and Kutubdia Para and Kutubdia Island have been studied to meet Objective 2. Padma and Kutubdia Para have some similarities and differences. Although they are situated in the coastal areas, they are from different zones and have some similar and some different physiographic characteristics. The households are exposed to similar types of climatic shocks but these happen at different times. They are from different administrative areas

in the country and have some similar and some different physical infrastructure features. The two communities have somewhat different levels of key livelihood assets and access to services. Kutubdia Para has some advantages, for example, it is near to a big tourist town which may offer several facilities such as livelihood alternatives and better access to most government and non-government offices and markets. Although most of the households in both communities are directly dependent on marine fisheries, their livelihood activities differ to some extent. Two thirds of Padma's households are involved in fishing in the Bay of Bengal and one third is involved in other fisheries related activities including fish drying. In contrast, these ratios are reversed among Kutubdia Para's households. Within each community the livelihood characteristics may be heterogeneous among different groups of households as, for example, their livelihood activities and level of assets may differ. Thus the study of livelihood vulnerability between these two communities and among different groups of households within the same community can enable an investigation of the factors responsible for making the community or households more or less vulnerable to the impacts of climate variability and change (Objective 1). The findings of such a study may therefore help find ways to assist the communities and households become less vulnerable or more adapted to climate variability and change.

To escape climate impacts or to adapt to them, the households of Kutubdia Para migrated from Kutubdia Island. Although they were originally the same people, more than two decades have passed since their migration. They still depend on some similar livelihood activities but also each has different ones. Their level of exposure to climate shocks and stresses, livelihood assets and access to them and other social services also vary to some extent. Thus comparing the two communities can enable an investigation into whether climate-induced migration has resulted in positive or negative outcomes for the migrants compared to the non-migrants, therefore shedding light on whether migration can be a viable strategy to address climate change (Objective 2).

As mentioned earlier, in Padma and Kutubdia Para a considerable proportion of the households are dependent on fishing from the same source (the Bay of Bengal). They use quite similar fishing methods and they are exposed to similar types of climate shocks and stresses. However, these activities and associated climatic risk may be managed in somewhat different ways in the two communities as they have somewhat

different livelihood characteristics and they are situated in different administrative areas. Thus, both communities can provide an opportunity to investigate the limits and barriers to adaptation of fishing activities to climatic disturbances (cyclones) (Objective 3). The similarities and differences between the two communities in their ways of managing climatic risks will make the findings more compelling and offer a chance to learn from comparative case study research. These findings will therefore help find ways to overcome these limits and barriers.

### **3.3 Data Collection**

This study follows a mixed method approach of data collection (Tables 10 and 11). Quantitative methods (e.g., structured household questionnaires) were used mainly for collecting data on context, whereas qualitative methods (e.g., oral history interviews, vulnerability matrices, key informants interviews and FGDs) were used to get rich, detailed and contextually grounded data (Nightingale, 2003).

Table 10. Summary of key methods used to address the aim and each objective.

<i>Research aim and objectives</i>	<i>Methods for primary data collection</i>	<i>Methods for data analysis</i>
Aim: to assess the vulnerability and adaptation of three Bangladeshi coastal small-scale fishing communities to the impacts of climate variability and change	Mixed methods	Quantitative and qualitative
Objective 1: to assess the vulnerability of fishery-based livelihoods to the impacts of climate variability and change in two coastal fishing communities and their households	Structured household questionnaires, oral history interviews, key informant interviews, vulnerability matrices and focus group discussion (FGDs)	Cluster analysis, construction of vulnerability indices by composite index approach, t-test, z-test and ANOVA for quantitative data, and content analysis (by coding) for qualitative data
Objective 2: to examine how climate-induced permanent migration has impacted vulnerability and adaptation of a coastal fishing community by comparing with the residual of its original community	Structured household questionnaires, oral history interviews, key informant interviews, vulnerability matrices and FGDs	Cluster analysis, descriptive statistics and z-test for quantitative data, and content analysis (by coding) for qualitative data
Objective 3: to identify and characterise limits and barriers to adaptation of fishing activities to cyclones and examine interactions between them in two fishing communities	Structured household questionnaires, oral history interviews, vulnerability matrices and FGDs	Descriptive statistics for quantitative data and content analysis (by coding) for qualitative data

Data were collected only from fishery-dependent households across the communities, except from some key informants outside the communities (described later in section 3.3.5) who are directly associated with the communities' interests. Fishery-dependent households include any level of, full-time, part-time or occasional, dependence on fisheries such as fishing, fish processing, boats and gear making and mending, and fish trading. A sampling frame for the fishery-dependent households was prepared in each community before data collection. Of the total 908 households in Padma, 89% (811 households) are fishery-dependent. Of the total 1193 households in Middle and North Kutubdia Para (this study was conducted in these two sections of Kutubdia Para), 83% (994 households) are fishery-dependent. From Kutubdia Island, 89 households were targeted – 11 households that remain in Kuzier Tek and another 78 who are settled on other parts of the island (see section 3.2.2.3). All of them are fishery-dependent at least occasionally.

The data were collected in October 2010 (reconnaissance study) and between February and July 2011 (main data collection) across the three communities. Some key informant interviews were also conducted in Kutubdia Para in May 2013 to update some qualitative data.

In the process of data collection, biases in sampling may lead to a distortion in the result (Varkevisser et al., 2003). Through the use of a wide variety of methods this research has ensured triangulation (“using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation”(Stake, 2005, p. 545)) which has reduced bias and increased accuracy and rigour in findings (Stocking and Murnaghan, 2001; Golafshani, 2003). In what follows, the data collection tools are described.

### **3.3.1 Structured household questionnaires**

Structured questionnaires were employed to collect data on household characteristics including composition of households, level of and access to capital assets, factors affecting capital assets, household activities and household history including past income generating activities (Appendix 1). The questionnaire was designed according to de Vaus (2002) and adapted for the specific context of coastal fishing communities in Bangladesh. Two important issues were considered before conducting the questionnaires so that responses were not influenced and the success of the survey not jeopardised. Firstly, care was taken when designing the questionnaire as the design and wording of the questions can have a significant effect on the answers obtained (Linden and Sheehy, 2004). The questionnaire was first developed in English then translated into Bengali carefully maintaining the meaning. Secondly, the questionnaires were pilot-tested with a small sample of respondents to verify the appropriateness of the questions asked and the wording used. This pilot phase resulted in some minor modifications to the questionnaires so that they could be tailored more appropriately to the local context.

The questionnaire enabled collection of both quantitative and qualitative data, representative of the communities and comparable between communities. The questionnaire included a mixture of closed and open-ended questions. The responses from closed questions allowed statistical analysis, whereas the open-ended questions gathered qualitative data eliciting more detail and personal opinions on specific issues.



These questionnaires were conducted as face-to-face interviews by me and two trained research assistants. All the questions were asked in the same way and in the same order, which enabled collection of a set of comparable answers on which statistical analysis could be performed. Only household heads were surveyed because they have a good sense of the household's vulnerability, security and livelihoods (Jansen et al., 2006b). The household heads are usually male and due to time constraints data were not collected separately from women member(s) of households, except in a few cases where male heads were absent. However, some studies show that surveying women separately may produce some new insights. For example, Fisher et al. (2010) found that husband's estimate of his wife's income may not provide reliable results. Although in this study context female members of a household have a little role in direct household income (except female-headed households), not surveying the female member(s) in a male-headed household is identified as a limitation of this study.

The households for this questionnaire were selected using a random sampling technique from the sampling frame of each community (described earlier) using a web-based random number generator tool (Random.org, 2011). The sample sizes were calculated using a methodology consistent with UN (2005) using the formula:

$$n_h = (z^2) (r) (1-r) (f) (k) / (p) (\bar{n}) (e^2) \dots \dots \dots (1)$$

where,  $n_h$  is the sample size in terms of number of households to be selected;  $z$  is the statistic that defines the level of confidence desired;  $r$  is an estimate of a key indicator to be measured by the survey;  $f$  is the sample design effect;  $k$  is a multiplier to account for the anticipated rate of non-response;  $p$  is the proportion of the total population accounted for by the target population and upon which the parameter,  $r$ , is based;  $\bar{n}$  is the average household size (number of persons per household); and  $e$  is the margin of error to be attained. The sample size calculation procedure using Equation 1 is shown in detail below:

The  $z$ -statistic is 1.96 for the 95-percent level of confidence. This level is generally regarded as the standard for assigning the degree of confidence desired in assessing the margin of error in household surveys (UN, 2005). The baseline value of an indicator

expressed as proportions that is,  $r$  is ideally informed by information available from other surveys that have been conducted in Padma. However no such authentic previous studies have been found. In this case the value of  $r$  is chosen as 0.50, because the variance of indicators that are measured as proportions reach their maximum as they approach 0.50 (Magnani, 1997, p. 16). That is, this value of  $r$  will ensure an adequate sample size irrespective of what the actual value of  $r$  is (Magnani, 1997, p. 16). The sample design effect,  $f$ , is set at 1.0 (no design effect) as this study chooses the simple random sampling technique. The non-response multiplier,  $k$ , is typically under 10 percent in developing countries (UN, 2005). The value of  $k$  is therefore set as 1.10. In the village of Padma, the target population is fisheries dependent households, which are about 90 percent of the total in this village. In this case  $p$  is 0.90. The average household size,  $\bar{n}$ , is taken from the available latest census (BBS, 2001) as 5.16 for Padma. For the margin of error,  $e$ , it is recommended to set the level of precision at 10 percent of  $r$  (UN, 2005); thus  $e = 0.10r$ .

Substituting these values gives,  $n_h = (1.96)^2 (0.50) (1 - 0.50) (1) (1.10) / (0.90) (5.1) (0.10 \times 0.50)^2 = 92.06$  for Padma.

Using Equation 1, the sample sizes were also calculated as 89 for Kutubdia Para and 88 for Kutubdia Island. Given the large respective population of Padma and Kutubdia Para and small respective population of Kutubdia Island, the sample sizes were adjusted to 100 for Padma, 100 for Kutubdia Para and 50 for Kutubdia Island (Table 11).

Table 11. Sample sizes for data collection from the study communities.

<i>Communities</i>	<i>Structured household questionnaires</i>	<i>Oral history interviews</i>	<i>Vulnerability matrices</i>	<i>Key informant interviews</i>	<i>Focus group discussions (FGDs)</i>
Padma	100	22	5	11 (5 during reconnaissance study + 6 during main data collection)	7 (2 during reconnaissance study + 5 during main data collection)
Kutubdia Para	100	21	4	14 (5 during reconnaissance study + 6 during main data collection + 3 later to update some data)	6 (2 during reconnaissance study + 4 during main data collection)
Kutubdia Island	50	17	3	6 (only during main data collection)	4 (only during main data collection)
Total	250	60	12	31	17

The structured household questionnaire data served as a means of selecting participants for other data collection methods. Initial descriptive statistics of the household livelihood data showed that the households are heterogeneous in terms of their livelihood characteristics. Livelihood characteristics of households are among the main factors that determine households' vulnerability to climate variability and change and their ability to adapt (Adams and Mortimore, 1997; David, 1998; Paavola, 2008; Sallu et al., 2010). As such, it was felt important that the selection of households for other data collection methods should consider this heterogeneity. The households in each community were classified using cluster analysis of household characteristics (see section 3.4.1.1 for details) and further data were collected from each cluster. This ensured adequate data from each relatively homogenous subgroup as well as addressing existing power relations among the households in a community, which may sometimes drive the process (Nelson and Wright, 1995), and which can dominate over the diversity of individual perceptions and needs (Clever, 2001).

Random sampling of households for structured household questionnaires and clustered household sampling associated with the other methods, ensured household selection representative of the diversity of households in the community and not biased towards either the rich or poor households or towards the most influential individuals.

### **3.3.2 Oral history interviews**

Oral histories provide a more detailed perspective of social processes and can provide key insights into the lives of people which structured questionnaires cannot elicit (Mather, 1996). In this study oral histories were used to gather in-depth information on past and present impacts of climate variability and change on respondents' livelihoods, and their coping and adaptation strategies, largely following the guidelines of EMOHA (Undated). The temporal scale of past data collection was mainly focussed on the last 30 years because this is the time scale generally considered within the range of human memory (Elliott and Campbell, 2002). Based on the literature reviews, information and experiences from the reconnaissance study, structured household questionnaires and informal discussions with stakeholders, a checklist for oral history interviews was prepared before the interview to ensure some structure and direction to the interview (Appendix 2). The checklist mainly included how past and current climate induced shocks (e.g., flooding and cyclones) and stresses (sea level rise, temperature, rainfall,

land erosion and salinity) impacted (negatively or positively) on households' livelihood assets, strategies, transforming structures and processes and overall livelihood capabilities and outcomes; how those impacts differed; how they responded to those shocks and stresses; how responses were facilitated or constrained; in future how are they going to address the shocks and stresses; and their recommendations for future responses.

In qualitative research a small number of samples is selected to get in-depth information rather than selecting large numbers with less detailed information (Creswell and Clark, 2007). A total of 60 oral history interviews were conducted across the three communities (Table 11). The household heads found to be most cooperative and enthusiastic during structured household questionnaires were selected from each cluster for oral history interviews. The number of interviews in each household cluster was calculated based on the proportion of households in each cluster, with a minimum of three from each cluster (except one smaller cluster). However, in a few cases, if it was felt that new information was still likely to be forthcoming, then more interviews were conducted.

The interviews were undertaken in the respondent's home. This is due to the fact that the location of the interview is important as it can have an effect on the power relationship between the researcher and the participants. The interview site itself can produce micro-geographies and provides a material space for the enactment and constitution of power relations (Elwood and Martin, 2000). The presence of uninvited members of the household or community can also affect the responses, as the respondent might be affected by pre-existing power relationships and interactions (Valentine, 1999). Thus, interviews were not conducted in public meeting places or in the presence of other individuals (except in a very few unavoidable cases). Interviewing at the respondents home was also viewed as private and it was therefore felt that respondents would feel more comfortable in such a setting.

I was the interviewer for all the oral history interviews and no research assistant was used. The oral history interviews were unstructured using open ended questions. There was a need to go back and forth and to ask participants follow up questions focussing on

the aim and objectives of this research. Research assistants were not able to deal with such complexities.

This study focussed on vulnerability and adaptation related to climatic issues. It was thought that when collecting the data it would be difficult to separate respondents' responses related to climatic issues from non-climatic ones. Thomas et al. (2007) have managed to tackle this issue by separating responses for climatic factors. They studied rainfall variability and its recognition and response by the farmers of South Africa. However, they did not ask climate related questions to the communities initially. Instead, they started questions with wider themes including environmental risk, uncertainty and food security. They introduced climate issues into questioning when raised by respondents or in the later stages of the process when different climate characteristics were considered. This study followed their methods.

### **3.3.3 Vulnerability matrices**

In this study two participatory methods – vulnerability matrix and FGD – are used. Vulnerability matrix is a participatory vulnerability assessment tool which falls under the participatory rural appraisal (PRA). Rural appraisal techniques are used to generate community scale information directly from the community members and can also be used to deepen the researcher's understanding of a specific topic (Mosse, 1994). The researchers do not “dominate or lecture – they facilitate, sit down, listen and learn” (Chambers, 1997, p. 103). The information generated by PRA can also be compared to and combined with other data obtained, for example, from interviews and questionnaires (Chambers, 1994). On the other hand, active involvement of local people in this type of participatory process can be helpful for themselves as well, such as through stimulation of their social action or change (Ziervogel and Calder, 2003).

In the vulnerability matrices a group of 6-8 (fewer for a smaller cluster) enthusiastic and cooperative heads of households in each household cluster participated to rank and elucidate how their livelihoods were vulnerable to several factors. For vulnerability matrices this research used the methodology developed by CARE (2009) and adapted to the local context. For each session, a matrix was prepared on a black board. The group was then asked to identify five resources that were most important for their livelihoods. These priority resources were listed down the left side of the matrix on the vertical.

Then they were asked to identify the greatest shocks or stresses to their livelihoods (the discussion was not limited to only climate-related shocks or stresses, but if the participants were not identifying climatic ones, they were prompted). The five most important shocks or stresses were listed horizontally across the top of the matrix. The group was then asked to score the level of impact on livelihoods resources (score: 3 = significant impact on the resource, 2 = medium impact on the resource, 1 = low impact on the resource, 0 = no impact on the resource). While coming to a consensus on the scores, the participants explained how the scores differed. After completing the matrix, the group was asked to further explain the impacts related to climate shocks and stresses, how they were responding those, how those responses were facilitated or limited and how those responses could be improved or new responses could be adopted.

Participatory methods are often criticised as time consuming and expensive. There are also other criticisms – such as risk of empowering existing social power allowing certain participants to have more or less influence (Cooke and Kothari, 2001), and limitation in generalizability from context-specific information (Martin and Sherington, 1997). These challenges were kept in mind and addressed while conducting vulnerability matrices. After preparing the matrices the discussion sessions were more focussed on the issues relevant to the objectives of the research and digressions by participants were kept as minimal as possible. Rapport building with the participants and knowing existing social pressure and culture helped to run the sessions smoothly. Disagreements within a group were used to encourage participants to explain their point of view (Kitzinger, 1994) but any attack was interrupted (CARE, 2009). Efforts were made to encourage all participants to share their views equally. The quieter participants were especially encouraged and they were given more time to express their opinions; the participants who wanted to influence more were controlled.

For both the participatory methods, places considered neutral to the participants were selected (Powell and Single, 1996). This neutrality means that places had no significance to the participants and no bearing on the subject under study (Powell and Single, 1996). It was also ensured that meeting places were comfortable and that the participants sat in a way so that they could see and hear each other clearly.

### **3.3.4 Focus group discussions (FGD)**

FGD is also a participatory method of data collection, which has become increasingly popular as a qualitative research method in social science (Burgess, 1996; Goss, 1996; Longhurst, 2003). Like other participatory methods, a key characteristic of FGD is the interaction between the participants. The stories that are shaped in FGDs better reflect the social nature of knowledge than a collection of individual accounts obtained from individual interviews (Goss and Leinbach, 1996). However, being a participatory method, FGD has some potential drawbacks which were addressed during data collection in a similar manner as for the vulnerability matrix (see above – section 3.3.3).

FGDs were conducted in two stages for this study – during the reconnaissance study and the main data collection. During the reconnaissance study, the goals of FGDs were to develop the research objectives and methodology by exploring the research context and issues as well as getting to know the study area and people. Then during the main data collection period, the FGDs were conducted to gather the data on livelihood vulnerability, coping and adaptation related to climate variability and change. A list of topics and possible questions for the participants were developed before the start of the FGDs to ensure some structure and direction in the discussions. More emphasis was given to clarifying issues which seemed unclear from the oral history interviews and vulnerability matrices. Each FGD session ran for about 3 hours and 5-8 issues were discussed. At the end of each FGD session, the participants were also asked to assign scores to some indicators of vulnerability (see Table 12 and section 4.3.2).

For an FGD, a group of 8-10 (Powell and Single, 1996) household heads were selected from each of the household clusters within a particular community (fewer for a smaller cluster). This ensured a grouping of relatively homogenous households in each FGD where participants were able to freely express their opinions. In Kutubdia Island an additional FGD was also conducted with the heads of women-headed households as this island has comparatively higher proportion of women-headed households and it was thought that gender might have consequences for their vulnerability and adaptation. The household heads who participated in vulnerability matrices were not included here (except in the smaller clusters). Instead, new heads within the same cluster were selected so as to cover more diverse opinions. The household heads, who had experience of central phenomena or were thought to be able to explore the key concepts,

were selected (Creswell and Clark, 2007). In addition, household heads who were found to be cooperative and enthusiastic during structured household questionnaires were selected. Overall the FGD sessions were run ensuring that the focus was kept, momentum maintained and that there was real participation and closure on questions (Coldwell and Herbst, 2004).

### **3.3.5 Key informant interviews**

Key informant interviews were conducted at two stages for this study – during the reconnaissance study and at the later stage of main data collection. The key informants included individuals inside and outside the communities. From inside the communities, community leaders (e.g., the local commissioner) and community members who were knowledgeable about the issues for this study were selected. Whereas, from outside the communities, government officials (e.g., the district fisheries officer), NGOs/development organisations' officials who were directly associated with the communities' interest and researchers were selected.

During the reconnaissance study, the goals of key informant interviews were to develop the research objectives and methodology by exploring the research context and issues, becoming acquainted with the study area and people, and researching the sources of secondary information. During the main data collection the goals of key informant interviews were to collect data on the issues in the research objectives or issues raised by respondents during the other data collection methods (e.g., if respondents mentioned any significant role of a local commissioner in the adaptation process, that specific commissioner was interviewed). Key informant interviews were therefore conducted at a later stage of the main data collection.

A total of 10 and 21 key informant interviews were conducted during the reconnaissance study and the main data collection respectively (Table 11). Key informant interviews were conducted following individual interview guidelines which were consistent with the oral history interviews described in section 3.3.2.

### **3.3.6 Positionality**

Positionality is another important issue during the data collection process. Collection of data from the field involves interaction between the researcher and the respondents. The



way the respondents treat the researcher is therefore important, as it can affect the quality of the data and therefore the entire research process. Due to this, it is important for the researcher to be aware that his/her own identity and positionality will shape the interaction between the researcher and the respondent(s) (England, 1994; Twyman et al., 1999). Race, class, family status, ethnicity and other social identities shape relationships between the researcher and the participants (Gilbert, 1994). In my case I was in an advantageous position as I am from a similar ethnic, cultural and language background to the respondents of this study but not exactly from the same locality. I chose research assistants, who conducted two thirds of the structured household questionnaires and helped me during vulnerability matrices and FGDs, from similar cultural, ethnic and language backgrounds as the respondents but not from the study communities. The research assistants were trained as to the importance of positionality for research. In this way, good communication between researchers and participants was ensured, while any pre-existing personal relationships that could have affected the outcome of the data were avoided.

Gender is another factor that can affect the quality of data collected (McNay, 2003). For this study the respondents (household heads) are usually male. Both the researcher and research assistants are also male. Gender of the researcher and research assistants has impacted little on the data collection as only two percent each for Padma and Kutubdia Para and ten percent for Kutubdia Island were female respondents. These women were largely comfortable during data collection, although on Kutubdia Island some of them wore hijabs.

### **3.3.7 Ethical considerations**

This study was approved by the University of Leeds Ethics Review Committee (Ref. No. AREA 09-134) before collecting data. The ethical considerations were necessary to safeguard research participants, the research process and the credibility of the research findings (Flick, 2009). Broadly, two main ethical issues were considered – participants' consent and confidentiality of data. Consent was taken from each participant before collecting data. Before taking consents, participants were given information sheets that sufficiently explained the purpose and the nature of this study. They were assured that the information would be used for research purposes only and they were given the opportunity to ask questions before signing the consent form. They were recruited

voluntarily, were not compensated and their names were not revealed. They also had the option to withdraw from the research at any time. To comply with confidentiality, the data (both hard and electronic copies) were not shared with anyone except the research team. Electronic data were stored on encrypted memory sticks and password protected computers for the short period before being transferred onto the 'M' or 'Z' drive of the University of Leeds IT system. Participants were assured that their names would always be kept anonymous.

### **3.4 Data Analysis**

#### **3.4.1 Quantitative data analysis**

Quantitative data were analysed in two stages – after finishing the collection of structured household questionnaires data and after finishing all data collection. During the first stage, cluster analysis of the households was conducted and during the second stage composite vulnerability indices, normalisation, Spearman's rank correlation, t-test, z-test, ANOVA and descriptive statistics were carried out. Cluster analysis is described here in detail but other methods are detailed in the later chapters (Chapters 4, 5 and 6).

##### *3.4.1.1 Cluster analysis*

To classify the households in each community in order to better inform qualitative data collection processes, cluster analysis was performed using SPSS software. Principal component analysis (PCA) contributed to this process to reduce redundancy in the data. Cluster analysis was performed using 19 variables (Table 12). These variables reflect households' livelihood characteristics, notably their dependence on fisheries and adaptive capacity. Section 4.3.2 describes the role of these variables on climate change vulnerability and adaptation.

Table 12. Variables used for cluster analysis across the three communities.

<i>Variables</i>	<i>Explanation of the variables</i>
Time involvement in fisheries (days/year)	Number of days a household was involved in fisheries in last year
Income from fisheries (%)	Percentage of a household income from fisheries sector in last year
Nutrients uptake from fish or seafood (kg/month)	Amount (per capita) of fish and seafood a household consumed in last year (kg/month)
Number of adult workforce	Number of individuals aged 14-60 in a household
Presence of non-elderly household head	Whether a household head is <50 years old or not
Experience of household head (years)	Experience of a household head in fisheries-related activities (years)
Highest level of education (years of schooling)	Highest years of schooling of any member of a household
Physical fitness of household head (days/year)	Number of days a year a household head remains physically fit to carry out livelihood activities
Presence of male headed household	Whether a household head is male or not
Index of quality of house	Aggregate index of a household's quality of house <sup>a</sup>
Number of fisheries materials	Number of types of fisheries related materials (boats, nets etc.) of a household
Index of use of technology	Aggregate index of a household's use of technology <sup>b</sup>
Index of natural capital	Aggregate index of a household's natural capital <sup>c</sup>
Ownership of jewellery	Whether a household owns jewellery (such as gold) or not
Having stored food	Whether a household has stored food (such as rice) or not
Per capita income (TK/ year)	Per capita income of a household (TK/year) <sup>d</sup>
Index of social capital	Aggregate index of a household's social capital <sup>e</sup>
Number of income generating activities	Number of income generating activities per household
Index of distance from services	Aggregate index of distance (time) of a household's house from services <sup>f</sup>

<sup>a</sup>Calculated as sum of household scores (i.e. 0=insufficient, 1=moderate, 2=good), based on 4 variables: availability of rooms per adult equivalent (0=less than 0.5 rooms per adult equivalent, 1=0.5-1 per adult equivalent, 2=>1 per adult equivalent), quality of outside walls (0=non-cemented material or without corrugated tin, 1=corrugated tin, 2=cement and brick casting/concrete), quality of roof (0=leaves/straw/tile, 1=corrugated tin, 2=concrete) and quality of floor (0=dirt, 1=brick/wood with non-cemented material, 2=concrete). Index ranges between 0 and 8. The scores on different variables were agreed by the household heads of this study during the FGDs.

<sup>b</sup>Calculated as sum of household scores (no=0, yes=1), based on the 6 variables: sanitary toilet, phone, radio/television, solar/electricity for energy, safe drinking water source, ownership of transportation. Index ranges between 0 and 6.

<sup>c</sup>Calculated as sum of household scores (no=0, yes=1), based on the 2 variables: possession of land and trees. Index ranges between 0 and 2.

<sup>d</sup>Per capita yearly income of a household was calculated by taking the total yearly household income (excluding own consumption of fish or other products and deducting business expenses or operating expenses) divided by the total number of family members in the household. The Bangladeshi currency Taka is abbreviated as TK. During data collection the conversion rate was TK76 = US\$1.

<sup>e</sup>Calculated as sum of household scores (no=0, yes=1), based on 13 variables: having relatives in the village, getting support from relatives in the village, having relatives outside the village, getting support from relatives outside the village, having contacts other than relatives inside the village, getting support from contacts other than relatives inside the village, having contacts other than relatives outside the village, getting support from contacts other than relatives outside the village, having membership with a community organisation, getting support from community organisation, having political party membership, getting support from political parties, and ability to cast vote in elections. Index ranges between 0 and 13.

<sup>f</sup>Calculated as sum of household scores (i.e. 0=insufficient, 1=moderate, 2=good), based on 7 variables: time needed to reach the nearest cyclone shelter (0=>10 minutes, 1=3-10 minutes, 2=<3 minutes), drinking water source (0=>15minutes, 1=5-15minutes, 2=<5minutes), market (0=>30 minutes, 1=10-30 minutes, 2=<10 minutes), disaster office (0=>45 minutes, 1=20-45 minutes, 2=<20 minutes), government offices (0 =>45minutes, 1=20-45 minutes, 2=<20 minutes), hospital/clinic (0=>30 minutes, 1=10-30 minutes, 2=<10 minutes), and time needed to reach the nearest educational institution (0=>20 minutes, 1=10-20 minutes, 2=<10 minutes). Index ranges between 0 and 14; lower value means more distance. The scores on different variables were agreed by the household heads of this study during the FGDs.

For the cluster analysis, the variables comparable between all the households were selected. Cluster analysis and PCA are also sensitive to the types of data that can be used. Interval and ratio scale data are often preferred. In addition, symmetric binary data (eg., yes/no type answer) can be regarded as interval data (Kaufman and Rousseeuw, 2005), where yes and no refer to two completely different meanings with nothing in common between them (Kaufman and Rousseeuw, 2005, p. 33). These type of binary data have also been used in cluster analysis and PCA by others such as Jansen et al. (2006a). Thus, for this study, only the types of data mentioned above were used for the cluster analysis and PCA.

PCA was used to create a new set of variables (i.e. principal component scores) which captured the character of the original variables in a condensed way by reducing the number of variables with a minimum loss of information (Hair et al., 1998). This method of replacement also solved the problem of high correlations between the original variables (Hair et al., 1998). The acceptable level of inter-correlations between the variables was confirmed by Bartlett's test of sphericity that indicates the presence of nonzero correlations between variables (Hair et al., 1998). The test found the correlation matrix is significantly different from the identity matrix (for Padma approx. Chi-Square = 339.89,  $df = 153$ ,  $p < 0.0001$ ; for Kutubdia Para approx. Chi-Square = 508.37,  $df = 171$ ,  $p < 0.0001$ ; and for Kutubdia Island approx. Chi-Square = 783.24,  $df = 171$ ,  $p < 0.0001$ ). The appropriateness of the PCA was also assessed by the Kaiser–Meyer–Olkin measure of sampling adequacy that looks into both correlations and pattern between the variables (Hair et al., 1998). This adequacy was identified as 0.648 for Padma, 0.699 for Kutubdia Para, and 0.697 for Kutubdia Island, all of which are within the acceptable range of above 0.50 (Hair et al., 1998). All the components having eigenvalues of less than 1 (latent root criterion) were rejected. The interpretation of the components was enhanced by an orthogonal rotation (VARIMAX method).

The PCA formed the basis of the cluster analysis. The principal component scores were used as input variables in the cluster analysis. This means that only the variables which are mutually independent (confirmed by the orthogonal VARIMAX rotation) were included in the cluster analysis. With this procedure, the problem of multi-collinearity (Hair et al., 1998) and arbitrary scale effects (Jansen et al., 2006b) which may alter the cluster analysis is avoided. This study used Ward's (hierarchical) clustering method,

based on squared Euclidean distances (Aldenderfer and Blashfield, 1984). The principle was that the cluster analysis identified different household groups which are characterised by maximum intra-group homogeneity and inter-group heterogeneity.

Since the cluster analysis informed further data collection methods, especially to ensure representative sampling taking into account the diversity of the households' characteristics, the *results of cluster analysis* are presented next rather than in a separate results chapter.

#### **3.4.1.1.1 Results of cluster analysis**

##### Household clusters within Padma

The cluster analysis produced 5 household clusters (also can be termed as “classes” or “groups”) for Padma (Table 13). Households in cluster 1 – the largest cluster (56% of the total households of Padma) – have the lowest number in the adult workforce and income generating activities, and the lowest levels of education. They are all male headed households and own jewellery, but they have lower (albeit not the lowest) amount of per capita income.

Households in cluster 2 have the lowest quality of house, number of fisheries materials, use of technology, levels of natural capital and percentage of households owning jewellery. However, all the households are headed by non-elderly males and the households need least amount of time to reach services indicating their better access to services.

Households in cluster 3 have the least time involvement in fisheries and proportion of income from fisheries, notwithstanding they have the highest levels of nutrient uptake from fish. They have the highest percentage of non-elderly household heads, levels of physical fitness of household heads, percentage of male headed households, levels of natural capital, percentage of households owning jewellery and number of income generating activities. However, they need the highest amount of time to reach services indicating their lesser access to services.

Households in cluster 4 have the highest amount of time involvement in and levels of income from fisheries. They also have the greatest experience in fisheries and highest percentage of male headed households, quality of house, number of fisheries materials, use of technology, percentage of households owning jewellery, percentage of households having stored food and levels of social capital. Their income levels are also the highest, more than three times higher than the second highest group of households in cluster 3. However, they have lowest percentage of non-elderly household heads.

Households in Cluster 5 – the smallest cluster (2% of the total households in Padma) – have the lowest levels of nutrient uptake from fish. They have the lowest experience in fisheries, levels of physical fitness of household heads, percentage of male headed households (all are female headed), percentage of households having stored food, levels of social capital and amount of per capita income. However, they have the highest percentage of non-elderly household heads, levels of education and percentage of households owning jewellery.

Table 13. Livelihood characteristics of different household clusters of Padma. Values represent either mean or percentage for a variable.

<i>Clusters</i>	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>	<i>Cluster 4</i>	<i>Cluster 5</i>
Percentage of households in each cluster	56	7	21	14	2
Time involvement in fisheries (days/year)	199	198	179	221	180
Income from fisheries (%)	92.77	86.60	67.94	98.36	94.04
Nutrients uptake from fish or seafood (kg/month)	1.78	1.64	2.86	2.40	0.48
Number of adult workforce	2.48	2.71	3.38	3.29	3.50
Percentage of non-elderly household heads	96.40	100	100	71.40	100
Experience of household head (years)	12.29	14.71	17.10	20.71	11.50
Highest level of education (years of schooling)	6.36	6.71	7.86	6.43	8.00
Physical fitness of household head (days/year)	318	324	338	320	285
Percentage of male headed households	100	100	100	100	0.00
Index of quality of house (higher value means better quality)	2.48	2.43	3.43	4.21	2.50
Number of fisheries materials	0.32	0.00	0.48	1.86	1.00
Index of use of technology (higher value means more use of technology)	1.55	1.43	2.76	3.50	3.00
Index of natural capital (higher value means more natural capital)	1.82	1.43	2.33	1.93	1.50
Percentage of households owning jewellery	100	0.00	100	100	100
Percentage of households having stored food	12.50	28.60	47.60	57.10	0.00
Per capita income (TK/ year)	12,295	12,712	18,605	63,123	11,690
Index of social capital (higher value means more social capital)	7.52	7.14	7.71	8.57	7.00
Number of income generating activities	2.20	2.86	3.48	2.64	3.00
Index of distance from services (higher value means less distance)	6.32	7.43	5.95	6.64	6.00

#### Household clusters within Kutubdia Para

The cluster analysis produced 4 household clusters for Kutubdia Para (Table 14). Households in cluster 1 have the highest levels of nutrient uptake from fish. They also have the highest percentage of non-elderly household heads, levels of education and physical fitness of household heads, percentage of male headed households, quality of house, number of fisheries materials, use of technology, percentage of households owning jewellery, percentage of households having stored food, amount of per capita income and levels of social capital, and lowest distance from services. However, they have the lowest experience in fisheries and number of income generating activities.

Table 14. Livelihood characteristics of different household clusters of Kutubdia Para. Values represent either mean or percentage for a variable.

<i>Clusters</i>	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>	<i>Cluster 4</i>
Percentage of households in each cluster	26	17	48	9
Time involvement in fisheries (days/year)	218	191	224	215
Income from fisheries (%)	96.42	72.11	95.85	99.90
Nutrients uptake from fish or seafood (kg/month)	3.39	2.72	2.73	2.65
Number of adult workforce	3.92	4.59	3.04	3.44
Percentage of non-elderly household heads	100	94.10	83.30	88.90
Experience of household head (years)	16.00	16.06	16.60	16.11
Highest level of education (years of schooling)	8.88	8.35	5.42	5.67
Physical fitness of household head (days/year)	349	309	349	345
Percentage of male headed households	100	100	100	66.70
Index of quality of house (higher value means better quality)	3.42	1.59	1.59	1.33
Number of fisheries materials	0.81	0.12	0.13	0.22
Index of use of technology (higher value means more use of technology)	4.31	3.18	2.08	2.11
Index of natural capital (higher value means more natural capital)	1.81	1.88	1.63	1.33
Percentage of households owning jewellery	100	100	100	22.2
Percentage of households having stored food	26.90	5.90	2.10	11.10
Per capita income (TK/ year)	79,540	21,344	17,677	17,551
Index of social capital (higher value means more social capital)	10.62	9.59	8.83	8.33
Number of income generating activities	1.50	2.12	1.71	1.78
Index of distance from services (higher value means less distance)	7.23	6.71	5.42	6.00

Households in cluster 2 have the lowest amount of time involvement in and income from fisheries. They also have the highest number of adult workforce, percentage of male headed households, percentage of households owning jewellery and number of income generating activities. However, they have the lowest levels of physical fitness of household heads, number of fisheries materials and levels of natural capital.

Households in cluster 3 have the lowest amount of time involvement in fisheries. They also have the lowest number in the adult workforce, percentage of non-elderly household heads, levels of education, use of technology and percentage of households having stored food, and highest distance from services. However, they have the greatest experience in fisheries, levels of physical fitness of household heads, percentage of male headed households, and percentage of households owning jewellery.

Households in cluster 4 have the highest percentage of income from fisheries but the lowest levels of nutrient uptake from fish. They also have the lowest percentage of male



headed households, quality of house, percentage of households owning jewellery, amount of per capita income and levels of social capital. However they have the highest levels of natural capital.

#### Household clusters within Kutubdia Island

The cluster analysis produced 3 very distinct household clusters for Kutubdia Island (Table 15). Households in cluster 1 have the lowest amount of time involvement and income, and levels of nutrient uptake from fisheries. They also have the lowest levels of all other variables except the percentage of non-elderly household heads, experience of household heads and number of income generating activities.

Table 15. Livelihood characteristics of different household clusters of Kutubdia Island. Values represent either mean or percentage for a variable.

<i>Clusters</i>	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>
Percentage of households in each cluster	44	42	14
Time involvement in fisheries (days/year)	86	199	124
Income from fisheries (%)	32.58	83.09	46.24
Nutrients uptake from fish or seafood (kg/month)	0.58	1.06	1.76
Number of adult workforce	2.23	3.33	7.00
Percentage of non-elderly household heads	59.10	95.20	57.10
Experience of household head (years)	15.91	12.90	19.14
Highest level of education (years of schooling)	4.00	7.29	13.14
Physical fitness of household head (days/year)	309	338	327
Percentage of male headed households	77.3	100	100
Index of quality of house (higher value means better quality)	1.09	1.33	2.64
Number of fisheries materials	0.00	0.00	1.57
Index of use of technology (higher value means more use of technology)	0.73	2.24	4.43
Index of natural capital (higher value means more natural capital)	0.73	1.81	2.43
Percentage of households owning jewellery	27.30	85.70	100
Percentage of households having stored food	0.00	0.00	71.40
Per capita income (TK/ year)	9,445	15,533	42,124
Index of social capital (higher value means more social capital)	8.68	9.10	10.29
Number of income generating activities	2.59	2.57	4.00
Index of distance from services (higher value means less distance)	3.00	8.33	9.43

Households in cluster 2 have the highest amount of time involvement and income from fisheries. They also have the lowest experience in fisheries, number of fisheries materials, percentage of households having stored food and number of income generating activities. However, they have the highest percentage of non-elderly

household heads, levels of physical fitness of household head and percentage of male headed households.

Households in cluster 3 have the lowest levels of nutrient uptake from fish. They also have the highest level of all other variables except the percentage of non-elderly household heads and levels of physical fitness of household heads.

### **3.4.2 Qualitative data analysis**

The qualitative data – oral history interviews, vulnerability matrices, FGDs and key informant interviews – were audio recorded, except the two key informant interviews that were hand written soon after the interviews, as recording was not permitted. The responses of the open ended questions of the structured household questionnaires were hand written on the questionnaires. The recorded data were transcribed in the original language (Bengali). Three quarters of the records were transcribed by a research assistant while others were transcribed by me. In addition, I heard all the recorded audios at least once to check any confusion, which increased reliability of data.

The qualitative data were analysed using the modified grounded theory approach. Literature review (and reconnaissance study and researcher's own experience about the phenomena under study) allowed possible predetermined categories (themes) of empirical data before analysing them (a priori approach) (Strauss, 1987). During the different steps of analysis, these categories were revised based on the themes that arose from the data (grounded theory approach) (Strauss and Corbin, 1990). Content analysis technique (cf. Miles and Huberman, 1994) was used to analyse the qualitative data before translation. Selected quotes were translated into English at the later stage of writing the chapters.

Analysis of qualitative data consisted of three steps: preparing and organising the data for analysis, reducing the data into themes through a process of coding and condensing the codes, and finally representing the data in tables or as part of a discussion (Creswell, 2007: 148). When all the transcripts were ready, codes were levelled on the text to assign units of meaning (Miles and Huberman, 1994). Pencils and highlighters of different colours were used for this purpose. Codes were attached to “chunks” of varying size – words, phrases, sentences or whole paragraphs of interest (Miles and

Huberman, 1994). In the coding process it was kept in mind that not the words themselves but their meaning matters (Miles and Huberman, 1994).

These codes were then condensed (development of subthemes and themes) where evidences were grouped and ideas were labelled so that they reflected increasingly broader perspectives in a process of sense-making (Creswell and Clark, 2007). Subthemes and themes were identified by the scrutiny techniques developed by Ryan and Bernard (2003): looking for repetitions, indigenous typologies, metaphors and analogies, transitions, similarities and differences and linguistic connectors. Reducing the data into themes further included sorting themes into a manageable few (i.e., deciding which themes are important to fulfil each objective), building a hierarchy of themes, and linking themes into theory (Ryan and Bernard, 2003).

I did all the coding myself and no coder was used, increasing the reliability of the data. Mixing of quantitative and qualitative data was done either by connecting two datasets (building one dataset on the other) or embedding (one dataset within the other where one type of data provides a supportive role for the other) (Creswell and Clark, 2007, p. 7). After finishing the analysis, the results were checked again with the original transcripts to ensure further reliability.

### **3.5 Conclusions**

This chapter has described the research design and methodology. It highlights methodological approaches including suitability of the case-study approach for this research. It also describes the study context and justifies the site selection process. Methods used for data collection have been described, including reflection upon their strengths and limitations. Issues such as positionality of the researcher and ethical considerations have also been considered. The various techniques of quantitative data analysis have been mentioned and cluster analysis has been described in detail. The qualitative data analysis technique has also been described in detail. Throughout this chapter reliability and validity, or trustworthiness, rigor and quality of this research have been considered. The next three chapters (Chapters 4 – 6) present the results of this thesis obtained during the processes described throughout this chapter.

## **Chapter 4 – Vulnerability of Fishery-Based Livelihoods to Climate Variability and Change**

### **Summary**

Globally, fisheries support livelihoods of over half a billion people who are exposed to multiple climatic stresses and shocks. Yet only limited research exists on the vulnerability of fishery-based livelihood systems to climate change. This chapter assesses the vulnerability of fishery-based livelihoods to the impacts of climate variability and change in two coastal fishing communities in Bangladesh (Objective 1). This chapter uses a composite index approach to calculate livelihood vulnerability and qualitative methods to understand how exposure, sensitivity, and adaptive capacity measured by sub-indices produce vulnerability. The results suggest that exposure to floods and cyclones; sensitivity (such as dependence on small-scale marine fisheries for livelihoods); and lack of adaptive capacity in terms of physical, natural and financial capital and diverse livelihood strategies construe livelihood vulnerability in different ways depending on the context. The most exposed community is not necessarily the most sensitive or least able to adapt because livelihood vulnerability is a result of combined but unequal influences of bio-physical and socio-economic characteristics of communities and households. But within a fishing community, where households are similarly exposed, higher sensitivity and lower adaptive capacity combine to create higher vulnerability. Initiatives to reduce livelihood vulnerability should be correspondingly multifaceted.

### **4.1 Introduction**

Fisheries support the livelihoods of about 660 – 820 million people, globally (FAO, 2012). Many of the people dependent on small-scale fisheries live in developing countries and face climatic shocks and stresses such as cyclones, floods, droughts, sea level rise, land erosion, and temperature and rainfall fluctuations (IPCC, 2007a). While few positive impacts on fisheries have also been reported, such as increased nutrient production in high latitude (Brander, 2010), seasonal increase in growth of rainbow trout (Morgan et al., 2001) and reduced cold-water mortalities of some aquatic animals (IPCC, 2007a), most of the impacts of climate change are overwhelmingly negative

(IPCC, 2007a). Climate change will tend to exacerbate non-climatic pressures on fisheries such as overfishing, pollution, and loss of habitat (Brander, 2006; Sumaila et al., 2011). Increasing temperatures, altered precipitation patterns, sea level rise, ocean acidification, and changes in dissolved oxygen concentration all affect the structure and productivity of marine and coastal ecosystems and fish populations (IPCC, 2007a; Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010; Johannessen and Miles, 2011). These impacts have already extended to fishery-dependent people in some regions (Perry et al., 2009). Extreme weather events such as cyclones and floods may further intensify these impacts by disrupting fishing operations and land-based infrastructure (Westlund et al., 2007). The land-based assets can also be deteriorated by sea level rise, land erosion, and variations in temperature and rainfall. These impacts may result in vulnerability of fishery-dependent livelihoods (Sarch and Allison, 2000; Coulthard, 2008; Iwasaki et al., 2009; Perry et al., 2009). Small-scale fishing communities are considered especially vulnerable to the negative impacts of climate variability and change (Downing et al., 1997; Dixon et al., 2003; IPCC, 2007a).

Examining the vulnerability of fishing communities and households to climate variability and change can help identify and characterise actions that can ameliorate adverse impacts. Despite its importance, knowledge of climate-induced impacts and vulnerability on the local scale of fishery-based livelihoods remains limited. Most studies have focused either on national scale of vulnerability of fisheries systems (e.g., Allison et al., 2009b; Quest-Fish, Undated) or of agricultural livelihoods (e.g., Vincent, 2007; Eakin and Bojórquez-Tapia, 2008; Paavola, 2008; Sissoko et al., 2011).

The objective of this chapter is to assess the vulnerability of fishery-based livelihoods to the impacts of climate variability and change in two coastal fishing communities and their households in Bangladesh (Objective 1). Bangladesh is chosen because this country, including its fisheries sector, is considered a hot spot of societal vulnerability to climate change (IPCC, 2007a; Yu et al., 2010b; Maplecroft, 2011). The marine fisheries sector in Bangladesh supports livelihoods of over half a million fishers, and their household members (DoF, 2012).

In what follows, section 4.2 reviews the exiting literature on vulnerability of fishery-based livelihoods to climate variability and change. Section 4.3 describes the case study,

materials and methods. Section 4.4 presents the results of this chapter. Section 4.5 provides discussions and finally section 4.6 concludes by highlighting the main findings and policy implications.

## **4.2 Fishery-Based Livelihoods and Vulnerability to Climate Variability and Change**

While a more general literature review related to the aim of this research has been outlined in Chapter 2, this section is devoted to a more focussed review relating to Objective 1. This section reviews the most up-to-date literature on climate change, vulnerability and fishery-based livelihoods, to outline the state-of-art, identify gaps and weaknesses in the literature and to identify possible areas of contribution for this chapter. In particular, this section reviews how climatic and socio-economic factors can shape vulnerability in fishery-based livelihood systems by impacting on livelihood assets, strategies and outcomes. This section further shows the scarcity of evidence based studies on vulnerability assessment in fishery-based livelihood systems related to climate variability and change.

Vulnerability of fishery-based livelihoods to climate variability and change can be defined as the degree to which a fishery-based livelihood system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (adapted from IPCC, 2007a, p. 883). Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a fishery-based livelihood system is exposed, its sensitivity, and its adaptive capacity (adapted from IPCC, 2007a, p. 883). Livelihoods can in turn be defined as “the capabilities, assets (stores, resources, claims and access) and activities required for a means of living” (Chambers and Conway, 1992, p. 6). Therefore, to assess livelihood vulnerability it is necessary to understand how components of vulnerability and fishery-based livelihoods interact.

The SLA, described in Chapter 2, can help assess livelihood vulnerability by highlighting how climate variability and change affect the vulnerability context, the asset base, and transforming structures and processes (Adato and Meinzen-Dick, 2002; Elasha et al., 2005; Badjeck et al., 2010). The asset base – human, physical, natural, financial and social capital – forms the building block of livelihoods and helps reduce

vulnerability (Daw et al., 2009; Badjeck et al., 2010). These assets are mediated by the vulnerability context (trends, shocks and seasonality), and transforming structures and processes. The transforming structures or processes include institutions such as laws, social relations and formal organisations (government agencies, NGOs, and private organisations) and related policies. Together these factors shape access to livelihood assets, livelihood strategies, and ultimately livelihood outcomes (Bebbington, 1999).

A combination of bio-physical and socio-economic factors shape the vulnerability of natural resource-based livelihood systems (e.g., Paavola, 2008; Sallu et al., 2010). In developing countries, rural people living in coastal zones depend on climate sensitive occupations such as fishing, agriculture, and forestry. In a small-scale fishing community, households are involved in fishery-related activities such as fishing, post-harvest fish processing, fish trading, and making and mending of fishing materials (OECD, 2001). They are served with limited physical infrastructure and often lack access to basic services such as education, health care, water, credit, and insurance (Olago et al., 2007; Iwasaki et al., 2009; MRAG, Undated).

Fishing is a high risk livelihood activity and unpredictable business (Coulthard, 2009). It is because of “the fugitive nature of the resource, the hostile environment of the seas, and perishability of the product” (MRAG, Undated, p. 3). One direct impact of climatic shocks, such as cyclones and floods, is loss of life. Climatic shocks have killed several hundred thousand people in coastal Bangladesh, many of them fishermen or their household members, friends, or relatives (IPCC, 2007a). Other impacts include physical injuries (Badjeck et al., 2010) and health effects (Kovats et al., 2003). Cyclones and floods also damage boats, nets, fishing gear, and fish landing centres, as well as educational, health, housing and other community infrastructure (Jallow et al., 1999; Adger et al., 2005b; Westlund et al., 2007).

Fish productivity, abundance, and distribution are also likely to be impacted by climate change (IPCC, 2007a; Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010), which may increase the cost of accessing fish catch (Badjeck et al., 2010). Fish processing costs may also increase; traditional fish drying is sensitive to variations in temperature and rainfall. Impacts on catch and processing will ultimately influence

employment, income, and nutrition of fishery-dependent households and communities through changes in local institutions and resource management (Badjeck et al., 2010).

For the above discussed reasons, climate variability and change importantly influences economic return from livelihood strategies. This in turn can impact on the vulnerability and adaptive capacity of households and communities. But all households within a community are not equally vulnerable; they may be differentially affected by climate variability and change on the basis of their level of adaptive capacity (Adger, 2003; Smit and Wandel, 2006) and sensitivity, which relates to their livelihood assets and strategies. Roncoli et al. (2001) found that poorer households are often less able to adapt. Coulthard (2008), however, considers in her study in a South-Indian lagoon, that fishers who have become locked into an overly specialised fishery are less able to adapt than the poorest.

Since climate change will impact on fishery-based livelihood systems in different ways, it is necessary to conduct more in-depth studies on vulnerability. Whilst a number of studies have investigated the impact of climate change on the vulnerability and adaptive capacity of the fisheries sector at the national scale (e.g., Allison et al., 2009b; Quest-Fish, Undated), little research has examined the impacts of climate variability and change on the livelihoods of small-scale fishing communities and households in developing countries, particularly in Bangladesh. National scale studies cannot provide specific enough findings applicable to the household or community scale (Hahn et al., 2009) and at the local scale vulnerability assessments of agricultural livelihood systems dominate (e.g., Vincent, 2007; Eakin and Bojórquez-Tapia, 2008; Paavola, 2008; Sissoko et al., 2011; Antwi-Agyei et al., 2012a). As the vulnerability of an agricultural livelihood system is different from that of fishery-based one, implications for vulnerability of one livelihood system to another is not necessarily transferable; more work is required in fishery-based systems. This chapter aims to fill this gap in understanding for one highly vulnerable region of the world.

However, determining the degree of livelihood vulnerability at the local scale is very difficult (Eakin and Luers, 2006) because of methodological challenges, detailed in Chapter 2 (section 2.6). To address these challenges, this chapter follows an integrated quantitative-qualitative approach to livelihood vulnerability assessment, described next.



## **4.3 Case Study, Materials and Methods**

### **4.3.1 Case study**

This chapter assesses livelihood vulnerability to climate variability and change in the two mainland fishing communities of Padma, Barguna District, and Kutubdia Para, Cox's Bazar District in southern coastal Bangladesh (Figure 5). Section 3.2 describes the Bangladesh context and these two communities as well as justifying why they were selected. Overall, the two communities share some characteristics but also have some different physiographic contexts and livelihood characteristics. They have also been exposed to multiple climatic shocks and stresses (Table 16) and are predicted to be exposed to these more in future due to climate change (see sections 3.2.1.1 and 3.2.1.3). Kutubdia Island has not been included in this chapter because this island has considerably different physiographic context and livelihood characteristics of its households compared to Padma and Kutubdia Para (see section 3.2.2 and Chapter 5 for details), hence comparing this island community with the mainland communities may lessen the scope of generalisation of theory (determinants and characteristics of livelihood vulnerability) from findings.

Using past and present climatic exposure and current livelihood data as indicators, this chapter first assesses the livelihood vulnerability in the two communities and their households using a composite vulnerability index approach. This is complemented by a qualitative examination of the livelihood vulnerability. First, the process of selection and characterisation of indicators are described followed by the data collection process and assessment of vulnerability using the approaches mentioned above.

### **4.3.2 Indicators of vulnerability**

Exposure, sensitivity, and adaptive capacity are the key factors that determine the vulnerability of households and communities to the impacts of climate variability and change (IPCC, 2007a). Indicators for each of these factors are therefore essential elements of a comprehensive vulnerability assessment. However, "many of these indicators cannot be quantified, and many of the component functions can only be qualitatively described" (Yohe and Tol, 2002, p. 27). For instance, effective governance is important for adaptive capacity (Paavola, 2008) but it is difficult to capture in an indicator (Vincent, 2007). The most useful indicators of vulnerability have construct

validity, are sensitive enough to capture variation, and broad enough to be transferable (Vincent, 2007).

Exposure in the context of this study is the nature and degree to which a fishery-based livelihood system is exposed to significant climatic variations (modified from IPCC, 2001, p. 987). Exposure indicators selected for this region characterise the frequency of extreme events, rate of land erosion and sea level rise, and variations in temperature and rainfall (Table 16). The two communities have experienced similar variations in maximum temperature so no indicator on it was included in index calculation. Only retrospective data on indicator values were used, no future projections were attempted due to unavailability at community scale. This is sufficient for the purposes of this study because the greater the level of exposure to climate variability (and change), the greater the relative propensity for communities and households to be impacted.

Table 16. Community exposure to climatic shocks and stresses.

<i>Climatic shocks and stresses</i>	<i>Padma</i>		<i>Kutubdia Para</i>		<i>Sources of data</i>
	<i>Mean</i>	<i>Standard Deviation</i>	<i>Mean</i>	<i>Standard Deviation</i>	
Number of past floods <sup>a</sup>	4	N/A	2	N/A	FGDs <sup>b</sup>
Number of past cyclones <sup>a</sup>	3	N/A	4	N/A	FGDs <sup>b</sup>
Past land erosion (m/year) <sup>a</sup>	16.67	N/A	0.67	N/A	FGDs <sup>b</sup>
Past sea level changes (mm/year)	2.9 <sup>c</sup>	N/A	1.4 <sup>d</sup>	N/A	CEGIS (2006)
Variation in past maximum temperature (°C) <sup>e</sup>	1.61	0.46	1.61	0.47	BMD (2011)
Variation in past minimum temperature (°C) <sup>e</sup>	1.81	0.70	1.44	0.63	BMD (2011)
Variation in past rainfall (mm) <sup>e</sup>	13.86	14.01	16.4	15.77	BMD (2011)

<sup>a</sup>Period discussed with respondents 1981-2011.

<sup>b</sup>Refer to data collection section (section 3.3.4).

<sup>c</sup>Mean change 1959-1986, Khepupara measurement station (20 km east of Padma).

<sup>d</sup>Mean change 1968-1991, Cox's Bazar station.

<sup>e</sup>Standard deviations of daily maximum temperature (°C), daily minimum temperature (°C), and daily total rainfall (mm) by month, between January 1981-May/June 2011, averaged. Data from: Khepupara station (Padma); Cox's Bazar station (Kutubdia Para).

Sensitivity in this context is the degree to which a fishery-based livelihood system is affected, either adversely or beneficially, by climate variability or change (adapted from IPCC, 2007a, p. 881). Sensitivity indicators characterise the first-order effects of stresses (IPCC, 2001; Polsky et al., 2007). At the local level exposure and sensitivity are almost inseparable and it is challenging to characterise them (Smit and Wandel, 2006).

Sensitivity indicators include livelihood characteristics such as dependence of livelihoods on climate sensitive activities and patterns of resource use (Smit and Wandel, 2006; Eakin and Bojórquez-Tapia, 2008). But many indicators of sensitivity are similar to those that influence a system's adaptive capacity (Smit and Wandel, 2006). In order to avoid using the same indicators for measuring sensitivity and adaptive capacity, only indicators of the dependence of livelihoods on climate sensitive activities in the fisheries sector, for employment, income and nutrition were used as sensitivity indicators (Allison et al., 2009b; Macfadyen and Allison, 2009) (Table 17). This assumes that households and communities with higher dependence on fisheries for employment, income, and nutrition are more likely to be impacted by climate variability and change (cf. Allison et al., 2009b).

Table 17. Indicators used to determine fishery-based livelihood vulnerability.

<i>Indicators</i>	<i>Explanation of the indicators</i>
<b><i>Indicators of Exposure</i></b>	
Refer to Table 16	Refer to Table 16
<b><i>Indicators of Sensitivity</i></b>	
Employment from fisheries	Number of days a household was involved with fisheries in last year
Income from fisheries	Percentage of a household income from fisheries sector in last year
Nutrients uptake from fisheries	Amount (per capita) of fish and seafood a household consumed in last year (kg/month)
<b><i>Indicators of Adaptive Capacity</i></b>	
Adult workforce	Number of individuals aged 14-60 in a household
Presence of non-elderly household head	Whether a household head is <50 years old or not
Experience	Experience of a household head in fisheries-related activities (years)
Education	Highest years of schooling of any member of a household
Health	Number of days a year a household head remains physically fit to carry out livelihood activities
Presence of male-headed household	Whether a household head is male or not
Quality of house	Aggregate index of a household's quality of house (see section 4.3.2)
Number of fisheries materials	Number of types of fisheries related materials (boats, nets etc.) of a household
Use of technology	Aggregate index of a household's use of technology (see section 4.3.2)
Distance from services	Aggregate index of distance (time) of a household's house from services (see section 4.3.2)
Natural capital	Aggregate index of natural capital of a household (see section 4.3.2)
Financial capital excluding income	Aggregate index of a household's financial capital excluding income (see section 4.3.2)
Per capita income	Per capita income of a household (Taka/year) (TK76 = US\$1) (see section 4.3.2)
Social capital	Aggregate index of a household's social capital (see section 4.3.2)
Number of income generating activities	Number of income generating activities per household

Adaptive capacity in the context of this study is the ability or capacity of the fishery-based livelihood systems to adjust to climate change (including variability and extremes), to take advantage of opportunities, or to cope with the consequences (modified from IPCC, 2001, p. 982). However, there is little consensus about the

characteristics and determinants of adaptive capacity at household, community, and national levels (Smit and Wandel, 2006; Jones et al., 2010) because the exploration of adaptive capacity has only just begun (Vincent, 2007). At the local level, adaptive capacity can be influenced by infrastructure, community structure and social groups, household structure and composition, knowledge, social capital (such as kinship networks and social support institutions), political influence, power relations, governance structures, managerial ability, and ability or inability to access livelihood assets, especially financial, technological, and information resources (Watts and Bohle, 1993; Adams and Mortimore, 1997; David, 1998; Adger, 1999; Handmer et al., 1999; Kelly and Adger, 2000; Barnett, 2001; Yohe and Tol, 2002; Wisner et al., 2004; Haddad, 2005; Ford et al., 2006; Smit and Wandel, 2006; Tol and Yohe, 2007; Vincent, 2007; Paavola, 2008; Sallu et al., 2010). Adaptive capacity is however context-specific varying across scales – countries, communities, social groups and households – and over time (Smit and Wandel, 2006), and best determined by a given climatic exposure in which a particular system is exposed (Vincent, 2007). Indicators of adaptive capacity for the fishery-based livelihoods should thus be developed considering the nature and type of exposure of households and communities. This chapter chooses to use adaptive capacity indicators covering a range of livelihood characteristics such as livelihood assets and strategies (Table 17), assuming that households and communities with more of these are better able to cope with and adapt to the impacts of climate variability and change. In what follows, how each of the local scale adaptive capacity indicators was selected and characterised are described.

A greater human capital facilitates adaptation of a household by enhancing its access to other capital assets and facilitating livelihood activities. Households with greater human capital such as a higher number available for the workforce (Sesabo and Tol, 2005), male-head (Adams and Mortimore, 1997; Sesabo and Tol, 2005; Allison et al., 2007; Paavola, 2008), non-elderly head (Adams and Mortimore, 1997; Ngo, 2001; Sesabo and Tol, 2005), more education (Adams and Mortimore, 1997; Heinz Center, 2000; Brooks et al., 2005), and better health (Adams and Mortimore, 1997) have a greater level of adaptive capacity. For example, a higher level of education can affect lifetime earnings of a household but on the other hand limited education can constrain its ability to understand disaster warning information and access recovery information (Heinz Center, 2000). Another example is that male-headed households are in a better position

to cope with or adapt to climate change than female-headed households because the latter have limited access to livelihood capital assets and strategies (Paavola, 2008). Six human capital indicators were used in this chapter: adult workforce (number of individuals aged 14-60 in a household), presence of non-elderly household head (whether a household head is <50 years old or not), experience (experience of a household head in fisheries-related activities), education (highest years of schooling of any member of a household), health (number of days a year a household head remains physically fit to carry out livelihood activities), and presence of male-headed household (whether a household head is male or not).

Physical capital assets including services, and households' or communities' access to them are considered as a key factor of adaptive capacity (Sen, 1981; Kelly and Adger, 2000; Adger et al., 2004; IPCC, 2007a). For example, quality and density of roads and other transport routes will determine the ability of rural populations to access markets and influence the feasibility and efficacy of aid distribution programmes in response to disasters such as floods (Adger et al., 2004). Technology such as radios, televisions or mobile phones can also play an important role in adapting to climate change for the rural households by helping them communicate and access information on changing weather conditions (Naab and Koranteng, 2012). On the basis of these conceptualisations, three physical capital indicators were used: quality of house, number of fisheries materials, and use of technology. An aggregate index of a household's quality of house was used for this chapter which is calculated as the sum of a household's scores (i.e. 0 = insufficient, 1 = moderate, 2 = good), based on 4 variables: availability of rooms per adult equivalent (0 = less than 0.5 rooms per adult equivalent, 1 = 0.5–1 per adult equivalent, 2 = >1 per adult equivalent), quality of outside walls (0 = non-cemented material or without corrugated tin, 1 = corrugated tin, 2 = cement and brick casting/concrete), quality of roof (0 = leaves/straw/tile, 1 = corrugated tin, 2 = concrete) and quality of floor (0 = dirt, 1 = brick/wood with non-cemented material, 2 = concrete). Index ranges between 0 and 8. The scores on different variables were agreed by the household heads of this study during the FGDs. A household's ownership of a number of types of fisheries related materials such as boats, nets etc. is used as proxy for number of fisheries materials. An aggregate index of a household use of technology was calculated as sum of a household's scores (no = 0, yes = 1), based on the 6 variables:

sanitary toilet, phone, radio/television, solar/electricity for energy, safe drinking water source, ownership of transportation. Index ranges between 0 and 6.

An aggregate index of distance (time) of a household's house from services is used as a proxy for access to services. This is calculated as the sum of a household's scores (i.e. 0 = insufficient, 1 = moderate, 2 = good), based on 7 variables: time needed to reach the nearest cyclone shelter (0 = >10 minutes, 1 = 3-10 minutes, 2 = <3 minutes), drinking water source (0 = >15minutes, 1 = 5-15minutes, 2 = <5minutes), market (0 = >30 minutes, 1 = 10-30 minutes, 2 = <10 minutes), disaster office (0 = >45 minutes, 1 = 20-45 minutes, 2 = <20 minutes), government offices (0 = >45 minutes, 1 = 20-45 minutes, 2 = <20 minutes), hospital/clinic (0 = >30 minutes, 1 = 10-30 minutes, 2 = <10 minutes), and time needed to reach the nearest educational institution (0 = >20 minutes, 1 = 10-20 minutes, 2 = <10 minutes). Index ranges between 0 and 14 where higher value means less distance. The scores on different variables were agreed by the household heads of this study during the FGDs.

Households' possessions and access to natural capital are also considered important which facilitates more livelihood activities and incomes and therefore adaptation (DFID, 1999; Townsley, 2004). An aggregate index of natural capital was calculated as the sum of a household's scores (no = 0, yes = 1), based on the 2 variables: possession of land and trees. Index ranges between 0 and 2. Households' possessions or access to other natural capital such as fishing or fish processing areas were not included as no satisfactory proxies could be identified.

Financial capital can provide greater access to other livelihood assets and play a crucial role in climate change adaptation (Brenkert and Malone, 2005; Madu, 2012). For instance, more financial capital generally provides access to markets, technology, and other assets which can be used to adapt to climate change (Brenkert and Malone, 2005). Liquid financial capital such as livestock offers readily available cash during economic hardship (Hesselberg and Yaro, 2006). Financial capital was captured in two indicators: financial capital excluding income and per capita income. An aggregate index of household financial capital excluding income was calculated as the sum of a household's scores (no = 0, yes = 1), based on the 3 variables: livestock, jewellery and stored food. Index ranges between 0 and 3. Per capita yearly income of a household

(Taka; abbreviates as TK) was calculated by taking the total yearly household income (excluding own consumption of fish or other products and deducting business expenses or operating expenses) divided by the total number of family members in the household. When the data were collected the conversion rate was US\$ 1 = TK 76.

Social capital such as networks, membership of community-based organisations, and relationships of trust and reciprocity play an important role in coping with and adapting to shocks and stresses (Carney, 1998). For example, when Sri Lanka was hit by tsunami in 2004, at first neighbours, friends, other family members and relatives helped the affected people before getting support from the authorities (Birkmann et al., 2006). Another example is that, in hillside communities of Bolivia, community organisation was an important factor in adopting adaptive strategies (Robledo et al., 2004). An aggregate index of household social capital was thus calculated as the sum of a household's scores (no = 0, yes = 1), based on 13 variables: having relatives in the village, getting support from relatives in the village, having relatives outside the village, getting support from relatives outside the village, having contacts other than relatives inside the village, getting support from contacts other than relatives inside the village, having contacts other than relatives outside the village, getting support from contacts other than relatives outside the village, having membership with a community organisation, getting support from community organisation, having political party membership, getting support from political parties, and ability to cast vote in elections. Index ranges between 0 and 13.

A diversified livelihood can adapt to change better including climatic shocks and stresses (Ellis, 2000; Allison and Ellis, 2001; Allison et al., 2007; Turner et al., 2007; McClanahan et al., 2008). The number of income generating activities each household was involved in was used as proxy for livelihood diversification.

### **4.3.3 Data collection and analysis**

The primary data for this chapter were collected using a multi-method approach from the fishery-dependent households (see section 3.3 for details) in Padma and Kutubdia Para. Sensitivity and adaptive capacity data were collected using household questionnaires, whereas exposure data were collected from secondary sources and FGDs (see section 3.3.4), listed in Tables 16 and 17. These data were used to produce

livelihood vulnerability indices for the communities and their households, detailed below.

#### 4.3.3.1 Livelihood vulnerability index

The calculation of the composite livelihood vulnerability index for each household consisted of four steps: selecting indicators, standardising indicators, calculating sub-indices and calculating vulnerability index. A composite index approach computes vulnerability indices by aggregating data for a set of indicators. An indicator represents a characteristic or a parameter of a system (Cutter et al., 2008) and it is an empirical, observable measure of a concept (Siniscalco and Auriat, 2005, p. 7). The composite index approach can help to identify indicators or determinants for targeting interventions and programmes (Eakin and Bojórquez-Tapia, 2008; Czúcz et al., 2009).

Using the suite of indicators and aggregate indices described in Tables 16 and 17, this chapter quantitatively assessed the vulnerability of fishery-based livelihood systems. Since each indicator was measured on a different scale, they were normalised (rescaled from 0 to 1) by using Equation 2.

$$index_{Si} = \frac{S_i - S_{min}}{S_{max} - S_{min}} \dots \dots \dots (2)$$

Where,  $index_{Si}$  is a normalised value of an indicator of a household,  $S_i$  is the actual value of the same indicator and  $S_{min}$  and  $S_{max}$  are the minimum and maximum values, respectively, of the same indicator.

After normalisation the respective values were averaged to yield the three sub-indices for exposure, sensitivity, and adaptive capacity. As household scale exposure data were not available, the same exposure sub-index score was used to calculate intra-community livelihood vulnerability indices. This enabled to gain insights into the determinants of livelihood vulnerability amongst similarly exposed households (Eakin and Bojórquez-Tapia, 2008). The household level sensitivity and adaptive capacity sub-indices were also normalised. The normalised adaptive capacity sub-index was inverted (1- index) for inclusion in the vulnerability index because the potential impact (which is a function of



exposure and sensitivity) of climate variability and change may be offset, reduced or modified by adaptive capacity (IPCC, 2007a).

Sub-indices were combined to create a composite vulnerability index by using an additive (averaging) (Equation 3) or multiplicative (Equation 4) approach. Both procedures were followed but, since they produced highly correlated vulnerability scores (Spearman's  $\rho$  0.97 for Padma and 0.98 for Kutubdia Para;  $p < 0.01$ ), the results of the multiplicative approach are highlighted because they better reflect low and high indicator and sub-index values (Hajkowitz, 2006).

$$V = (E + S + (1-AC))/3 \dots \dots \dots (3)$$

$$V = E \times S \times (1-AC) \dots \dots \dots (4)$$

Where V, E, S and AC represent vulnerability, exposure, sensitivity and adaptive capacity of a household, respectively.

The dataset from the sampled households was divided into quartiles of vulnerability (very high, high, moderate, and low), each representing a quarter of the population sampled, for each indicator and index (Tables 19 and 20). Z-test or t-test (depending on the sample size) was conducted to determine significant differences between two data sets. ANOVA was conducted to determine significant differences between more than two data sets. ANOVA was also conducted to investigate significance of an indicator in distinguishing the vulnerability classes.

To calculate vulnerability indices the indicators can be considered as either equal/un-weighted (e.g., Sullivan et al., 2002; Allison et al., 2009b; Hahn et al., 2009) or variable/weighted (e.g., Vincent, 2007; Eakin and Bojórquez-Tapia, 2008; Gbetibouo et al., 2010) importance. Advantages with the un-weighted indicators-based vulnerability analysis are that the findings using this tool can be scaled up more confidently and that the tools can be used in a diverse set of users (Hahn et al., 2009). However, it is been criticised because each of the respective indicators of exposure, sensitivity and adaptive capacity may not be equally important to the households of each community and may

therefore be given different weights when constructing the sub-indices (Blaikie et al., 1994; Bohle et al., 1994; Eakin and Bojórquez-Tapia, 2008).

This chapter calculated vulnerability indices using equal weightings for each indicator (Sullivan et al., 2002), due to the absence of any robust weighting method (Deressa et al., 2008). The currently used weighting methods are either considered as subjective (e.g., expert judgement) or statistically biased (e.g., principal component analysis and regression analysis). As an alternative, this chapter discusses the role of each component after calculating vulnerability, using qualitative data collected during oral history interviews, vulnerability matrices (adapted from CARE, 2009) and FGDs. This also served as a means to validate the vulnerability index.

To ensure representative sampling of qualitative data in each community, cluster analysis of household sensitivity and adaptive capacity data was conducted (see section 3.4.1.1) which produced five and four clusters, respectively for Padma and Kutubdia Para. A total of 22 and 21 oral history interviews (3-5 from each cluster depending on the number of households in each cluster) were conducted in Padma and Kutubdia Para, respectively (see section 3.3.2 for details). Single vulnerability matrix and FGD were conducted from each cluster in each community (see sections 3.3.3 and 3.3.4 for details). The qualitative data were transcribed in Bengali and analysed using coding techniques of content analysis before translation (see section 3.4.2).

## 4.4 Results

### 4.4.1 Vulnerability

Table 18 presents the values for vulnerability sub-indices and indices for Padma and Kutubdia Para, while Tables 19 and 20 present the values for original indicators, sub-indices and indices for different household classes of Padma and Kutubdia Para. Taking into account the sub-indices of exposure, sensitivity and adaptive capacity, the results of the z-test show that Padma's households experience significantly higher (0.17) ( $p < 0.01$ ) livelihood vulnerability than Kutubdia Para's households (0.11). Within each community where the households are similarly exposed, the sensitivity and adaptive capacity sub-indices show (in ANOVA) that vulnerability also differs significantly ( $p < 0.001$ ) between the household classes (very high, high, moderate and low) within each community. The very high, high, moderate and low household classes in Padma have the vulnerability indices of 0.29, 0.20, 0.15, and 0.05, respectively (Table 19). While in Kutubdia Para, the very high, high, moderate and low household classes have the vulnerability indices of 0.18, 0.13, 0.10 and 0.05, respectively (Table 20).

Table 18. Vulnerability sub-indices and indices for Padma and Kutubdia Para.

<i>Components</i>	<i>Padma</i>		<i>Kutubdia Para</i>	
	<i>Mean</i>	<i>Standard deviation</i>	<i>Mean</i>	<i>Standard deviation</i>
<sup>a</sup> Exposure	0.67	0.52	0.33	0.52
<sup>b*</sup> Sensitivity	0.54	0.20	0.61	0.19
<sup>b</sup> Adaptive capacity	0.49	0.21	0.45	0.19
*Vulnerability	0.17	0.09	0.11	0.05

<sup>a</sup>To explore significant differences in exposure between the two communities, data sets for t-test were produced directly from the indicators. <sup>b</sup>To explore significant differences in sensitivity and adaptive capacity between the two communities, data sets for z-test were produced from the sub-indices that were in turn produced from the indicators. \*Indicates significant difference (normalised values were used) between Padma and Kutubdia Para in z- test ( $p < 0.01$ ).

The results also highlight that, at the community scale, the highest livelihood vulnerability to climate variability and change does not coincide with highest sensitivity and lowest adaptive capacity. Padma's households are less sensitive and have more adaptive capacity than those of Kutubdia Para's, but are nevertheless more vulnerable because of their heightened exposure (see Table 18). But looking into classes of differently vulnerable households within a community (where all households are similarly exposed), it is found that higher sensitivity and lower adaptive capacity almost typically combine to create higher livelihood vulnerability (see Tables 19 and 20).

Table 19. Vulnerability classification of households in Padma.

<i>Indicators</i>	<i>Very highly vulnerable<sup>1</sup></i>	<i>Highly vulnerable<sup>1</sup></i>	<i>Moderately vulnerable<sup>1</sup></i>	<i>Low vulnerable<sup>1</sup></i>	<i>Mean</i>	<i>Standard deviation</i>
Number of households	25	25	25	25	25	0
<b><i>Indicators of sensitivity</i></b>						
Employment from fisheries (days/year)***	220	199	205	165	197	40
Income from fisheries (%)***	98	93	94	67	88	19
Nutrients uptake from fisheries (kg/month)***	2.22	1.49	1.97	2.56	2.06	1.14
<b><i>Sub-Index of sensitivity***</i></b>	<b><i>0.67</i></b>	<b><i>0.52</i></b>	<b><i>0.59</i></b>	<b><i>0.38</i></b>	<b><i>0.54</i></b>	<b><i>0.20</i></b>
<b><i>Indicators of adaptive capacity</i></b>						
Number of adult workforce**	2.16	2.92	3.20	3	2.82	1.01
Presence of non-elderly household head	1	0.92	0.88	0.96	0.94	0.24
Experience (years)*	9.84	14.48	17.08	17.12	14.63	9.33
Education (years)	6.56	6.24	7.04	7.12	6.74	2.18
Health (days)	317	313	324	336	323	47
Presence of male-headed household	1	0.96	0.96	1	0.98	0.14
Quality of house**	2.52	2.36	3.36	3.44	2.92	1.32
Number of fisheries materials*	0.28	0.28	0.84	0.84	0.56	0.87
Use of technology***	1.40	1.84	2.60	2.56	2.10	1.24
Distance from services	6.76	6.40	5.88	6.40	6.36	1.35
Natural capital***	0.64	1.00	1.32	1.24	1.05	0.64
Financial capital excluding income***	1.80	1.76	2.24	2.44	2.06	0.68
Per capita income (TK)*	13,052	11,312	25,644	33,004	20,753	28,652
Social capital***	7.32	6.72	8.84	7.80	7.67	1.94
Number of income generating activities**	2.08	2.40	2.60	3.28	2.59	1.16
<b><i>Sub-Index of adaptive capacity***</i></b>	<b><i>0.34</i></b>	<b><i>0.39</i></b>	<b><i>0.60</i></b>	<b><i>0.65</i></b>	<b><i>0.49</i></b>	<b><i>0.21</i></b>
<b><i>Index of Livelihood Vulnerability***</i></b>	<b><i>0.29</i></b>	<b><i>0.20</i></b>	<b><i>0.15</i></b>	<b><i>0.05</i></b>	<b><i>0.17</i></b>	<b><i>0.09</i></b>

<sup>1</sup>Values are mean of all households in a particular vulnerability class.

\*Indicates significant difference (normalised values were used) between vulnerability classes in ANOVA test; \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

Table 20. Vulnerability classification of households in Kutubdia Para.

<i>Indicators</i>	<i>Very highly vulnerable<sup>1</sup></i>	<i>Highly vulnerable<sup>1</sup></i>	<i>Moderately vulnerable<sup>1</sup></i>	<i>Low vulnerable<sup>1</sup></i>	<i>Mean</i>	<i>Standard deviation</i>
Number of households	25	25	25	25	25	0
<b><i>Indicators of sensitivity</i></b>						
Employment from fisheries (days/year)***	228	220	215	200	216	25
Income from fisheries (%)***	99	97	95	79	92	16
Nutrients uptake from fisheries (kg/month)**	3.69	2.65	2.43	2.81	2.89	1.32
<b><i>Sub-Index of sensitivity***</i></b>	<b><i>0.76</i></b>	<b><i>0.63</i></b>	<b><i>0.59</i></b>	<b><i>0.47</i></b>	<b><i>0.61</i></b>	<b><i>0.19</i></b>
<b><i>Indicators of adaptive capacity</i></b>						
Number of adult workforce***	2.84	3.12	3.44	4.88	3.57	1.92
Presence of non-elderly household head	0.88	0.88	0.88	0.96	0.90	0.30
Experience (years)	15.72	15.56	15.76	18.20	16.31	9.00
Education (years)***	4.68	5.76	7.44	9.48	6.84	3.04
Health (days)	338	340	352	339	342	33
Presence of male-headed household*	0.88	1.00	1.00	1.00	0.97	0.17
Quality of house***	1.28	1.68	2.04	3.18	2.04	1.53
Number of fisheries materials**	0.04	0.24	0.44	0.52	0.31	0.49
Use of technology***	1.84	2.60	2.88	4.08	2.85	1.46
Distance from services**	5.20	5.68	7.08	6.68	6.16	2.10
Natural capital **	0.80	1.00	1.04	1.12	0.99	0.33
Financial capital excluding income***	1.36	1.60	1.72	2.24	1.73	0.65
Per capita income (TK)**	18,406	18,043	41,647	59,398	34,374	46,875
Social capital ***	8.32	9.00	10.24	9.96	9.38	1.70
Number of income generating activities**	1.56	1.48	1.56	2.32	1.73	0.93
<b><i>Sub-Index of adaptive capacity***</i></b>	<b><i>0.27</i></b>	<b><i>0.38</i></b>	<b><i>0.49</i></b>	<b><i>0.64</i></b>	<b><i>0.45</i></b>	<b><i>0.19</i></b>
<b><i>Index of Livelihood Vulnerability***</i></b>	<b><i>0.18</i></b>	<b><i>0.13</i></b>	<b><i>0.10</i></b>	<b><i>0.05</i></b>	<b><i>0.11</i></b>	<b><i>0.05</i></b>

<sup>1</sup>Values are mean of all households in a particular vulnerability class.

\*Indicates significant difference (normalised values were used) between vulnerability classes in ANOVA test; \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

#### 4.4.2 Exposure

Padma is more exposed to climate variability and change than that of Kutubdia Para (Tables 16 and 18). While this difference is not statistically significant ( $p > 0.05$  in  $t$ -

*test*), qualitative data demonstrate considerable climatic impacts in the two communities. Although it was not possible to distinguish exposure between the classes of households in a community, vulnerability matrices identify floods and cyclones are the main determinants of livelihood vulnerability in the two communities but how exposure creates livelihood vulnerability depends on the context of each community. According to almost all the participants, floods are the most important determinant of vulnerability inland, while at sea it is cyclones. Padma is more exposed to floods whereas Kutubdia Para is more exposed to cyclones (see Table 16). In both communities cyclones are typically followed by surges (floods) and together they cause vastly adverse impacts on household livelihood assets, strategies and outcomes. As an extreme case, one of the participants from Padma stated during an oral history interview “*during Sidr, water [surge] suddenly came and washed away not only my three family members but also my house...*”. In addition to impacting land-based assets, cyclones also cause loss of life and fishing materials in the sea. One FGD participant from Padma for example stated “*he who can die, can catch fish from the sea*”.

Other exposures have little or no impact on livelihoods. Land erosion and sea level rise have resulted in the displacement (and resettlement in nearby areas) of about 5% of the households (estimated from qualitative data) in Padma over the past three decades but none in Kutubdia Para. While variations in maximum temperature and rainfall have impacted less than 20% (estimated from qualitative data) of fish drying process in Kutubdia Para in some years, no effects were reported in Padma. Variation in past minimum temperature has not found to pose any considerable negative impacts on livelihoods in either community.

#### **4.4.3 Sensitivity**

Sensitivity to climate variability and change is influenced by conditions at the community and household level. Overall the z-test shows that the sensitivity is significantly higher among Kutubdia Para’s households (0.61) ( $p < 0.01$ ) than among those of Padma (0.54) (Table 18). The higher sensitivity of livelihoods in Kutubdia Para is due to their high dependence on climate sensitive fisheries activities for employment, income, and nutrition (see Table 20). Oral history interviews and FGDs reveal that over the past two and half decades the households in Kutubdia Para have had progressively increasing access to facilities that have raised their level of involvement in fisheries.

Some of the households have extensified their livelihood strategies by fishing and drying fish outside the normal seasons when climatic stresses and shocks are more pronounced. This extensification has increased their dependency on fisheries and is the potential source of increased vulnerability.

ANOVA shows that sensitivity varies significantly between the household vulnerability classes in each community ( $p < 0.01$ ) (Tables 19 and 20). The very high, high, moderate and low household classes in Padma have the sensitivity sub-indices of 0.67, 0.52, 0.59 and 0.38, respectively. While in Kutubdia Para, the very high, high, moderate and low household classes have the sensitivity sub-indices of 0.76, 0.63, 0.59 and 0.47, respectively. ANOVA further shows that all three indicators of sensitivity are significant ( $p < 0.001$  for most indicators) in distinguishing vulnerability classes in both communities. Therefore, instead of selecting a specific indicator of sensitivity as a determinant of livelihood vulnerability, it is better to treat them together as dependence on small-scale marine fisheries.

#### **4.4.4 Adaptive capacity**

Adaptive capacity depends on the context of each household and community, but some indicators appear to be general determinants of livelihood vulnerability in the two communities. Unlike sensitivity, z-test shows that the sub-index of adaptive capacity does not differ significantly ( $p > 0.05$ ) between the two communities (Table 18). However, ANOVA shows that significant differences ( $p < 0.01$ ) exist in adaptive capacity between the household vulnerability classes of each community (Tables 19 and 20). ANOVA also shows that a range of indicators such as the number of adult workforce, quality of house, number of fisheries materials, natural capital, financial capital excluding income, per capita income, social capital, and number of income generating activities are significant ( $p < 0.001$  to  $p < 0.05$ ) in distinguishing vulnerability classes of households in both communities (Tables 19 and 20). In what follows, how these significant indicators influence livelihood vulnerability are discussed.

Among the six human capital indicators only the 'number of adult workforce' in a household is significant (Tables 19 and 20). According to FGD participants, the lack of adult workforce increases livelihood vulnerability by limiting the household's ability to

tackle emergencies during extreme weather events, as well as its access to livelihood assets and strategies. For instance, during cyclone *Sidr* some of the household heads of Padma remained at sea or otherwise outside of their home, and due to lack of adults the households were less able to move their members and assets in a timely way.

The 'quality of house' was identified as an important adaptive capacity indicator in the vulnerability matrices. The quality of house improved as the level of vulnerability decreased (Tables 19 and 20). Most houses in the two communities have dirt walls and thatched straw or weak corrugated tin roofs, and they are usually destroyed by extreme weather events. For example, according to vulnerability matrix participants, *Sidr* destroyed most houses in Padma and *Gorki* destroyed half of the houses in Kutubdia Para.

Boats and nets were also identified as important indicators of adaptive capacity – less vulnerable households had more of them than more vulnerable households (Tables 19 and 20). The lack of boats and nets limits a household's choice and, in some cases, requires a household to adopt more climate sensitive strategies. For example, offshore fishing during cyclones is regarded as dangerous. But in Padma, some household heads (boat crews) without a boat of their own were coerced to catch fish in cyclonic seas by those (boat owners) who do own boats.

Lack and loss of natural capital increase livelihood vulnerability by reducing the number of livelihood activities and capacity to cope with climatic stresses and shocks. Competition, overfishing, and lack of enforcement of fishing regulations have reduced fish stocks. Lack of other natural capital such as trees and agricultural land also reduces adaptive capacity. For example, according to oral history interviews, not having coconut or palm trees in or near the homestead restricts the ability of some households of Padma to take shelter during a flood.

Financial capital, particularly income, is also an important indicator of adaptive capacity. Lack of income increases livelihood vulnerability by reducing both coping and adaptive capacity. The most vulnerable classes of households are not able to augment their livelihood assets and, sometimes, not even access these assets due to their low incomes, which in turn increases their vulnerability. Lack of other financial capital such



as livestock, jewellery, and stored food can limit a household's coping mechanisms. For example, according to oral history interviews and FGDs, not having stored food forced some households, especially in Padma, to sell valuable items at low prices during past extreme weather events.

Social capital such as access to relatives and friends helped households to cope with climatic shocks. However, their ability to cope and adapt was constrained because of the absence of community organisations. The most vulnerable households had the least social capital, whilst moderately vulnerable households had most and low vulnerable households had a moderate amount of it (Tables 19 and 20). That is, social capital is not the sole determinant of vulnerability among households.

A household's involvement in a diverse set of income-generating livelihood activities or strategies reduces the vulnerability of the household, more clearly so in Padma than in Kutubdia Para (Tables 19 and 20). Without livelihood diversification, dependency on fisheries becomes pronounced and so does livelihood vulnerability because fishing and fish processing have high exposure to cyclones, floods, and variations in maximum temperature and rainfall.

## **4.5 Discussion**

This section provides specific discussion related to this chapter only, while more general discussion integrating this chapter and the next two empirical chapters is provided in Chapter 7.

This chapter has assessed the vulnerability of fishery-based livelihoods to the impacts of climate variability and change using locally relevant indicators of exposure, sensitivity, and adaptive capacity. Understanding how these components and indicators influence the vulnerability of livelihoods provides an important starting point for directing future research and climate change coping and adaptation initiatives for fishery-based livelihood systems.

To assess livelihood vulnerability, this chapter uses a composite index approach to calculate sub-indices and indices of vulnerability, followed by qualitative methods to understand how exposure, sensitivity and adaptive capacity measured by sub-indices

produce vulnerability. The equal weighing for each indicator to calculate vulnerability, used in this study, is sometimes criticised because all the indicators may not be equally important for a given household or community (Eakin and Bojórquez-Tapia, 2008). However, there is no universal means of weighing and each method has some criticisms (Deressa et al., 2008). With the method of equal weighing (Sullivan et al., 2002; Hahn et al., 2009) followed by qualitative discussion of the role of each indicator and sub-index after calculating vulnerability, this study was able to overcome the criticism of weighing. The qualitative methods of assessing the association of vulnerability with relevant indicators also served as a means of validating the vulnerability indices and sub-indices. The integration of quantitative and qualitative methods has increased the generalizability of the findings. The households were classified into four vulnerability classes and significance of each indicator in distinguishing these classes was investigated by ANOVA. In this way significant indicators of vulnerability were identified. Therefore, this research shows that the composite index approach together with ANOVA can be useful at the household scale in distinguishing the factors that determine their differential level of vulnerability; and can have implication for prioritising factors for reducing vulnerability. The integration of the composite index approach, ANOVA and qualitative methods to assess livelihood vulnerability has therefore offered an important method for vulnerability analysis to climate variability and change.

Fishery-based livelihoods in households of Padma and Kutubdia Para have high exposure to climate-related shocks and stresses, especially floods and cyclones, because the communities are located near the coastline and livelihoods are dependent upon marine fishing from small vessels. Sensitivity of livelihoods to climate variability and change is determined by dependency on marine fisheries for livelihood because of unavailability of alternative livelihoods, lack of financial capital to invest in alternative livelihoods, lack of institutional support for livelihood diversification, and lack of human capital to engage in alternative livelihood strategies. Adaptive capacity of households is limited because of the lack of physical, natural, and financial capital, and limited diversification of livelihoods. These factors are interrelated. Because of the lack of financial capital (i.e., income or access to credit), households cannot augment their physical capital (i.e., boats or nets) or diversify their livelihoods. These results resonate

with research that has found that the most vulnerable households and communities are usually also poor (e.g., Paavola, 2008; Black et al., 2011b; Deressa et al., 2011).

Exposure, sensitivity, and adaptive capacity influence the vulnerability of fishery-based livelihoods in varied ways. Those who are most exposed are not necessarily the most sensitive or least able to adapt. That means the climatic stresses and shocks have unequal impacts in different fishery-dependent communities. This aligns with research on the vulnerability of agriculture-based livelihoods that has also found the most exposed regions are not necessarily most sensitive (Gbetibouo et al., 2010). Also, having the least adaptive capacity does not necessarily make a household or a community most vulnerable because of its lower sensitivity and/or exposure. But within a fishing community, where households are similarly exposed, higher sensitivity and lower adaptive capacity combine to create higher vulnerability (for similar results in agricultural communities, see Eakin and Bojórquez-Tapia (2008)). These findings highlight how socio-economic inequalities can underpin livelihood vulnerability (Dyson, 2006; Laska and Morrow, 2006).

The contextual nature of livelihood vulnerability and considerations of spatial and temporal scale make it challenging to develop robust indicators. The selection of indicators often involves a trade-off between specificity, transferability, accuracy, and certainty (Vincent, 2007). There is room for refining indicator-based approaches to vulnerability assessment as better indicators, models, and data become available. Particular consideration of system dynamics is required in future. For example, this chapter ranked households in each community into different livelihood vulnerability classes. However, no classification will prevail over the long-term because micro-scale (household) livelihoods are more dynamic than the macro-economy (Alwang et al., 2001). Also, future vulnerability will be shaped not only by climate change but also by adopted development pathways (IPCC, 2007a).

In the coming decades the vulnerability of fishery-based livelihoods may substantially increase because of climate change. In the absence of adaptation, increased frequency and intensity of cyclones and floods would result in greater loss of life at sea and in the coastal zone, greater damage to fishing materials and household assets, and a loss of fishery-related income. If sea level rise accelerates as projected during this century

(MoEF, 2005), coastal Bangladesh will experience permanent inundation and accelerated erosion of the land base of its coastal communities. Changes in temperature and rainfall can have direct impacts on the capacity for fish drying, which is the most common fish processing activity in this region. But the future livelihood vulnerability is also intimately linked with technological, demographic, and socioeconomic trends and how they influence the ability of fishery-dependent households and communities to adapt.

#### **4.6 Conclusion**

This chapter analysed vulnerability of fishery-based livelihoods to climate variability and change using a combination of composite index and qualitative methods. The findings of this chapter suggest that different components of vulnerability affect livelihoods in varied ways. Because of the different levels of exposure, the highest sensitivity does not always lead to highest livelihood vulnerability, and the highest adaptive capacity does not always result in the lowest livelihood vulnerability. Exposure, sensitivity, and adaptive capacity are highly context-dependent. A large number of factors influence livelihood vulnerability in the two communities. The most important climate-related elements of exposure are floods and cyclones, while the key factor determining sensitivity of an individual household is the dependence on marine fisheries for livelihoods. Adaptive capacity is underpinned by the combination of physical, natural, and financial capital and is influenced by the diversity of livelihood strategies.

This research provides an important starting point for directing future research into the vulnerability of fishery-based livelihood systems to climate variability and change. Further work is needed in order to move towards an improved characterisation of vulnerability and to identify most suitable means for households and communities to cope with and adapt to the impacts of climate change. Nonetheless, based on the findings of this research, it can be tentatively said that efforts to reduce livelihood vulnerability in coastal fishing communities should be multifaceted so as to simultaneously tackle exposure, sensitivity, and adaptive capacity.

Some findings in this chapter direct the research objective of the next chapter. This chapter finds that Kutubdia Para's households are more sensitive and have less adaptive capacity than those of Padma's, but are nevertheless less vulnerable because of their lesser exposure. This lesser exposure is due to the fact that Kutubdia Para's households migrated from Kutubdia Island two decades ago to escape land erosion, flooding and sea level rise. This raises the question of how successful their migration is in coping with or adapting to climate shocks and stresses which is examined in the next chapter.

## **Chapter 5 – Migration as Adaptation to Climate Variability and Change**

### **Summary**

Climate change is predicted to displace millions of people in the coming decades. There is an on-going debate about climate-induced migration but little empirical evidence exists about it. This chapter examines how climate-induced migration has impacted vulnerability and adaptation of a coastal fishing community in Bangladesh (Objective 2). This chapter uses household questionnaires, interviews and participatory methods to compare households who migrated from the Kutubdia Island to the mainland with those stayed behind. The results suggest that the resettled households are less exposed to floods, sea level rise and land erosion than those who stayed behind. They also have more livelihood assets, higher incomes and better access to water supply, health and educational services, technology and markets. This is not the case with households that remained on Kutubdia Island. In this case study migration has thus been a viable strategy to respond to climate variability and change. However, migration is by no means a panacea. Its feasibility depends on the ability of the destination to reduce exposure to climatic stresses and shocks, provide climate-resilient livelihood opportunities and facilitate adaptation over long term.

### **5.1 Introduction**

Environmental change is one driver of human migration (Perch-Nielsen et al., 2008; Black et al., 2011a; Black et al., 2011b; Black et al., 2011c; McLeman, 2011; Barnett and O'Neill, 2012). It can drive migration by altering the availability of ecosystem services and exposure to shocks and stresses (Black et al., 2011a). On the other hand, migration can also be considered a coping or adaptation strategy to tackle the impacts of environmental and climatic change (McLeman and Smit, 2006; Tacoli, 2009). As such, migration is of increasing interest to both policymakers and researchers (e.g., Action Aid, 2007; Stern, 2007; Warner et al., 2009).

It is common to consider climate-induced migration as a failure to adapt – this is the undertone of arguments which claim that millions of people will be forced to move by climate change (Myers, 2002; Nicholls et al., 2011). Rise in sea level alone may displace up to 187 million people by 2100 (Nicholls et al., 2011). Reuveny (2007) in turn predicts more frequent conflicts in the developing world as a result of climate change and migration.

The reality is that the evidence base on climate-induced migration is very limited (as argued by Black et al., 2011b; GOS, 2011). Available studies have examined drivers of climate-induced migration; few studies have assessed its outcomes or successfulness for the migrants. Many studies have asked for more empirical studies on this issue to support the public policy (e.g., IPCC, 2007a; Stern, 2007; GOS, 2011). Evidence on the outcomes of climate-induced migration can provide important insights for developing strategies to cope with and adapt to changing climate.

This chapter compares livelihood vulnerability and adaptation outcomes of households who migrated from Kutubdia Island to mainland Bangladesh with those who stayed behind. The chapter demonstrates how migration has reduced vulnerability and increased capacity to cope with climate variability and to adapt to climate change. The migrants' exposure to land erosion, sea level rise and flooding has also been reduced and they have more livelihood assets and better access to assets and social services after migration. The findings have important implications for other similarly situated communities for addressing climate variability and change.

In what follows, section 5.2 discusses the links between climate change and migration, and the current research on outcomes of climate-induced migration. The case study and methodology are detailed in section 5.3. Section 5.4 examines the livelihood activities of non-migrants and migrants, and analyses the implications of migration by comparing their livelihood, vulnerability and adaptation. Section 5.5 provides discussion of the findings, and section 5.6 concludes by stating the main findings and policy implications.

## **5.2 Climate Change and Migration**

Whilst a more general literature review related to the aim of this research has been outlined in Chapter 2, this section is devoted to a more focussed review related to Objective 2. This section reviews the most up-to-date literature on climate change and migration to outline the state-of-art, to identify gaps and weaknesses in the literature and to identify possible areas of contribution for this chapter. In particular, this section reviews how climatic and non-climatic factors drive the human migration process and considers what are the positive and negative outcomes of climate-induced migration. This section further shows the lack of evidence based research on outcomes of climate-induced migration within or outside the fisheries sector.

Climatic stresses and shocks such as sea level rise, flooding and land erosion displace millions of people throughout the world (IPCC, 2007a) and their number is predicted to increase due to climate change (Myers, 2002; Nicholls et al., 2011). Climate-induced migration is more likely in drought-prone areas, flood-prone river valleys, low-lying coastal plains, deltas and small islands where livelihoods are dependent on natural resources (McLeman and Hunter, 2010). Fishing communities typically live on low-lying coasts and islands exposed to multiple climatic stresses and shocks (Daw et al., 2009). Thus they may be subjected to climate-induced displacement and migration.

Climate change is not the only driver of migration, it is influenced by many other economic, political, social, and demographic drivers (McLeman and Smit, 2006; Black et al., 2011a; Black et al., 2011b; GOS, 2011; McLeman, 2011; Piguet et al., 2011). Lee (1966) suggested that drivers of migration can be grouped into 'push' and 'pull' factors. Push factors, such as adverse physical environment, operate at the point of origin and trigger emigration, whilst pull factors, such as job opportunities, operate at the destination and encourage immigration (Lee, 1966). Black et al. (2011b) consider that key reasons for migration are to improve income, join family members, escape persecution and avoid environmental and other threats. People also migrate because of limited adaptive capacity (Kates, 2000; Black et al., 2011b) created by lack of access to livelihood assets (Piguet et al., 2011). On the other hand, poor people may not have sufficient resources and assets to migrate (Piguet et al., 2011; Black et al., 2013b). Migration does not necessarily lead to a positive outcome: some people may migrate to destinations where they will be more vulnerable than before (Black et al., 2011b).



Slow-onset phenomena such as sea level rise may result in long-term migration, whereas rapid onset phenomena such as tropical cyclones may lead to temporary displacement (Piguet et al., 2011). Piguet et al. (2011) found that most studies of environmentally-induced migration have focussed on internal migration. Forced migration may happen because of conflict, development or conservation projects or environmental stress (Castles, 2003).

Climate-induced migration may reduce vulnerability or enhance adaptation to climate variability and change (Paavola, 2008; Warner et al., 2008; Black et al., 2011b). On the other hand, it may also lead to loss of assets, reduced opportunities and increased vulnerability (Hunter, 2005). Migration outcomes are influenced by the degree to which migrants depend on the environment for their livelihood and social factors mitigating or exacerbating the impact of climatic stresses and shocks (Kniveton et al., 2008). Migration distances are also important. Risks lessen when migrants resettle within customary lands (Kuruppu and Liverman, 2011) but increase with migration distance (Barnett and O'Neill, 2012).

The SLA, described in Chapter 2, suggests that the outcomes of migration can vary depending on the vulnerability context (trends, shocks and seasonality), migrants' livelihood assets (human, physical, social including political, financial and natural capital), and institutional structures and processes which mediate access to livelihood assets and opportunities (Scoones, 1998). Migration may reduce vulnerability by reducing exposure to climatic shocks and stresses (Warner et al., 2008) or by helping to diversify livelihoods and risks and build resilience (Paavola, 2008; Black et al., 2011b). Migration over shorter distances can create access to new livelihood assets and activities (Koczberski and Curry, 2005). Longer distance migration can generate financial capital (remittances) for members of households who do not migrate (Paavola, 2008).

Involuntary migration often leads to adverse livelihood outcomes or maladaptation (Mortreux and Barnett, 2009; Barnett and O'Neill, 2012). Forced migrants can face landlessness, un- or under-employment, homelessness, marginalization, food insecurity, reduced access to common-pool resources and ill health (Cernea, 1997). They may also lose their lifestyle, culture and identity (Mortreux and Barnett, 2009).

To conclude, climate variability and change can be an important driver of migration amongst fishing communities. Although many studies have investigated drivers of climate-induced migration, few studies have reported evidence on the outcomes of climate-induced migration which remain inconclusive. In the fisheries sector, the majority of studies to date have focussed on temporary seasonal migration in response to fluctuation of fish stocks (Daw et al., 2009) and as part of fishers' diversified livelihood strategy (Wouterse and Taylor, 2008). Much less research has studied permanent climate-induced migration, which is where this chapter aims to contribute.

### **5.3 Case Study, Materials and Methods**

#### **5.3.1 Case study**

This chapter examines two Bangladeshi coastal fishing communities to assess the outcomes of climate-induced migration for livelihoods, vulnerability and adaptation. Over the past four decades both gradual environmental change and extreme events such as floods and tropical cyclones have displaced millions of Bangladeshis (Walsham, 2010). People often migrate short-term to cope with extreme events (Paul and Routray, 2010; Black et al., 2011b). The link between extreme events and long-term migration is less well understood (Paul, 2005; Walsham, 2010; Penning-Rowsell et al., 2013). Land erosion and salinity intrusion are examples of environmental stresses that induce long-term migration (Penning-Rowsell et al., 2013). In the context of future climate change the coastal communities of Bangladesh are predicted to be exposed to more climatic shocks and stresses (see sections 3.2.1.1 and 3.2.1.3) which have the potential to displace more coastal people of Bangladesh including fishing communities.

This chapter examines two fishing communities – Kutubdia Para and Kutubdia Island – in the Cox's Bazar district of southern coastal Bangladesh (Figure 5). Section 3.2.2.3 finds that Kutubdia Island had been exposed to climatic shocks and stresses such as cyclones, floods and land erosion which ultimately drove migration for part of its households to Kutubdia Para between 1986 and 1997. For a more detailed description of these two communities see sections 3.2.2.2 and 3.2.2.3.

### **5.3.2 Data collection and analysis**

This chapter gathered qualitative and quantitative materials on fishery-dependent ‘migrant’ (Kutubdia Para) and ‘non-migrant’ (Kutubdia Island) households. A detailed description of the data collection process has been given in section 3.3. Structured household questionnaires (150) were used to collect quantitative data on livelihood capital assets, activities and distance from public services across the two communities. Oral history interviews (38), key informant interviews (15), vulnerability matrices (7) and FGDs (8) were used to gather qualitative materials on migration, vulnerability, coping and adaptation across the two communities. To ensure representative sampling of oral history interviews, vulnerability matrices and FGDs in each community, cluster analysis of household livelihood characteristics data was conducted (see section 3.4.1.1).

To determine difference in climatic exposure and livelihood characteristics, quantitative community scale data were analysed using descriptive statistics, while quantitative household scale data were analysed using descriptive statistics and z-tests. Qualitative data were transcribed in Bengali and analysed by using coding techniques of content analysis before translation (see section 3.4.2).

## **5.4 Vulnerability, Adaptation and Livelihoods of Non-migrants and Migrants**

### **5.4.1 Livelihood activities**

Both non-migrant and migrant households are involved in a range of livelihood activities, some related to fisheries and others not (Table 21). The structured household questionnaires and oral history interviews indicate that fishing and fish drying are two key livelihood activities. Over the years the proportion of fishing households has decreased, both among migrants and non-migrants. FGDs and oral history interviews indicate that fishermen in both communities catch fish with boats and gear in the far shore, typically 4-8 hours drive by motorised boat from the shore. The first fishing season runs from July to October and the second from December to June. Most fishermen catch fish during the second season. Between 3 and 30 people work on each boat during a fishing operation that lasts between 6 hours and 15 days.

Table 21. Livelihood activities in Kutubdia Island (non-migrants) and Kutubdia Para (migrants).

Category	Livelihood activity	Percentage of households engaged in activity		
		In original community in 1980s, before migration <sup>1</sup>	Among non-migrants in 2011 <sup>2</sup>	Among migrants in 2011 <sup>2</sup>
Fisheries related	Fishing in the sea	39	36	34
	Fish drying	48	12	66
	Boat renting	10	6	9
	Boat making and repairing	2	2	2
	Fish trading	4	4	4
	Net making and mending	6	6	4
	Shrimp post-larvae collecting	0	32	4
	Mollusc shell collecting	0	20	0
	Aquaculture	0	8	0
Non-fisheries related	Salt producing	32	66	2
	Agriculture	40	28	0
	Daily labouring	15	24	12
	Cattle rearing	20	12	7
	Shop keeping	4	8	3
	Temporary seasonal migrating for work	0	14	0
	Driving (rickshaw or motorcycle)	0	4	8
	Small furniture making	0	8	0
	Job	0	6	3
	Begging	0	4	0

<sup>1</sup>Estimated from qualitative data; <sup>2</sup>calculated from household questionnaires.

The number of households drying fish has increased among migrants but has decreased among non-migrants since 1980s (Table 21). Fish is dried in open air and is affected by rainfall, temperature and humidity. Today about 80% of fish is dried between November and February. In the past 15 years an extended drying period has emerged – the remaining 20% of fish is dried in September, October, March, April and May.

In both non-migrant and migrant communities households are also involved in other fishery-related activities such as boat renting, boat making and repairing, fish trading, and net making and mending. Three new activities – shrimp post-larvae collecting, mollusc shell collecting and aquaculture have emerged among the non-migrants since 1990s. A considerable proportion of non-migrant households are involved in non-fishery livelihood activities such as salt production, agriculture, wage labour and livestock rearing (Table 21).

### 5.4.2 Vulnerability, adaptation and livelihoods

The migrants' and non-migrants' exposure to cyclones and variations in temperature and rainfall are comparable and has not changed much over the past few decades (Table 22). Cyclones impact livelihoods by damaging fishing activities and assets threatening fisherfolk life in the sea, and by damaging land-based assets, activities and services. Interviews, vulnerability matrices and FGDs suggest that cyclones impact on fishing activities of non-migrant and migrant fisherfolk similarly, as both catch fish from the same source in the same way.

Table 22. Community exposure to climatic shocks and stresses over past few decades.

<i>Climatic shocks and stresses</i>	<i>Migrants</i>		<i>Non-migrants</i>		<i>Sources of data</i>
	<i>Mean</i>	<i>Standard Deviation</i>	<i>Mean</i>	<i>Standard Deviation</i>	
Number of flood events <sup>a</sup>	2	N/A	4	N/A	FGDs
Number of cyclone events <sup>a</sup>	4	N/A	4	N/A	FGDs
Land erosion (m/year) <sup>a</sup>	0.67	N/A	96.67	N/A	FGDs
Sea level rise (mm/year)	1.4 <sup>b</sup>	N/A	2.1 <sup>c</sup>	N/A	CEGIS (2006)
Variation in maximum temperature (°C) <sup>d</sup>	1.61	0.47	1.52	0.46	BMD (2011)
Variation in minimum temperature (°C) <sup>d</sup>	1.44	0.63	1.48	0.63	BMD (2011)
Variation in rainfall (mm) <sup>d</sup>	16.4	15.77	14.93	15.00	BMD (2011)

<sup>a</sup>Between 1981-2011.

<sup>b</sup>Mean change 1968-1991, Cox's Bazar station.

<sup>c</sup>Mean change 1969-2003, Lemsikhali station.

<sup>d</sup>Standard deviations of daily maximum temperature (°C), daily minimum temperature (°C), and daily total rainfall (mm) by month were averaged. Data between January 1981 and June 2011 from Cox's Bazar station (Kutubdia Para), and between January 1985 and December 2010 from Kutubdia station (Kuzier Tek).

Interviews and FGDs also indicate that temperature and rainfall changes have had little impact on fish drying during the normal drying period. During the extended drying period (e.g., in May 2011) the weather is more variable. During rainfall, hot temperature and humid weather, raw or semi-dried fish attracts blowfly and can be degraded by its larvae.

Non-migrants have been considerably more exposed to floods, land erosion and sea level rise than migrants in the past decades (Table 22). Non-migrants have experienced 4 major floods while migrants have experienced only 2 floods (Table 22). The tidal surges brought by cyclones did more damage to livelihoods among the non-migrants:

key informants reported that *Gorki* caused 667 and 9 deaths among the non-migrants and migrants, respectively. Oral history interviewees and vulnerability matrices participants suggested that almost all non-migrants' houses were destroyed or severely damaged by *Gorki* while only a half of the migrants had similar experience.

Non-migrants have been more exposed (96.67 m/year) to land erosion than migrants (0.67 m/year) (Table 22). Land erosion has displaced non-migrant households and destroyed land used for fish drying, agriculture, salt production and community infrastructure. One oral history interviewee told: "*I had to move my house 6 times due to land erosion. It has destroyed all – my trees, my fish drying business, my children's school*". Non-migrants have also been exposed to higher (2.1mm/year) sea level rise than the 20<sup>th</sup> century global trend of 1.7 to 1.8 mm/year (IPCC, 2007a). Sea level rise means higher tidal and surge waters, which are associated with higher rates of land erosion in non-migrant settlements.

Vulnerability to climatic shocks and stresses depends not only on the level of exposure but also on how a community or household can tackle them given their livelihood characteristics (IPCC, 2007a). Interviews and FGDs indicate that the livelihood characteristics of migrants and non-migrants were at first quite similar. Oral history interviews indicate that at first lack of livelihood assets and access to assets restricted livelihood activities and strategies in both communities. For the non-migrants this is because of damage to houses and land used for fish drying, fish landing, salt production and agriculture. The migrants experienced several hardships from food insecurity to violence in the first year after settlement. One FGD participant told: "*in the early days we had to eat wild fruits and musclemen from nearby town disturbed us*". Key informants and FGD participants explained that when the community became established, the government, donor agencies and NGOs built roads and a school, which improved their access to markets, education and other public services. The migrant households started commercial fishing and fish drying, and some of them became involved in net making and mending, shop keeping, tailoring and selling labour in the nearby town. The migrants considered that their livelihoods had improved year after year.

Currently, the migrants have more livelihood assets and enjoy better access to them (Table 23 presents their current livelihood characteristics). Their per capita income is over twice than that of non-migrants and the difference is statistically significant ( $p < 0.05$ ) in z-test. If own consumption of fish was accounted for, the income difference would be even greater as migrants consume three times more fish (2.89kg/month) than the non-migrants (0.94kg/month). The difference in consumption of fish is statistically significant between the households of the two communities. The migrants are healthier and fitter because of their access to safe drinking water and better nutrition. For example, heads of migrant households are able to work significantly more (342 days/year) compared to heads of non-migrant households (324 days/year). Migrants need only 5 minutes to access safe drinking water while non-migrants need 15 minutes to do the same and the difference is statistically significant. Better housing (the index of quality of house is significantly higher (2.04) among migrants than that of non-migrants (1.41)) gives more protection for the migrants against climatic shocks. They have better access to phones, sanitary toilets and electricity and are closer to markets and public services (see Table 23). This improved access again increases their capacity to cope with and adapt to climatic shocks and stresses. For instance, oral history interviewees told that greater use of phone and electricity increases the productivity and profitability of fish drying. They also suggested that better communication and proximity to government and disaster offices help cope before, during and after extreme weather events.

Table 23. Current livelihood characteristics in study communities.

<i>Livelihood characteristics</i>	<i>Non-migrants</i>		<i>Migrants</i>	
	<i>Mean</i>	<i>Standard Deviation</i>	<i>Mean</i>	<i>Standard Deviation</i>
Household size	6.30	3.01	6.36	2.94
*Age of household head (years)	43.46	14.74	37.37	10.09
Highest education (years of schooling)	6.66	4.28	6.84	3.04
Number of adult workforce	3.36	2.12	3.57	1.92
*Physical fitness of household head to conduct livelihood activities (days/year)	324	29	342	33
*Quality of house (see section 4.3.2)	1.41	0.88	2.04	1.53
Number of fishing or fish drying materials	0.22	0.68	0.31	0.49
Percentage of households use sanitary toilet	18	N/A	21	N/A
Percentage of households use phone	50	N/A	75	N/A
Percentage of households use radio or television	34	N/A	22	N/A
Percentage of households use solar or electricity for energy	14	N/A	55	N/A
Percentage of households use safe drinking water source	70	N/A	100	N/A
Percentage of households own transportation	2	N/A	12	N/A
Percentage of households possess land	10	N/A	7	N/A
Percentage of households possess tree	62		92	
*Per capita fish consumption (kg/month)	0.94	0.67	2.89	1.32
Percentage of households have livestock	70	N/A	70	N/A
Percentage of households have jewellery	62	N/A	93	N/A
Percentage of households have stored food	10	N/A	10	N/A
*Per capita income of households (TK) (see section 4.3.2)	16,577	24,942	34,374	46,875
*Percentage of income from fisheries source	56	36	92	16
Social capital (see section 4.3.2)	9.08	0.97	9.38	1.70
*Number of income generating activities	2.78	0.95	1.73	0.93
*Time involvement in fisheries (days/year)	139	78	216	25
<i>Time needed to reach the nearest public services (minutes)</i>				
*Cyclone shelter	18.54	20.12	39.10	7.89
*Safe drinking water source	15.34	21.97	4.91	6.05
*Market	33.18	28.03	15.51	7.85
*Disaster office	43.70	28.92	31.31	6.46
*Government office complex	45.00	28.41	31.31	6.46
Hospital or clinic	35.52	26.85	30.24	6.98
*Educational institution	20.46	19.05	11.49	8.54

\*Statistically significant ( $p < 0.05$ ) difference exists in z-test.

Non-migrants use radio or television more (Table 23) than migrants, which offers the former better access to information such as weather forecasts. But migrants use phones more as an alternative access to information. Interviews and FGDs indicate that more cyclone shelters have been built after the island was hit by cyclone *Gorki* in 1991. Non-migrants live closer to cyclone shelters (Table 23) but interviews, vulnerability matrices and FGDs indicate that the island's cyclone shelters suffer from lack of capacity and maintenance and cannot be used to store food, clothes and water, or assets such as



livestock, fishing gear and fish. Although the migrants need more time to reach a cyclone shelter, they are better placed to save their lives and assets. For instance, according to oral history interviewees, they could take shelter in and move most of their assets to the nearby Cox's Bazar town during cyclone *Gorki*.

Migrant households are more dependent on marine fisheries for their income, employment and nutrition than non-migrant households (see Table 23). Whilst improving livelihood outcomes in the short-term, greater dependency on climate-sensitive fisheries may not be sustainable longer-term (Allison et al., 2009b). But migrants have more income they can invest in diversifying their livelihoods. Oral history interviews show that the wealthier migrants are already investing more in their children's education and others are keen to do so, with the hope that their children will obtain more secure livelihoods in the future. Finally, whilst non-migrants have a larger number of livelihood activities than migrants it has not resulted in higher incomes (Table 23): interviews and FGDs suggest that most livelihood activities on the island offer only part-time or occasional involvement. As one FGD participant noted: "*we have low income jobs here. We do not have any work about half of the year.*" Thus their livelihood diversification responded to lack of better opportunities. For example, FGDs revealed that land erosion destroyed fish drying fields, curtailing this activity and pushing people to part-time and low-income activities such as shrimp post-larvae collection (started in 1997, providing income for 2-3 months per year for about one fifth of a household's daily financial needs) and mollusc-shell collecting (started in 2004, generating less income than shrimp post-larvae collecting).

Non-migrants face a difficulty in continuing their livelihoods and most of them are desperate to migrate away from the island. But they cannot do so due to lack of assets and outside support, and the uncertainty of livelihoods at the destination. Structured household questionnaires indicate that they have little or no savings or assets that they could sell to cover the costs of migration. FGDs and vulnerability matrices also suggest that there are no buyers for their land because of erosion risk. Although banks and micro-credit providers exist, most households do not have access to credit because they do not have collateral. Micro-credit is also insufficient to cover the costs of migration and oral history interviews indicate that there is distrust between the households and microcredit lenders. Non-migrants also have covariate risks which make networks less

useful. They have substantial amount of social capital and extensive networks (see Table 23) but oral history interviews indicate that relatives and contacts are also poor, and therefore cannot provide sufficient support or assistance needed to meet the costs of migration. Moreover, about a third of non-migrant households are indebted to neighbours and relatives: repaying the loans has greater priority than migration to maintain their social status. FGDs show that this indebtedness is due to borrowing money during the seasons of the year when they do not have income generating activities to do.

A third of non-migrant households consider that their old age restricts their income, livelihood activities and is a barrier to migration. Structured household questionnaires indicate that heads of non-migrant households are significantly (showed in z-test) older (43.46 years) than heads of migrant households (37.37 years): 22% of heads of non-migrant households are 60 years or older while this is true of only 4% heads of migrant households. About 10 % of heads of non-migrant households are female, which also restricts their migration. Oral history interviews and a FGD (that was conducted with women only) suggested that women have less income earning opportunities in the community. On Kutubdia Island, adult women, apart from widowers and divorcees, are not allowed to work outside their home. They are only involved in fishing gear making and mending, and small-scale fish drying on their yards. Female-headed households would also face greater livelihood uncertainty in the destination of migration.

## **5.5 Discussion**

This section provides specific discussion related to this chapter only, while more general discussion integrating this chapter, the previous chapter and the next chapter is provided in Chapter 7.

The results of this chapter contradict the literature which suggests that climate change-induced migration may result in adverse outcomes or maladaptation (Reuveny, 2007). The findings corroborate with the literature suggesting that climate induced migration *may* bring considerable positive outcomes for migrants (Black et al., 2011b).

The results highlight that migration to Kutubdia Para has yielded several positive outcomes for the migrants. They are less exposed to floods, sea level rise and land erosion, and their exposure to cyclones and variations in temperature and rainfall is no worse than that of non-migrants. The results resonate with Warner et al.'s (2008) argument that migration can reduce exposure to climate change impacts. The migrants have more livelihood assets and have better access to them. They have improved opportunities to engage in livelihood activities and access to markets, communication and public services. These factors have increased income generation potential among the migrants (Koczberski and Curry, 2005).

These positive outcomes did not materialise immediately though. The migrants struggled with the loss of assets, conflicts and uncertainty in the aftermath of migration, part of which resonates with the arguments of Reuveny (2007) that migration may bring about conflicts. However, the situation started improving within a few years, positive livelihood outcomes reducing the migrants' vulnerability and increasing their capacity to cope with and adapt to climate impacts. There was also public legitimization of relocation and support for it. Migrants however remain dependent on climate-sensitive marine fisheries. The migrants can invest their higher incomes in more climate resilient livelihood strategies such as businesses or build human capital by investing in education (some parents are already doing so), however, enabling diversification away from climate-sensitive livelihoods.

The households that remained on Kutubdia Island have maintained more diversified livelihoods but their incomes are substantially lower in a situation where they are both exposed and vulnerable to climate impacts. Natural resource dependent rural households often spread risk and reduce vulnerability by diversifying livelihoods and income sources in this way (Chambers et al., 1989; Ellis, 2000; Allison and Ellis, 2001). However, while diversified livelihoods may help managing risks, they may not improve incomes: diverse livelihood activities like those on Kutubdia Island may only provide part-time or occasional involvement and modest economic returns (see Paavola, 2008).

This chapter concludes that migration has been a viable strategy to cope with climate variability and to adapt to climate change for those households that migrated from Kutubdia Island to Kutubdia Para in mainland Bangladesh. Sea level rise, land erosion,

cyclones and flooding will be the most important climate change impacts facing the migrants and non-migrants in the future. The migrants are likely to be less impacted than non-migrants if they can reduce dependency on fishery-related activities. Fish drying may be negatively impacted by climate change impacts particularly during the extended period. However, the vast majority of fish is dried in the normal period which limits the potential impact. Moreover, new technologies such as solar driers are becoming available to avoid adverse climate change impacts. In addition, the migrants in Kutubdia Para suffer less from land erosion and are on mainland close to a town, which offers better access to livelihood assets and services.

## **5.6 Conclusion**

This chapter assessed the outcomes of migration by comparing a climate-induced resettled coastal fishing community with its original one in Bangladesh. A multi-method approach that used both quantitative and qualitative data was adopted. The results suggest that climate induced migration can result in positive livelihood outcomes, reduced vulnerability and increased capacity to cope with climate variability and to adapt to climate change. Therefore, migration *may* be a feasible strategy to cope with and adapt to climate change and does not necessarily lead to maladaptation.

To address the challenges the migrants are facing (i.e., reduce dependency on fisheries) and to ensure long-term resilience to climate induced shocks and stresses, the migrant community could invest part of their income into non climate-sensitive livelihood activities; and enhance their human capital by education and training to help diversify livelihoods.

The non-migrants have not been able to reduce their vulnerability or to increase their ability to cope with climate variability or to adapt to climate change. They have become trapped in a vulnerable position. External intervention and support (from the national government and beyond) will be needed. Protecting them would require a dike around the island, which is unlikely to be built given limited resources in Bangladesh. Migration to a mainland location remains an alternative. However, non-migrants are unlikely to be able to migrate on their own due to their limited assets. In light of experience of the migrants, government could foster resettlement legitimacy in carefully

chosen destinations that reduce exposure to climate change impacts and provide access to livelihood activities and assets.

This research highlights that migration is a complex and contextual phenomenon. More evidence is needed on its merits from other contexts. Given the dependence of outcomes of migration on policies and politics, it may be difficult to generalise about the potential of migration as a response to climate change. Any initiatives to rely on migration as a coping or adaptation strategy would need to carefully assess the potential destinations and the support needed to ensure resettled communities are better off over the short- and long-term.

Migration is only one example of coping with or adapting to climate variability and change. There are many other strategies that fishing communities adopt which can be constrained by multiple limits and barriers which are examined in the next chapter.

## **Chapter 6 – Limits and Barriers to Adaptation of Fishing Activities to Climate Variability and Change**

### **Summary**

Limits and barriers to adaptation restrict people's ability to address the negative impacts of climate change or manage risks in a way that maximises their wellbeing. There is a lack of evidence of this on small-scale fishing communities in developing countries. This chapter identifies and characterises limits and barriers to adaptation of fishing activities to cyclones and examines interactions between them in two fishing communities in Bangladesh, using household questionnaires, oral history interviews, vulnerability matrices and focus group discussions. The limits include physical characteristics of climate and sea such as higher frequency and duration of cyclones, and hidden sandbars. Barriers include technologically poor boats, inaccurate weather forecasts, poor radio signals, lack of access to credit, low incomes, underestimation of cyclone occurrence, coercion of fishermen by the boat owners and captains, lack of education, skills and livelihood alternatives, unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets. These local and wider scale factors interact in complex ways and constrain completion of fishing trips, coping with cyclones at sea, safe return of boats from sea, timely responses to cyclones and livelihood diversification. The findings indicate a need for further detailed research into the determinants and implications of such limits and barriers, in order to move towards an improved characterisation of adaptation and to identify most suitable means to overcome the limits and barriers.

### **6.1 Introduction**

Adaptation is inevitable to address the impacts of climate variability and change but adaptation efforts are impeded in many ways. Limits and barriers to adaptation restrict people's ability to identify, assess and manage risks in a way that maximises their wellbeing (IPCC, 2007a; Adger et al., 2009b; Moser and Ekstrom, 2010; IPCC, 2012). Limits are obstacles that are in some sense absolute (Adger et al., 2007), while barriers are mutable (Adger et al., 2009a). Limits and barriers to adaptation arise due to certain characteristics of the people involved, the nature of a specific system and/or the larger

context within which the people and systems operate (Moser and Ekstrom, 2010). Barriers to adaptation can prevent the development and implementation of adaptations from taking place (Adger et al., 2007). Due to presence of barriers high adaptive capacity does not necessarily translate into successful adaptation (O'Brien et al., 2006).

Small-scale fisheries that support livelihoods of more than 90% of capture fisherfolk and produce about 50% of global seafood catches (FAO, 2012) are impacted by climate variability and change. These impacts include not only those on fish populations (Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010) but also on the livelihoods of the dependent communities (Allison et al., 2005; Westlund et al., 2007; Coulthard, 2008; Perry et al., 2009; Badjeck et al., 2010). To minimise these impacts and take advantage of opportunities they need to adapt successfully. Morgan (2011) predicts that due to the high vulnerability of fisherfolk and a heavy reliance on specific fisheries for income, fishing communities may face considerable limits and barriers to adaptation to climate change. Many of these limits and barriers are interrelated and combine to constrain adaptation (Adger et al., 2007; Jones and Boyd, 2011). But there is a lack of evidence on limits and barriers to adaptation and interactions between them. The objective of this chapter is to identify and characterise the limits and barriers to adaptation of fishing activities to cyclones and examine interactions between them, gaining insights from two coastal small-scale fishing communities in Bangladesh.

In what follows, section 6.2 reviews the existing literature on limits and barriers to climate related adaptation. Section 6.3 describes the case studies and methodology. Section 6.4 identifies and characterises the limits and barriers to adaptation. Section 6.5 examines the interaction between limits and barriers, situates findings into other literature and discusses the theoretical contribution. Section 6.6 concludes by highlighting the main findings and practical implications.

## **6.2 Limits and Barriers to Adaptation to Climate Variability and Change**

The general literature review related to the aim of this research has been outlined in Chapter 2. This section is devoted to a more focussed review related to Objective 3. It reviews the most up-to-date literature on limits and barriers to climate change

adaptation to outline the state-of-art, to identify gaps and weaknesses in the literature and to identify possible areas of contribution for this chapter. Particularly this section reviews concepts and different types of limits and barriers, how they constrain adaptation and how they interact. This section further shows the scarcity of evidence based research on limits and barriers to adaptation in fishing activities to climate variability and change.

Adaptation is the “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2007a, p. 869). In many cases local adaptation measures are reactive and short term (coping strategies) (Bohle, 2001) which can limit the scope for adaptation in the longer term (IPCC, 2012). In this chapter, both short- and long-term responses are regarded as adaptation. Limits and barriers to local adaptation measures can emerge at multiple spatial and temporal scales (Adger et al., 2005a).

Some distinguish limits and barriers to adaptation, while others use the terms interchangeably. This chapter considers limits as “the conditions or factors that render adaptation ineffective as a response to climate change and are largely insurmountable” (Adger et al., 2007, p. 733). These limits are faced when thresholds or tipping points associated with social and/or natural systems are exceeded (IPCC, 2012). On the other hand, “barriers are the conditions or factors that render adaptation difficult as a response to climate change” (Nielsen and Reenberg, 2010, p. 142) but they are often mutable (Adger et al., 2009a) or can be “overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc.” (Moser and Ekstrom, 2010, p. 22027).

Limits and barriers to adaptation can be natural, technological, economic, social or formal institutional. Natural limits range from ecosystem thresholds to geographical and geological limitations (Jones and Boyd, 2011). Dramatic climate change may alter the physical environment so as to limit adaptation possibilities (Nicholls and Tol, 2006). The limits of adaptation will also depend on the inherent sensitivity of some ecosystems, habitats and species (Adger et al., 2007). The impacts of climate change surpass critical thresholds (Adger et al., 2007) and cause ecosystem regime shifts (Scheffer et al., 2001), which in turn can limit economic and social adaptation (van



Vliet and Leemans, 2006) especially of communities those directly depend on ecosystems such as fisheries and agriculture (Adger et al., 2007).

Technological barriers (sometimes classified as limits if unaffordable) to adaptation include lack of hard engineering structures (e.g., Reeder et al., 2009) but lack of smaller equipment, tools and techniques may also constrain adaptation. Although some adaptations may be technologically possible, they may be constrained by economic and cultural barriers (Adger et al., 2007). Technological barriers may also lead to inaccurate information due to, for example, limitations in modelling the climate system or lack of accurate weather forecasts. Insufficient information and knowledge on the impacts of climate change may continue to hinder adaptation particularly in Asia (Cruz et al., 2007).

Economic barriers constrain adaptation of low-income households and communities (Adger et al., 2007). Mahon (2002) contended that cost of vessel insurance, gear replacement, repairs, operation, safety measures and increased investment were all barriers to adaptation among fishing communities. In agricultural communities, lack of financial capital is one barrier to adaptation, such as adoption of improved crop varieties and diversification of livelihoods (Smit and Skinner, 2002). In recent years microfinance has emerged in many developing countries but it does not often reach the poorest and most vulnerable groups (Amin et al., 2001; Helms, 2006). Budget constraints can also pose a barrier when adaptation measures involve high upfront cost. Those with limited financial capital will focus on short-term gain rather than on the potential long-term benefits of reduced vulnerability (Kunreuther et al., 1978; Thaler, 1999).

Some studies have pointed out the significance of social barriers to adaptation (Lof, 2006; Coulthard, 2008; Adger et al., 2009a; Jones and Boyd, 2011). Adger et al. (2009a) suggest that ethics (how and what people value), knowledge (how and what people know), risk (how and what people perceive) and culture (how and what people live) are key aspects of social barriers. Thus social barriers are concerned with the social and cultural processes of society (Jones and Boyd, 2011) including informal institutions and human capital. Depending on worldviews, values and beliefs, people perceive, interpret, and think about risks and their adaptation to them (Adger et al., 2007; Moser

and Ekstrom, 2010). People frequently underestimate the possibility of the occurrence of climate events even if they are aware of the risks (Smith and McCarty, 2006). Some empirical studies have shown that individuals may not seek information on these possibilities of the occurrence of climate events before making their decisions (Magat et al., 1987; Camerer and Kunreuther, 1989; Hogarth and Kunreuther, 1995). Barriers may also exist in locally-organised collective action because of the difficulties of building effective coalitions with organisations of interest (IPCC, 2012). Leadership can be critical carrying out adaptation actions; lack of leadership can create barriers, whereas effective leadership can help overcome barriers (Moser and Ekstrom, 2010).

Formal institutional barriers may constrain adaptation because they define the processes and rules that govern and regulate access and entitlement to livelihood assets (DFID, 1999). The ways in which actors are able to access assets play a role in determining their vulnerability and ability to cope with and adapt to stress (Kelly and Adger, 2000). Institutions can restrict the choice of livelihood strategies for some people; on the other hand they can open up opportunities for others (Scoones, 1998) and favour some groups over others (Sallu et al., 2010). Institutional barriers have limited the ability of the rural communities to cope with extreme climate events by limiting access to markets and in terms of unfavourable development policies (O'Brien et al., 2004b; Eakin, 2005).

The discussion above indicates that a range of limits and barriers may influence adaptation to climate variability and change by stopping, delaying or diverting the adaptation process (Moser and Ekstrom, 2010). Empirical studies on limits and barriers to adaptation to climate change have been published in biological, agronomic, economic, sociological, psychological, and urban planning literature. Few studies have focussed on the limits and barriers to adaptation and interaction among them in fisheries sector. A number of studies have developed theoretical frameworks for limits and barriers (e.g., Adger et al., 2009a; Moser and Ekstrom, 2010). More empirical studies are needed to aid adaptation decision-making. As Moser and Ekstrom (2010, p. 22029) suggest “more systematic empirical research must be undertaken to verify our observations”. Most of the studies published to date focus on agricultural communities (e.g., Jones and Boyd, 2011; Oxfam, 2011). The studies on fisheries and climate change have largely focussed on physical climate impacts on oceanic productivity and fish production (e.g., Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010), and

macro scale impacts on economies and society (e.g. Allison et al., 2009b; Quest-Fish, Undated). A limited number of recent studies have focussed on impacts, vulnerability and adaptation to climate variability and change in fishing communities and on their livelihoods (e.g., Coulthard, 2008; Badjeck et al., 2010), but very few of them have examined limits and barriers. This study seeks to fill the gap by identifying and characterising limits and barriers to adaptation of fishing activities to cyclones and examining interactions between them in two small-scale fishing communities in Bangladesh. This chapter focusses only on fishing related limits and barriers because fishing is one of the main livelihood activities in the two communities (see sections 3.2.2.1 and 3.2.2.2). This research focusses on both minor and major cyclones as these are the main climate shocks affecting fishing activities (see sections 3.2.2.1 and 3.2.2.2).

## **6.3 Case study, Materials and Methods**

### **6.3.1 Case study**

This chapter assesses limits and barriers to adaptation in the fishing activities in two mainland communities: Padma, and Kutubdia Para (Figure 5). Section 3.2 describes the Bangladesh context and these two communities as well as explains why they were selected. Overall, the two communities share some characteristics but also have some different physiographic contexts, livelihood characteristics and they are located in different administrative areas. Kutubdia Island has not been included here because section 3.2.2 and Chapter 5 show that this island has considerably different physiographic context and livelihood characteristics of its households compared to Padma and Kutubdia Para, thus comparing this island community with the mainland communities may lessen the scope of generalisation of theory (limits and barriers to adaptation) from findings.

Unlike Chapters 4 and 5, this chapter focuses on only a subset of the population, i.e., those households involved in fishing activities. Due to the absence of related secondary information the remainder of this section is based on the primary data collected (see section 6.3.2). The structured household questionnaire data (see Table 24) demonstrates that livelihood characteristics of fishing-dependent households vary, to some extent but not considerably, between the two communities. Average level of education is somewhat higher in Padma's households than that of Kutubdia Para's, while average

household size, age of household head, experience in fishing activities, income from fishing and time involvement in fishing are higher in Kutubdia Para's household than those of Padma's. Average per capita income is almost the same between them but the standard deviation is much higher among Padma's households.

Most households in the two communities directly depend on fisheries; small-scale fishing in the Bay of Bengal is one of their main livelihood activities. Some characteristics of their fishing activities have already been described in section 3.2.2. In addition, Table 25 reports the main characteristics of fishing activities and their exposure to cyclones. Three types of actors are involved in fishing – boat owners (investors), boat captains and fishermen (boat crews). A boat owner provides a boat and materials, and appoints a captain who is in turn responsible for running fishing trips and appointing crews.

Table 24. Livelihood characteristics of fishing-dependent households (source: structured household questionnaires – see section 3.3.1).

<i>Characteristics</i>	<i>Padma</i>		<i>Kutubdia Para</i>	
	<i>Mean</i>	<i>Standard deviation</i>	<i>Mean</i>	<i>Standard deviation</i>
Household size	4.64	1.26	5.85	1.78
Age of household head (years)	36.80	10.08	37.15	8.23
Experience in fishing (years)	14.64	9.37	18.29	8.75
Highest level of education (years)	6.81	2.08	5.50	2.22
Income from fishing (%)	89.34	18.01	94.80	12.63
Per capita income (TK/year)	20,873	29,460	20,885	13,657
Time involvement in fishing (days/year)	199.21	39.74	227.06	23.55

Table 25. Characteristics of fishing activities and their exposure to cyclones (source: structured household questionnaires and qualitative data – see section 3.3).

<i>Characteristics</i>	<i>Padma</i>	<i>Kutubdia Para</i>
Fishing areas	Bangladeshi coastal waters in the northwest Bay of Bengal	Bangladeshi coastal waters in the northeast and northwest Bay of Bengal
Fishing season	July to October; one third also operates December to April	December to June; one third also operates July to October
Type of boat	15-50 feet wooden boats with 20-60 Horse Power engines	15-65 feet wooden boats with 40-110 Horse Power engines
Number of fishermen work per boat	3-18	3-30
Duration of a fishing operation	6 hours-15 days	6 hours-15 days
Distance of fishing area from mainland (km)	2-30	2-35
Cost for making a boat with engine (TK)	100,000 - 1,650,000	100,000 – 2,500,000
Primary species of fish harvested	Hilsa shad ( <i>Tenualosa ilisha</i> ), croaker ( <i>Johnius</i> spp), goby ( <i>Taenioides cirratus</i> ), skates and rays	Bombay duck ( <i>Harpadon nehereus</i> ), ribbon fish ( <i>Lepturacanthus savala</i> ), Gangetic hairfin anchovy ( <i>Setipinna phasa</i> ), Indian river shad ( <i>Gudusia chapra</i> ) and hilsa shad
Exposure to cyclones over the past 3 decades	Major cyclones in 2005 and 2007 ( <i>Sidr</i> ); 5-7 minor cyclones each year	Major cyclones in 1991 ( <i>Gorki</i> ) and 1997; 5-7 minor cyclones each year

In both communities, boats usually have diesel engines and radios. Offshore boats do not receive radio signal. Kutubdia Para’s boats are better than those in Padma: they are bigger in size, have more powerful engines and are made more robustly. In addition, some of them are equipped with life jackets and navigation instruments, which are mostly absent on Padma’s boats. At the end of fishing trips, the fish (all of Padma and half of Kutubdia Para) are sold at auction markets controlled by the commissioning agents.

In both communities, their fishing activities have been exposed both to major and minor cyclones over the past 30 years (Table 25). Major cyclones have caused major destruction while minor cyclones affect fishing in the two communities by creating the abandonment of fishing trips, and sometimes damaging boats or killing fishermen.

### 6.3.2 Data collection and analysis

Eighty nine and thirty four percent of all fishery-dependent households are involved in fishing activities in Padma and Kutubdia Para, respectively. The heads of these

households are boat owners, boat captains or fishermen from whom data were collected. Ninety nine percent of these household heads are male.

A multi-method approach that combines both qualitative and quantitative methods was used to collect data. See section 3.3 for more about the data collection process. Structured household questionnaires (89 in Padma and 34 in Kutubdia Para) were used to collect quantitative and qualitative livelihood data from randomly selected participants. Oral history interviews (20 in Padma and 10 in Kutubdia Para) were also employed to gather rich, detailed and contextually grounded qualitative data on adaptation to climate variability and change, and limits and barriers to such adaptation across the two communities. To triangulate the above data vulnerability matrices (5 in Padma and 4 in Kutubdia Para) and FGDs (5 in Padma and 4 in Kutubdia Para) were also used.

Quantitative data were analysed using descriptive statistics. Qualitative data were transcribed in original language (Bengali) and analysed using content analysis (by coding techniques) before translation (see section 3.4.2).

## **6.4 Limits and Barriers to Adaptation of Fishing Activities to Cyclones**

Cyclones are identified in both communities as the main climatic shocks impacting on fishing activities. To cope with and adapt to them people use many strategies that are constrained by a number of limits and barriers (Table 26). In what follows, how adaptation strategies are constrained by limits and barriers as well as interactions between them are discussed.

### **6.4.1 Natural limits**

The Bay of Bengal is a major cyclone prone area in the world (Gray, 1968). The participants have found that the rate and duration of cyclones have increased over the past 20-30 years. They consider that major cyclones such as *Sidr* and *Gorki* prevent completion of fishing trips by destroying fishing assets, killing fishermen, and complicating coping mechanisms at sea and safe return of boats from sea. The participants also consider that minor cyclones also constrain fishing activities but to a lesser extent. But minor cyclones occur 5-7 times a year and their cumulative impacts

over several years may be greater than those of major cyclones that occur once in several years. Consequently, minor cyclones may be more of a threat to livelihoods than the uncertain risk of major cyclones. When explaining the difficulty in responding to these cyclones, a participant from Padma said in his oral history interview that “*the cyclones resulted in rough seas with stronger winds and bigger waves. The waves lifted our boat several feet and damaged it*”.

You discuss the super cyclones, and also the minor cyclones which affect fishing activities ‘to a less extent’. The effects may be less, but if they occur more frequently (e.g. if they inhibit fishing activities during the cyclone season, several times a year) perhaps their impacts are greater? Please clarify this point in the text. The greater frequency of small cyclones (inhibiting normal fishing practice) may be more of a threat to livelihoods than the uncertain risk of more super cyclones? (This is especially so given the comment on p.137 that boat owners coerce fishers to fish in cyclones!)

Table 26. Limits and barriers to adaptation of fishing activities to cyclones in Padma and Kutubdia Para.

<i>Form of limit and barrier</i>	<i>Observed by Padma’s respondents</i>	<i>Observed by Kutubdia Para’s respondents</i>
Natural	Higher frequency and duration of cyclones, and hidden sandbars	Higher frequency and duration of cyclones, and hidden sandbars
Technological	Absence of radio signal offshore, inaccurate cyclone forecast, lack of safety equipment and navigational instruments, and poor quality boats and engines	Absence of radio signal offshore, inaccurate cyclone forecast, and lack of safety equipment and navigational instruments
Economic	Low incomes and lack of access to credit	Low incomes and lack of access to credit
Social	Lack of education, skills and livelihood alternatives, underestimation of cyclone occurrence, and coercion of fishermen by the boat owners and captains	Lack of education, skills and livelihood alternatives, and underestimation of cyclone occurrence
Formal Institutional	Unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets	Unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets

Two thirds of the boat captains in both communities consider that when attempting to retreat to safe places they are also constrained by hidden sandbars in near shore areas. One boat captain from Padma said in his oral history interview that “*during cyclonic weather I could not locate the sandbar as the sea became turbid...my boat stuck into the bar and was damaged by the waves*”.

#### **6.4.2 Technological barriers**

Some technological barriers are similar in the two communities while others differ between them (Table 26). One third of boat captains in both communities, who catch fish offshore, cannot receive the weather forecast because of absence of radio signal. Their chance of being exposed to cyclones therefore increases and they are not able to return safely to shore in time. Two thirds of those who catch fish onshore do get radio signal but in most circumstances they cannot return safely in time due to shortcomings in the forecasting of cyclones. Oral history interviewees indicate that sometimes there are cyclones in the sea although no forecast is broadcast on the radio. Sometimes when forecasts are broadcast, no cyclone actually occurs. Finally, sometimes forecast comes too late to enable safe return. One oral history interviewee from Kutubdia Para stated that *“we heard the forecast too late both in 1991 and 1997. In both cases we experienced huge loss”*. Hence, inaccurate weather forecast can increase exposure to cyclones.

Oral history interviews highlight that in both communities when captains feel that a cyclone is going to occur, they abandon the fishing trip and try to return to shore. But Padma's boats struggle more to return as well as to stay in the sea at the onset of or during cyclones. A few hours are not enough to return to shore with less powerful engines and without navigational instruments. Their weaker boats are damaged more easily and pose threats to fishing assets and the life of fishermen. Sometimes boats capsize and as 97% of them do not have proper safety equipment (e.g. life jackets), risks to fishermen's life increase. They rely on inadequate measures such as tying net floats together or using plastic drums or bamboo as floats. One fisherman from Padma recalled in his oral history interview that *“...there was no life jacket on the boat and we struggled to drift using floats or plastic drums when a cyclone hit”*.

#### **6.4.3 Economic barriers**

Economic barriers are more pertinent in Padma than in Kutubdia Para (Table 26). In both communities fishermen consider fishing as risky activities due to cyclones and most of them do not want to continue to fish. However a number of barriers prevent them diverting from fishing. During oral history interviews they have identified that low



incomes and lack of access to credit to invest in alternative livelihood activities are two key barriers. Per capita household income is only around 21,000TK/year in the two communities (Table 24). To express the level of income, access to credit and desire to divert away from fishing, an oral history interviewee (fisherman) from Padma said “*I am poor and do not have sufficient access to credit... fishing in the sea is risky. If I had money I would do business inland as there is no risk on life there*”.

Padma’s boat owners have limited access to formal credit. Household questionnaires indicate that formal sources of credit (banks and NGOs micro-credit) provide only 8% of the credit needed in fishing businesses and charge an interest rate of between 16 and 35% per year. Due to lack of access to formal credit with low interest, the boat owners invest their own savings (provide 12% of total credit) and take informal credit with high interest rates to run their businesses. Local informal money lenders provide 18% of the credit but charge 100% interest per year. *Dadondars* (another type of informal money lender) provide 62% of the credit but charge 2% on fish revenue equating to an interest rate of between 120 and 240% per year, indirectly. Oral history interviewees from Padma emphasise that they need to catch substantial amounts of fish during the fishing season to repay the credit and interest and to gain some profit. Catching substantial amounts of fish requires completing most of the fishing trips even in cyclonic conditions, which increases exposure to cyclones and the chance of loss of boats, gear and life. To minimise the loss of boats and gear, the boat owners in Padma minimise capital investment. Most fishermen said in oral history interviews that boat owners use cheaper and less durable materials to make boats, cheaper and less powerful engines, and do not provide life jackets or modern equipment. This strategy can be treated as maladaptation as it reinforces technological barriers and increases risks for the fishermen.

In contrast Kutubdia Para’s boat owners have better access to formal credit. Household questionnaires suggest that boat owners in Kutubdia Para obtain credit for running fishing businesses from the same sources as Padma. However, in Kutubdia Para, formal, own savings and informal sources provide 42%, 18% and 40% of total credit, respectively. This means that the boat owners do not need to rely mainly on informal credit with higher rates of interest but have better access to formal credit with much lower interest rates. Abandonment of few fishing trips due to cyclonic weather does not

create a problem for them to repay the credit and interest, and to gain some profit. This is one of the reasons why the boat-owners in Kutubdia Para do not induce fishermen catching fish in cyclonic conditions and do not reduce capital investment.

#### **6.4.4 Social barriers**

Social barriers are also more pertinent in Padma than in Kutubdia Para (Table 26). Diverting away from fishing activities is constrained, in both communities, by lack of education and skills for alternative livelihoods, and limited availability of alternative livelihood activities. Due to low levels of education (Table 24) people struggle to obtain jobs. Most people have only fishing skills learned from their forefathers. As explained by an oral history interviewee from Padma *“I am illiterate and not qualified to get a job; I do not have any other skills [than fishing] to change my profession”*. This lack of education and skills is, according to all interviewees, due to low incomes and lack of access to formal credit. Current non-fishery based activities (such as daily labouring) employ people on a part-time basis and are less well paid than fishing, making them less economically viable options.

Inaccurate cyclone forecasts have led to an underestimation of occurrence of cyclones in both communities. Oral history interviews suggest that despite cyclone forecasts boat captains frequently think that no cyclones will occur and are reluctant to return at the onset of cyclones. This underestimation increases exposure of boats and fishermen to cyclones and prevents timely response to cyclones when they occur.

Thirty percent of the fishermen in Padma claim that their boat captains and owners coerce them to catch fish in minor cyclones. Cyclones of scale 3 or above are considered dangerous by the Government of Bangladesh (MODM, 1998). These fishermen are often forced to continue fishing up to scale 5 cyclones. This strategy generates positive economic outcomes for boat owners and captains (captains who can lead to catch more fish are more paid) but risks the safety of fishermen. The fishermen cannot resist because of fear of punishment by the boat owners' trade union (cooperative society). Thus coercion poses a barrier to adaptation. As one of the boat owners from Padma said: *“...they [fishermen] must obey the guidelines imposed by us [boat owners]. If they do not, they are punished by our trade union”*. The punishment can include exclusion from fishing in the following fishing season and a fine. The boat

owners' trade union in Kutubdia Para differs. Whilst fishermen are persuaded to maximise catch they are not punished if the catch is reduced by cyclones.

#### **6.4.5 Formal institutional barriers**

In both communities, the unfavourable credit schemes reinforce economic barriers. The oral history and FGD participants reported that obtaining formal bank credit requires assets as collateral, education, knowledge of the credit system and good relationships with credit providers. Almost all fishermen in both communities, most of the boat owners in Padma, and half of the boat owners in Kutubdia Para do not have the prerequisites for obtaining credit. The participants find that obtaining microcredit does not require similar prerequisites but that it poses limitations: low amounts of credit (10,000 to 30,000TK), rigid and frequent (weekly) repayments, and de facto resources for collateral (micro-credit does not formally require collateral but credit providers still need to be confident that there will be no interruption in interest payment).

All the participants reported that piracy occurs in some of the fishing areas because of lack of enforcement of maritime laws. Padma's participants in vulnerability matrices ranked piracy as the main non-climatic factor affecting fishing activities negatively. The pirates sometimes take money before fishing, rob fish and fishing assets, and keep people on-board as hostages for ransoms. One boat owner from Padma said in his oral history interview that *"I need to buy 2 tokens [informal money receipts] at the cost of 40,000TK from two groups of pirates in a season to do fishing"*. In few cases the pirates have killed fishermen and captains if they resist or do not provide ransom. Together, piracy increases investment and incurs economic losses for the fishing business, thereby reinforcing economic barriers.

All participants observed that overfishing has occurred near-shore due to lack of enforcement of fishing regulations. Near-shore overfishing pushes boats further from shore where they are more exposed to cyclones.

Lack of enforcement of fishing regulations also impairs safety in boats and reinforces technological barriers. According to the fishing regulations each fishing boat needs to have a license, life-saving equipment for each fisherman, a radio, a transponder (navigation instrument) etc. Yet the authorities frequently ignore the safety code,

especially in Padma. According to fishermen in Padma (during FGDs), some boat owners manage to license their boats without following the regulations, by bribing the authorities. Some boats in Padma do not have a license at all. These boats are hardly monitored at all to check their compliance with regulations.

Lack of access to fish markets makes fishing less profitable and creates pressure to catch more fish. All fish from Padma and half of the fish from Kutubdia Para need to be sold in an auction via commissioning agents. According to oral history and FGD participants these agents charge 1% of the revenue. If informal credit is taken from a commissioning agent (*dadondar*) to run the fishing, then the fish must have to be sold, sometimes at lower prices, via that particular agent who charges for both selling the fish and giving credit. This fish marketing system is considered by the boat owners as unfair as it reduces their profit, and ultimately forces the fishermen to maximise the catch.

## **6.5 Discussion**

This section provides specific discussion related to this chapter only, while more general discussion integrating this chapter and the previous two empirical chapters is provided in Chapter 7.

The results of this chapter broadly resonate with other recent studies that highlight a range of limits and barriers to adaptation to climate variability and change (IPCC, 2007a; Adger et al., 2009a; Adger et al., 2009b; Moser and Ekstrom, 2010; Jones and Boyd, 2011; Morgan, 2011; IPCC, 2012). Adaptation of fishing-dependent people is impeded by both natural and anthropogenic factors: physical characteristics of climate and sea, technologically poor boats, inaccurate weather forecasts, poor radio signals, lack of access to credit, low incomes, lack of education, skills and livelihood alternatives, underestimation of cyclone occurrence, coercion of fishermen by boat owners and captains, unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets.

Some earlier literature has suggested that limits and barriers interact to constrain adaptation (e.g., Adger et al., 2007; Jones and Boyd, 2011). The finding of this chapter corroborate this, highlighting how individual, local and broader factors originating from

both internal and external sources interact in a complex way to combine to impede adaptation (Figure 6). Together they constrain completion of fishing trips, coping with cyclones at sea, return of boats from sea safely, timely responses to cyclones, and livelihood diversification.

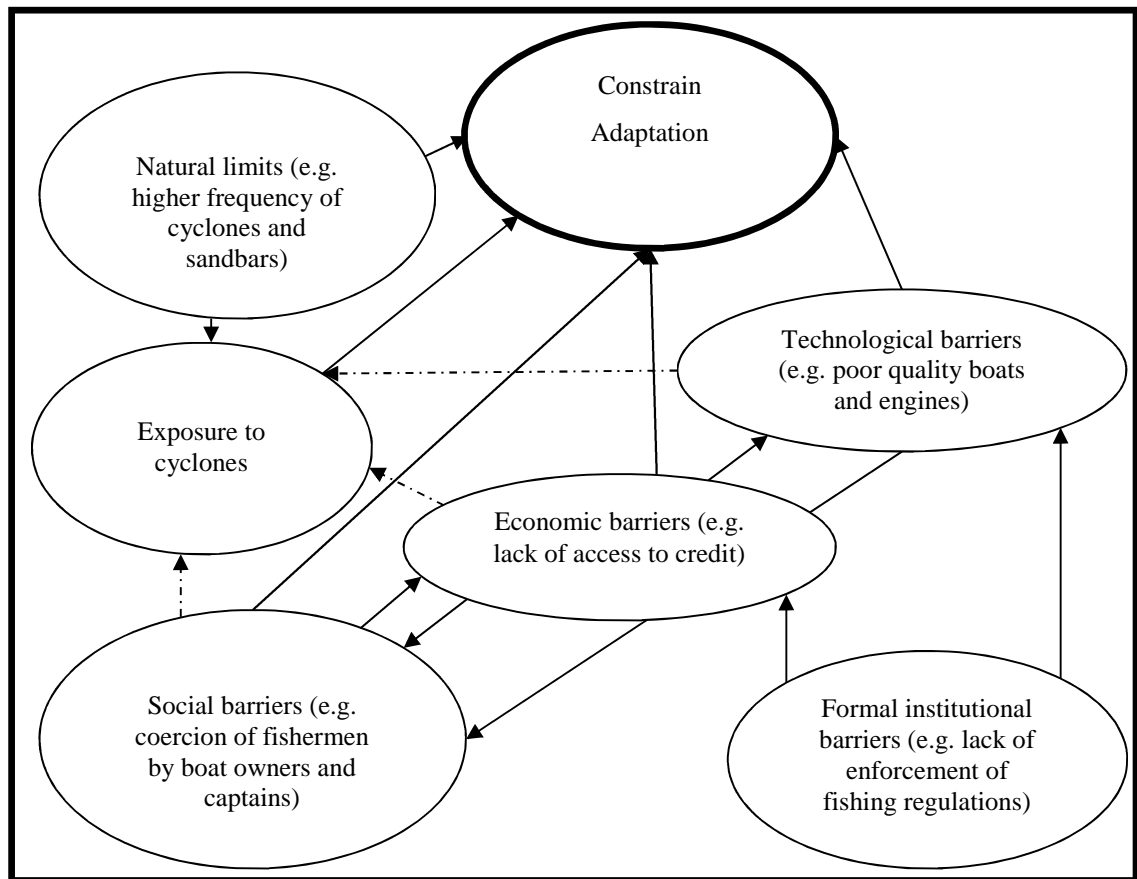


Figure 6. Interactions between limits and barriers to constrain adaptation of fishing activities to cyclones (→ means X constrain(s) Y; -.-> means X exposes people to Y more).

Natural limits increase exposure to cyclones and damage fishing assets (due to higher frequency and duration of cyclones, and sandbars), and together constrain completion of fishing trips, coping with cyclones at sea and safe return of boats from sea. This is due to the physical characteristics of the Bay of Bengal and its climate. This echoes that geographical limitations can constrain adaptation (Jones and Boyd, 2011). Exposure to cyclones also increases indirectly due to all types of barriers. Together these barriers have increased exposure by not informing the boat captains about cyclones at all (absence of radio signals offshore), confusing them about the occurrence of cyclones (inaccurate cyclone forecasts), reducing the capability of boats to return to shore

(technologically poor boats) or influencing fishing during cyclones (e.g. coercion to fish during cyclones).

Inaccurate cyclone forecasts and poor radio signals are the wider scale technological barriers that constrain adaptation of fishing activities at the local scale. Another technological barrier (technologically poor boats) is underpinned by economic (lack of access to credit) and formal institutional barriers (lack of enforcement of fishing regulations). This finding is in accord with Adger et al. (2007) who suggests that technological barriers may be constrained by economic and cultural barriers. Lack of access to credit also leads to maladaptation in the form of reduced investment in boat safety and quality, which undermines the safety of fishermen. This finding is in line with the literature that considers individuals with limited financial capital often focus on short-term financial gain rather than on the long-term vulnerability reduction, despite its benefits (Kunreuther et al., 1978; Thaler, 1999). Therefore short-term strategies can limit the scope for long-term adaptation (IPCC, 2012). Lack of access to credit is in turn reinforced by unfavourable credit schemes (a formal institutional barrier).

Fishermen's livelihood diversification is constrained by a combination of economic and social barriers that are interrelated. This finding resembles that of Smit and Skinner (2002) who found that in agricultural communities livelihood diversification is constrained by a lack of financial capital. In other words, adaptation measures of low-income groups are constrained by economic barriers (Adger et al., 2007). While some organisations offer micro-credit, most fishing-dependent people do not have access to it; in line with Amin et al. (2001) and Helms (2006) who found that micro-credit usually does not often reach the most vulnerable groups.

The direct and indirect impacts of social barriers in constraining adaptation support the theory that individual and social characteristics interact with underlying values to form barriers (Adger et al., 2009a). Our results also support the evidence that institutional barriers play an important role to constrain adaptation to stresses (O'Brien et al., 2004a; O'Brien et al., 2004b; Eakin, 2005; Sallu et al., 2010). If institutions fail to respond to changing conditions and risks, a system's vulnerability can be exacerbated (Adger, 2006).

Lack of enforcement of fishing regulations, and the coercion of crews to fish by Padma boat owners and captains reduce the fishermen's ability to adapt to cyclones. The presence of boat owners' trade union further reinforces their power. Thus individual adaptation is constrained by social norms and institutional processes as well (Adger et al., 2005a; Jones and Boyd, 2011).

The fishing activities will face further challenges due to increased cyclones in the future (Sugi et al., 2009; Yu et al., 2010a; Chowdhury et al., 2012). Reduction of greenhouse gas emission is necessary to overcome the limits, which need to be complemented with planned adaptation. There is no single adaptation which would overcome all barriers. Several complementary measures are needed, including improved fishing boats, improved cyclone forecasts and radio signals, increased access to low-interest credit, fish markets and insurance, enforcement of fishing regulations and maritime laws, development of human capital through education and skills, and creation of livelihood alternatives.

## **6.6 Conclusion**

This chapter identified and characterised a number of limits and barriers to adaptation of fishing activities to cyclones in two Bangladeshi fishing communities. The natural limits are similar in both communities but technological, economic, social and formal institutional barriers are more contextual. These limits and barriers are also interrelated and combine to constrain adaptation, for example, completion of fishing trips, coping with cyclones at sea, safe return of boats from sea during cyclones, timely responses to cyclones, and fishermen's livelihood diversification from risky fishing activities.

Global climate change mitigation is essential over the longer term to overcome the limits to adaptation and to build resilience, because adaptive capacity may be limited to only lower levels of climate change ( $\leq 2 - 3^{\circ}\text{C}$ ) (IPCC, 2007a). Given the interrelated nature and combined influence of many barriers, overcoming them is complex and needs planned adaptation strategies.

Both internal and external factors pose barriers to adaptation and some barriers are reinforced by others. To overcome these barriers, planned adaptation, both public and

private, should occur at multiple scales. Public action on improvement of cyclone forecasting and radio signalling can reduce risk and improve responses to cyclones. Modernisation of fishing technology, both public and private, can also accrue similar benefits. Access to less expensive credit through institutional reform at the public sphere could accrue both public and private benefits such as help transform fishing technology, prevent maladaptation and diversify livelihood strategies as well as reduce the cost of fishing. Institutional reform can also improve enforcement of maritime laws and access to fish markets to help reduce the overall costs of fishing business. Enforcement of fishing regulations by government and provision of insurance by government or private sectors (may be subsidised) would increase safety of fishermen. Finally, building fishermen's human capital at the public and private spheres and creation of alternative livelihood activities by government would help diversify their livelihoods.

These findings form the basis for further detailed research into the determinants and implications of such limits and barriers. More studies are needed in order to move towards an improved characterisation of adaptation and to identify the most suitable means to overcome the limits and barriers.



## **Chapter – 7 Discussion**

### **7.1 Introduction**

Climate change is already happening and it is predicted that further climate change will occur irrespective of cuts in greenhouse gas emissions (IPCC, 2007b). Without adaptation, the impacts of climate change are making and will make society vulnerable (IPCC, 2007a; Stern, 2007). This has led to an increasing focus on vulnerability and adaptation within the international climate change debates and development arena (IPCC, 2007a; Pielke et al., 2007; Stern, 2007). Chapters 1 and 2 recognise this importance and identify gaps within vulnerability and adaptation literature, particularly those concerning fishing communities and their livelihoods, a sector less studied in this regard. Addressing these gaps is crucial because a greater understanding of how vulnerable societies are and how they are adapting has implications for reducing vulnerability or risks, and facilitating adaptation and resilience.

This study contributes to an understanding of vulnerability and adaptation by investigating ways in which fishing communities in Bangladesh are vulnerable and adapting to climate variability and change. It provides a detailed analysis of livelihood vulnerability in coastal fishing communities, outcomes of their climate-induced migration as an adaptation strategy, and limits and barriers to their adaptation of fishing activities based on new empirical evidence. This discussion chapter consolidates the thesis by integrating findings from the previous three chapters. It identifies lessons that can be learnt from the comparative case study research and implications for the debate on vulnerability and adaptation to climate change. Together this chapter discusses the contribution of this research by tying the emergent findings to existing literature which enhances the internal validity, generalizability and level of theory building from this research (Eisenhardt, 1989). As a whole this chapter highlights how the overall aim of this research has been achieved.

In what follows, section 7.2 demonstrates how each objective has been achieved. Section 7.3 synthesises the findings across the empirical chapters and highlights associated contributions. Finally, section 7.4 explores scaling up and transferability of findings.

## **7.2 Addressing the Research Objectives**

This section outlines how each objective, set out in Chapter 1, has been achieved by briefly highlighting the research motivation, methodology, and main results and discussion.

*Achieving the first objective – to assess the vulnerability of fishery-based livelihoods to the impacts of climate variability and change in two fishing communities and their households in Bangladesh.*

The marine fisheries systems are already in crisis due to over fishing, loss of habitat, pollution and disturbance (Brander, 2006; Coulthard, 2009). Chapters 2 and 4 review that climate variability and change is an additional pressure to these systems and is predicted to impact on millions of people who depend upon them (e.g., IPCC, 2007a; Perry et al., 2009). Consequently, more vulnerable livelihoods are predicted (Sarch and Allison, 2000; Coulthard, 2008; Iwasaki et al., 2009; Perry et al., 2009). Most studies on fisheries and climate change focus on either the impacts on marine ecosystem or fluctuations in fish stocks (IPCC, 2007a; Cheung et al., 2009; Brander, 2010; Drinkwater et al., 2010; Johannessen and Miles, 2011) or on the macro scale fisheries systems (e.g., McClanahan et al., 2008; Allison et al., 2009b; Quest-Fish, Undated). Vulnerability of livelihoods of fishery-dependent people to climate variability and change is occasionally investigated. The objective of Chapter 4 was therefore to assess the vulnerability of fishery-based livelihoods to the impacts of climate variability and change in two coastal fishing communities in Bangladesh as a means of boosting empirical evidence on this.

To assess livelihood vulnerability, methodological novelty was developed through the integration of both quantitative and qualitative data and analysis. First a composite index approach was used to calculate sub-indices and indices of vulnerability using a range of indicators. This was followed by statistical and qualitative methods to examine how exposure, sensitivity and adaptive capacity measured by sub-indices create vulnerability. With the use of equal weighing for each indicator to calculate vulnerability followed by qualitative discussion of the role of each indicator and sub-index after calculating vulnerability, this chapter was not only able to overcome the criticism of weighing the indicators but also increase the comparability and

generalizability of the findings. The qualitative methods of assessing the association of vulnerability with relevant indicators further served as a means of validating the vulnerability indices and sub-indices. The households in each community were classified into four vulnerability classes and significance of each indicator in distinguishing these classes was investigated using ANOVA. In this way statistically significant indicators of vulnerability were identified. Thus, this chapter shows that the composite index approach together with ANOVA can be useful at the household scale in distinguishing the factors that determine their differential levels of vulnerability; and can have implications for prioritising factors for reducing vulnerability. The integration of the composite index approach, ANOVA and qualitative methods to assess livelihood vulnerability has thus contributed to methodological discussion of approaches to vulnerability analysis, particularly to the weighing of vulnerability indicators, validation of vulnerability indices and sub-indices, selection of significant vulnerability indicators, and explanation of the role of indicators and sub-indices of vulnerability.

Vulnerability to climate change varies between hazards, places, communities and social classes (Adger, 2003; Smit and Wandel, 2006). Chapter 4 finds that livelihood vulnerability is a result of combined but unequal influences of bio-physical and socio-economic characteristics of fishing communities and households. As a whole, Padma's households are more vulnerable than those of Kutubdia Para. This is because the households in Padma are much more exposed to climate shocks and stresses than their Kutubdia Para's counterparts. However, they are neither more sensitive nor have they less adaptive capacity than their Kutubdia Para's counterparts. Thus, those who are most exposed are not necessarily the most sensitive or least able to adapt. Gbetibouo et al. (2010) have also found that the most exposed agriculture regions are not necessarily the most sensitive. But within a region or community where households are similarly exposed, higher sensitivity and lower adaptive capacity combine to create higher vulnerability (Eakin and Bojórquez-Tapia, 2008). As evident in this chapter, within Padma, where the several groups of households are similarly exposed to climate shocks and stresses, higher sensitivity and lower adaptive capacity combine to produce higher livelihood vulnerability. A similar trend is also found between the household groups in Kutubdia Para.

The differential levels of sensitivity and adaptive capacity between different household groups highlight that socio-economic inequalities underpin livelihood vulnerability (Dyson, 2006; Laska and Morrow, 2006). Chapter 4 highlights that both the communities are heterogeneous – the household classes differ significantly in terms of their sensitivity and adaptive capacity. All the three sensitivity indicators are significant in distinguishing vulnerability classes in both of the communities. However, all the adaptive capacity indicators have not contributed similarly to produce vulnerability for each household class. Some are statistically significant while others are not. A range of indicators, namely, the number of adult workforce, quality of house, number of fisheries materials, natural capital, financial capital excluding income, per capita income, social capital, and number of income generating activities are significant in distinguishing adaptive capacity between the classes of households in either community. Thus these indicators can be regarded as general determinants of adaptive capacity in the two communities.

*Achieving the second objective – to examine how climate-induced permanent migration has impacted vulnerability and adaptation of a coastal fishing community in Bangladesh by comparing with the residual of its original community, in order to shed light on the viability of migration as a strategy to address climate change.*

Climate change is predicted to displace millions of people in coming decades (Myers, 2002; Nicholls et al., 2011). In the contemporary literature human migration is regarded as a potential adaptation strategy to address climate change, especially for people living in coastal low-lying areas. However, there is an on-going debate whether such migration would be successful or maladaptive.

While a growing body of literature suggests different drivers (McLeman and Smit, 2006; Black et al., 2011a; Black et al., 2011b; GOS, 2011; McLeman, 2011; Piguet et al., 2011) and types of migration (Paavola, 2008; Piguet et al., 2011), only a few postulate the likely consequences of migration (Paavola, 2008; Mortreux and Barnett, 2009; Black et al., 2011b; GOS, 2011; Barnett and O'Neill, 2012). None of them used primary empirical data as evidence to conclude the successfulness, or otherwise, of migration. The objective of Chapter 5 was thus to examine how climate-induced migration impacts vulnerability and adaptation of a coastal fishing community in

Bangladesh, in order to shed light on the viability of migration as a strategy to address climate variability and change.

Chapter 5 selected Kutubdia Para, the less vulnerable community in Chapter 4, to which households migrated two decades ago from Kutubdia Island to respond to climate shocks and stresses. Data on migration, livelihoods, vulnerability and adaptation across the two communities were gathered using household questionnaires, interviews, vulnerability matrices and FGDs. The data were analysed using descriptive statistics, z-test and qualitative coding techniques of content analysis.

Climate change-induced displacements and migration may result in negative outcomes or maladaptation (Reuveny, 2007). However, the findings of Chapter 5 do not suggest this. They rather support the literature that suggests that climate induced migration may bring considerable positive outcomes for migrants (Black et al., 2011b).

The results of Chapter 5 suggest that migration has resulted in several positive outcomes for the migrants. Chapter 5 finds that the migrants are considerably less exposed to the climatic shocks and stresses such as floods, sea level rise and land erosion. These findings corroborate other literature which found that migration can reduce climatic exposure (Warner et al., 2008). Migrant households have better levels of and access to important livelihood assets. Particularly, they have, on average, higher incomes, better health and houses, improved access to technology, water, health and education services, markets, and offices that provide different services than those of non-migrants remaining on the island. One of the reasons for these positive outcomes may be due to the fact that migration took place in the mainland areas and near a big tourist town. These facilitated access to livelihood assets and activities as well as helping tackle climate variability. These findings support the hypothesis that migration can create access to new livelihood assets and activities (Koczberski and Curry, 2005).

These positive outcomes considerably reduce vulnerability and increase capacity to cope with and adapt to climate variability and change. This is not the case with those households that remain on the island: their livelihoods remain more diverse and incomes substantially lower in a situation where they are more exposed and vulnerable to climate variability and change. Natural resource dependent rural households often

spread risk and reduce vulnerability by diversifying livelihoods and income sources in this way (Chambers et al., 1989; Ellis, 2000; Allison and Ellis, 2001). However, while diversified livelihood strategies may help reduce vulnerability, they may not yield high income: diverse livelihood activities like those among the households in Kutubdia Island may only provide part-time or occasional involvement and modest economic return (see Paavola, 2008).

While migrants face challenges such as higher dependency on climate sensitive marine fisheries which can be a barrier to long-term adaptation, they are in a better position to overcome these challenges. They can invest their higher incomes in climate resilient livelihood strategies or to build human capital, which also facilitates diversion away from climate-sensitive livelihoods. Migration has thus in this case been a viable strategy to tackle the negative impacts of climate variability and change on livelihood outcomes over the timeframe studied. Clearly the contexts in this case have been critical in determining success and more empirical research is required to investigate this issue further across a range of contexts.

*Achieving the third objective – to identify and characterise limits and barriers to adaptation of fishing activities to cyclones and examine interactions between them in two fishing communities in Bangladesh.*

Limits and barriers constrain adaptation to climate variability and change (IPCC, 2007a; Adger et al., 2009b; Moser and Ekstrom, 2010; IPCC, 2012). The small-scale fisheries sector, which supports the livelihoods of 90% of more than half a billion fishers (FAO, 2012), may not be an exception in this respect (Morgan, 2011). Many of these limits and barriers are interrelated and combine to constrain adaptation (Adger et al., 2007; Jones and Boyd, 2011). However, there is a lack of empirical evidence on limits and barriers to adaptation and particularly investigation of the interactions between them. The objective of Chapter 6 was thus to identify and characterise the limits and barriers to the adaptation of fishing activities to cyclones and examine interactions between them, gaining insights from two coastal small-scale fishing communities in Bangladesh.

To achieve this objective, Chapter 6 used household questionnaires, oral history interviews, vulnerability matrices and FGDs to collect data on livelihoods, adaptive

strategies related to fishing, and limits and barriers to such strategies in Padma and Kutubdia Para. The data were analysed by descriptive statistics and qualitative coding techniques of content analysis.

Results illustrate that adaptation of fishing activities to cyclones is constrained by both natural and anthropogenic factors: physical characteristics of climate and sea, technologically poor boats, inaccurate weather forecasts, poor radio signals, lack of access to credit, low incomes, lack of education, skills and livelihood alternatives, underestimation of cyclone occurrence, coercion of fishermen by boat owners and captains, unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets. These findings broadly resonate with other recent studies that highlight a range of limits and barriers to adaptation to climate variability and change (IPCC, 2007a; Adger et al., 2009a; Adger et al., 2009b; Moser and Ekstrom, 2010; Jones and Boyd, 2011; Morgan, 2011; IPCC, 2012).

Results in Chapter 6 also show that individual, local and broader factors originating from both internal and external sources interact in complex ways to combine to impede adaptation. For example, exposure of boat captains and crews to cyclones increases due to all types of barriers. Together the barriers have increased exposure through not informing the boat captains about cyclones at all (absence of radio signals offshore), confusing them about the occurrence of cyclones (inaccurate cyclone forecasts), reducing the capability of boats to return to shore (technologically poor boats) or influencing fishing during cyclones (e.g., coercion to fish during cyclones). Taken as a whole, all the limits and barriers constrain completion of fishing trips, coping with cyclones at sea, return of boats from sea safely, timely responses to cyclones, and livelihood diversification. These findings corroborate other literature that has suggested that limits and barriers interact to constrain adaptation (e.g., Adger et al., 2007; Jones and Boyd, 2011), and provide empirical evidence on how interactions occur.

### **7.3 Insights across Empirical Chapters: a Synthesis**

Contributions from each results chapter have already been discussed in the above section and in Chapters 4, 5 and 6. Combining these may bring some other insights which can contribute to climate related impacts, vulnerability, adaptation, fisheries and livelihood literature.

The aim of this research was to assess the vulnerability and adaptation of three Bangladeshi coastal small-scale fishing communities to the impacts of climate variability and change. This research used a mixed method comparative case study approach and integrated insights from SLA, composite index and climate change vulnerability and adaptation approaches into its framing.

The SLA has been used as a livelihood analysis tool in numerous studies (including fisheries) over the last few decades. Some studies have also used SLA for impact, vulnerability and adaptation assessments related to climate variability and change in natural resource-based communities, households and individuals. This thesis has broadened the usefulness of SLA by using it as an approach to assess livelihood vulnerability and adaptation to climate variability and change in the fisheries sector. To assess vulnerability and adaptation, this research uses climatic shocks and stresses as exposures that relate to the “vulnerability context” of SLA. This research also uses other elements of SLA such as livelihood capital assets, activities and strategies as well as transforming structures and processes that mediate access to these. These components have served, to a large extent, to explain in particular the adaptive capacity and process of vulnerability and adaptation. SLA was also integrated with other theories, approaches or methodological tools to overcome its limitations related to this research. For instance, to overcome the limitation that SLA may not be able to ensure representative sampling in a heterogeneous community (Ferrol-Schulte et al., 2013), a random sampling technique and cluster analysis were used (see section 3.3.1 and 3.4.1.1).

Exposure to climatic shocks and stresses have a direct impact upon livelihoods (DFID, 1999; Ellis, 2000) and therefore can influence the vulnerability and adaptation of fishing communities (Daw et al., 2009; Badjeck et al., 2010). But these impacts vary between and within fishing communities depending on their location and livelihood characteristics. Chapter 4 identifies floods and cyclones as the two main shocks to which fishing communities are exposed. Chapter 5 finds that floods, along with other stresses, result in displacement of households, while Chapter 6 recognises that cyclones constrain adaptation of fishing activities at sea. Chapter 4 also finds that stresses such as variation in temperature and rainfall have little impacts on livelihoods, while variation in minimum temperature has no considerable negative impact. Land erosion and sea



level rise also have little impacts on Padma's and Kutubdia Para's households but they had massive impacts on Kutubdia Island's households which led to their migration to Kutubdia Para (discussed in Chapter 5).

Livelihood assets form the fundamental basis of adaptive capacity and adaptation for fishery-dependent people (Daw et al., 2009; Badjeck et al., 2010) as well as for others (Scoones, 1998; Ellis, 2000). Chapter 4 identifies that physical capital such as boats and nets are important indicators of adaptive capacity – less vulnerable households have more of them than more vulnerable households. Both Chapters 4 and 6 find that lack of boats and nets limits a household's choice and, in some cases, coerces a household to adopt more climate sensitive livelihood strategies. For example, offshore fishing during cyclones is regarded as dangerous. But in Padma, some household heads (boat crews) without a boat of their own are coerced to catch fish in cyclonic seas by those (boat owners) who do own boats. However, Chapter 6 has further found that presence of boats and nets are not enough – it is their quality which matters. The technologically poor boats act as a barrier to adaptation. Thus physical capital forms a key factor of adaptive capacity and adaptation, as suggested in other literature (Sen, 1981; Kelly and Adger, 2000; Adger et al., 2004; IPCC, 2007a).

Natural capital is also considered important, lack of which can restrict opportunities for livelihood activities and income and thereby adaptation (DFID, 1999; Townsley, 2004). Chapter 5 identifies that loss of some natural capital such as loss of fish drying fields due to land erosion and flooding in Kutubdia Island has drastically reduced the amount of fish that can be dried there and therefore has played a role in reducing adaptive capacity or increasing vulnerability by pushing households into part-time and low paid activities, and reducing their incomes. Chapter 6 finds that due to lack of fish stock near the shore, the fishermen catch fish offshore with more exposure to cyclones. Chapter 4 finds that absence of non-fisheries related natural capital such as big trees near homestead areas limits the ability of some households in Padma to take shelter during floods.

Financial capital can provide greater access to other livelihood assets and play an important role in climate change adaptation (Brenkert and Malone, 2005; Madu, 2012). However, many coastal fishing communities have restricted access to credit (De Silva

and Yamao, 2007; Westlund et al., 2007; Mills et al., 2011). Chapter 4 identifies that financial capital, particularly income, is an important indicator of adaptive capacity. The most vulnerable classes of households of Padma and Kutubdia Para are not able to augment their livelihood assets and, sometimes, cannot even access these assets due to their low incomes, which in turn increases their vulnerability. Chapter 5 finds that households in Kutubdia Island cannot migrate because of their lack of financial capital as well as other factors. Chapter 6 finds that lack of income and access to credit poses a barrier to the adaptation of fishing-dependent people by constraining livelihood diversification and reinforcing other barriers. They are often unable to raise formal bank loans due to lack of collateral (see De Silva and Yamao, 2007 for similar findings). Informal sources of credit, typically with high rates of interest, are often their main source of credit (see Tietze and Villareal, 2003 for similar findings). These findings echo previous findings that lack of credit is a key problem for fishing communities in developing countries (Perry et al., 2009).

Households with greater human capital have a greater level of adaptive capacity; lack of human capital constrains adaptive capacity (Adams and Mortimore, 1997; Ngo, 2001; Brooks et al., 2005; Sesabo and Tol, 2005; Allison et al., 2007; Paavola, 2008). Chapter 4 indicates that lack of adult workforce members increases livelihood vulnerability by limiting a household's ability to tackle emergencies during extreme weather events, as well as its access to livelihood assets and strategies. Chapter 5 finds that older age and female gender of some household heads have prevented the adaptation (migration) of some households on Kutubdia Island. Chapter 6 further finds that lack of education and alternative skills constrains adaptation (livelihood diversification).

Local level collective action and leadership are important aspects facilitating or constraining adaptation (Moser and Ekstrom, 2010; IPCC, 2012). Chapter 4 identifies that households' ability to cope and adapt is constrained, partly because of the absence of community organisations. Chapter 6 finds that there is no trade union for the fishermen but due to the presence of boat owners' trade unions, some of the fishermen are coerced by the boat owners and captains to fish during cyclones. Other social capital such as relatives and friends help households cope with climatic shocks (see Chapter 4). Chapter 5 finds however that networks may be less useful and there may be covariate

risks. The poorer non-migrants have extensive social networks who are also poor, and therefore cannot help non-migrants' adaptation sufficiently.

Fishery-dependent people often reduce vulnerability to fluctuation in fishing incomes by diversifying their livelihoods, which helps them adapt to change better (Sarch and Birkett, 2000; Allison and Ellis, 2001; Turner et al., 2007; Westlund et al., 2007; Coulthard, 2008; McClanahan et al., 2008). Chapter 4 identifies that households' involvement in a diverse set of income-generating livelihood activities increases the adaptive capacity or reduces vulnerability. Chapter 5 however finds that although Kutubdia Island's households are involved in more income generating activities nonetheless their livelihood conditions are not good (they have less than half the incomes of Kutubdia Para and therefore less adaptive capacity) or are still more vulnerable than their counterparts in Kutubdia Para. This is because their activities are part-time in nature and are less well paid. This is due to the fact that they did not diversify their income sources voluntarily, rather they were pushed to diversify by the repeated exposure to climatic shocks and stresses in situations where there was a lack of suitable income generating opportunities. For example, FGDs revealed that on Kutubdia Island, land erosion destroyed fish drying fields, curtailing this activity and pushing households to part-time and low-income activities such as shrimp post-larvae collection (providing income for 2-3 months per year for about one fifth of a household's daily financial needs) and mollusc-shell collecting (generating less income than shrimp post-larvae collecting).

Wider scale factors such as vulnerability contexts, and transforming structures and processes influence vulnerability, adaptation and livelihoods at the local scale (Scoones, 1998; DFID, 1999). As evident in this thesis – some wider scale climatic shocks and stresses have influenced vulnerability and adaptation across the empirical chapters. Some formal institutional factors in Chapter 5 such as government policies influence the process of adaptation for both non-migrants and migrants. In Chapter 6 formal institutional barriers such as unfavourable credit schemes and lack of enforcement of fishing regulations and maritime laws, as well as technological factors such as inaccurate cyclone forecasts and poor radio signals, constrain adaptation.

This thesis reinforces the findings that past exposure to repeated climate and weather events enables people to develop experience in managing these events (cf. e.g., Grothmann and Patt, 2005; Ford et al., 2006; Reid et al., 2007). Fishing communities are not passive victims of climate variability and change but actively respond to the changes they face. As they learn from their past experiences, they combine short- and long-term responses to cope with and adapt to climatic shocks and stresses. Chapter 4 finds that Kutubdia Para's households experience lesser livelihood vulnerability than that of Padma. Their climate-induced migration has brought more successful outcomes, to a large extent, than the Kutubdia Island's households (Chapter 5). Chapter 6 finds that Kutubdia Para's fishing-dependent people face lesser barriers to adapt their fishing activities than their Padma counterparts and are more resilient and better adapted to climatic shocks and stresses. Thus, past experience of risk encourages adaptive action against potential future risks and may help people prepare better for future climate change (Tschakert, 2007).

However, past experience of risks may not be sufficient to adapt to future climate change (Allison et al., 2005; FAO, 2008). Repeated exposure to climatic shocks and stresses can lead to greater vulnerability through the loss of people's assets, adaptive capacity and resilience and, therefore, can prevent their adaptation (Ford et al., 2006). Chapter 4 finds that the highest livelihood vulnerability to climate variability and change does not coincide with the highest sensitivity and lowest adaptive capacity because of the influence of exposure on vulnerability. If the exposure level becomes sufficiently high then the community is forced to leave the settlement, as was the case for Kutubdia Island's households in Chapter 5. This echoes findings that when thresholds or tipping points associated with social and/or natural systems are exceeded, the systems cannot be reverted or can face greater difficulty in adaptation (IPCC, 2012).

Very low levels of adaptive capacity prevent adaptation and households find themselves in a "trap". Carter et al. (2007) suggest that there may be an asset threshold level below which households are caught in an asset poverty trap. Chapter 4 finds that in classes of differently vulnerable households within a community (where all households are similarly exposed) higher sensitivity and lower adaptive capacity combine to create higher livelihood vulnerability. This means that if the adaptive capacity is very low then it can be a critical factor for vulnerability and adaptation. The current households of

Kutubdia Island have very low capacity to adapt and cannot migrate, although they want to migrate (discussed in Chapter 5). They are unable to transform their livelihoods into a more adapted state. Thus they can be considered as trapped households and are unable to exit from this situation on their own.

Adaptive capacity is context-specific and varies not only from community to community but also among social groups and individuals (Smit and Wandel, 2006; Adger et al., 2007), which indicates social inequalities within a community. Chapter 4 identifies that significant differences exist in adaptive capacity between the household vulnerability classes of both Padma and Kutubdia Para. Within adaptation research, the issue of equity has become an important issue, especially because processes of change can lead to greater inequality between households (Gray, 2005).

The discussion above supports the widely held view that, in addition to climate factors, a range of socio-economic factors play a role in shaping vulnerability and adaptation (e.g., IPCC, 2007a; Paavola, 2008; Sallu et al., 2010). The communities are impacted by climate related factors especially cyclones, storm-surge-induced floods, sea level rise and land erosion. The different livelihood assets, activities or strategies and the factors influencing these have played an important role in shaping sensitivity, adaptive capacity, outcomes of migration and barriers to adaptation. It is very likely that adaptation to future climate change will be facilitated or constrained by similar factors that have influenced past and current adaptation. Thus adapting to future climate change will not only be determined by the climate itself but also by the local and national social, political and economic conditions (Thomas and Twyman, 2005; Ford et al., 2006; Reid and Vogel, 2006; IPCC, 2007a; Reid et al., 2007; Tschakert, 2007; Paavola, 2008).

Although vulnerability is very much determined by local conditions and community characteristics, the success of vulnerability reduction or adaptation is often constrained by root causes and factors at the macro-level, which are difficult for communities or households to influence (Schipper, 2004). The social, political and economic conditions of the regions in which households live determine, to a certain extent, the strategies available to them and may constrain them or force them into unsustainable pathways. The non-migrants on Kutubdia Island are continuously exposed to climate shocks and

stresses that make them more vulnerable. Unfavourable formal institutions have constrained the fishermen to adapt their fishing activities to cyclonic disturbances. Throughout the study sites, households have had to rely mainly on their own strategies and on community support systems for adaptation, as concerned formal authorities have only played a limited role in facilitating adaptation. Thus formal authorities need to provide some guidance and a facilitating environment for coastal fishing communities and households, as autonomous adaptation is not always sufficient. The practical implications of this research highlighted in the conclusion (section 8.2) can help formulate this guidance.

#### **7.4 Scaling-up and Transferability of Findings**

An important issue within vulnerability and adaptation research and within the development community is the transferability of adaptation responses and the scaling up lessons learnt from local case studies. Development practitioners are calling for lessons to be learnt from case study research in order to help facilitate adaptation in other communities. There have been calls within the adaptation and climate change community for greater local level case study and comparative research in order to identify generic aspects of adaptation, especially the key features leading to successful adaptation (Reid and Vogel, 2006; Smit and Wandel, 2006).

Smit and Wandel (2006) suggest that research on practical adaptation initiatives can be used to compare across communities and societies in order to identify aspects of adaptation that are effective. By carrying out local level studies in three communities, it was possible to investigate whether there are generic findings that may have implications for other communities in this region. These types of findings can be commonly scaled up from the case-study communities to their larger archetypal livelihood region (Iwasaki et al., 2009). Developing countries, in particular the coastal people of south and south-east Asia whose primary income source is the fisheries resources of the Bay of Bengal, can be considered as the larger archetypal livelihood region of this study. The Bay of Bengal fisheries cater for people from seven countries: Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand. The climatic conditions of these countries are largely influenced by the Bay of Bengal. In a review, Townsley (2004) found that these fisheries-dependent people have some

common characteristics such as high vulnerability to natural hazards such as cyclones and floods, exposure to seasonality of climate, prevalence of poverty, relatively high level of dependency on natural/common property resources, use of traditional small-scale methods of fish exploitation and having strong market orientation to sell or exchange products for livelihoods. He also found some unique characteristics among some fishery-dependent people; such as the presence of ethnic groups and caste systems mostly on the northern and western side. Coulthard (2008) also found caste systems in south India which influenced adapting to environmental change in this fisheries. This caste system is not found in the current study communities. Therefore, the findings of this study may only *partly* be transferred and scaled up to other coastal fishing communities in the Bay of Bengal region as the characteristics of the population of this study only have some similarities with the characteristics mentioned in these countries. The methodological approach to vulnerability assessment developed in this study may also have the potential to be transferred to other sectors (e.g., agriculture).

However, Twyman et al. (2011) suggest that it is challenging to scale up the lessons from case-study research to larger scales. When developing future institutional and local response interventions to facilitate adaptation to future climate change, Reid and Vogel (2006, p. 204) suggested “one size will not fit all”. Thus, caution should be maintained about what lessons can be learned and transferred between case studies, especially as the impacts of climate change will be different between different places and social groups (IPCC, 2007a).

## **Chapter – 8 Conclusions**

### **8.1 Summary of Contributions**

This research has assessed the vulnerability and adaptation of three coastal fishing communities to the impact of climate variability and change in Bangladesh. The case study approach has combined climate change vulnerability and adaptation approaches, composite index approach and SLA to develop the research framework and guide the overall data collection and analysis processes. This integrated approach has enabled the investigation of local scale processes which influence on vulnerability or adaptation, while embedding these in broader processes, which either facilitate or constrain them. Following a mixed-method approach the data were collected using household questionnaires, interviews, vulnerability matrices and FGDs as well as from secondary sources. The use of a mixed-method approach, throughout the research, has retained rigour through triangulation of data sources while permitting flexibility in data collection and gathering richer in-depth data to deepen the understanding of the issues in this research.

While assessing vulnerability to climate variability and change, Chapter 4 shows that the composite index approach combined with ANOVA can be useful at the household scale to distinguish the factors that determine their differential level of vulnerability; and can be used to determine priority factors for reducing vulnerability. The integration of composite index approach, ANOVA and qualitative methods to assess livelihood vulnerability has also contributed to a methodological discussion of approaches to vulnerability analysis, particularly to the weighing of vulnerability indicators, validation of vulnerability indices and sub-indices, selection of significant vulnerability indicators, and explanation of the role of indicators and sub-indices of vulnerability. Chapter 4 highlights that the level of livelihood vulnerability to climate variability and change differs not only between communities but also between different household groups within a community, depending on their level of exposure, sensitivity and adaptive capacity. Exposure to floods and cyclones; sensitivity (such as dependence on small-scale marine fisheries for livelihoods); and lack of adaptive capacity in terms of physical, natural and financial capital and diverse livelihood strategies construe livelihood vulnerability in different ways depending on the context. The most exposed



community is not necessarily the most sensitive or least able to adapt because livelihood vulnerability is a result of combined but unequal influences of bio-physical and socio-economic characteristics of communities and households. But within a fishing community, where households are similarly exposed, higher sensitivity and lower adaptive capacity combine to create higher vulnerability.

Assessing the outcomes of climate-induced internal migration (Chapter 5), this research also demonstrates that migration *may* be a viable strategy to cope with or adapt to climate variability and change. The migrant households are less exposed to climate shocks and stresses than their non-migrant counterparts. They also have more livelihood assets and have better access to them. They enjoy higher incomes, better health, better access to water supply, health and educational services, technology and markets, than the households who did not migrate. Although they are comparatively more dependent on climate-sensitive marine fisheries, they are in a better position to divert away from climate-sensitive livelihoods through investing their higher incomes in other activities or in the building of human capital to enable this diversification. The non-migrants have not been able to reduce their vulnerability or to increase their ability to respond to climatic shocks and stresses. They face difficulty in continuing their livelihoods and most of them are keen to migrate away from the island. However, they cannot do so due to lack of assets and outside support, and the uncertainty of livelihoods at the destination. They have become trapped in a more vulnerable position and are unable to exit this situation on their own.

Examining the limits and barriers to adaptation of fishing activities to cyclones (Chapter 6) across the case study sites, this thesis further illustrates that adaptation is constrained by multiple interacting limits and barriers. The limits include physical characteristics of climate and sea such as higher frequency and duration of cyclones, and hidden sandbars. Barriers include technologically poor boats, inaccurate weather forecasts, poor radio signals, lack of access to credit, low incomes, underestimation of cyclone occurrence, coercion of fishermen by the boat owners and captains, lack of education, skills and livelihood alternatives, unfavourable credit schemes, lack of enforcement of fishing regulations and maritime laws, and lack of access to fish markets. These local and wider scale factors interact in complex ways and constrain completion of fishing trips, coping

with cyclones at sea, safe return of boats from sea, timely responses to cyclones and livelihood diversification.

Based on the findings of this study it can be said that the coastal fishing communities have been impacted by several climatic shocks and stresses and they have traditionally coped with or adapted to the normal range of climate impacts but not always sufficiently well. Further reinforcing the findings in Chapter 5, this chapter illustrates that autonomous adaptation is not sufficient for them to address the current climate variability and change. In the coming decades the vulnerability of fishery-based livelihoods may substantially increase because of climate change. Almost all the livelihood assets and strategies of fishing communities will face the impacts of sea level rise, land erosion, cyclones and associated flooding, as these are predicted to be exacerbated due to climate change (IPCC, 2007b; Met Office, 2011). Without adaptation, increased levels of cyclones and floods will result in greater loss of life in the coastal areas and at sea, greater damage to fishing boats, gear and other household assets, especially a loss of fishery-related income. An accelerated sea level rise as projected during this century (MoEF, 2005), will result in permanent inundation and accelerated erosion of the land base of Bangladeshi coastal communities. Alterations in temperature and rainfall can have direct impacts on the capacity for fish drying, which is the most common fish processing activity in this region. In short, future climate change is predicted to impact outside the normal range, for which additional adaptation will be needed for the fishing communities (Allison et al., 2005; FAO, 2008).

## **8.2 Implications of the Research**

The findings of this study allow identification of a range of measures that could help address the impacts of current and future climate variability and change for the fishing communities in Bangladesh and potentially, beyond. The findings are of particular relevance to the Government of Bangladesh's policy goal of "assess[ing] potential threats [of climate change] to the marine fish[eries] sector and develop[ing] adaptive measures" (see section 3.2.1.3).

Reduction of impacts, vulnerability or risks, increase in adaptive capacity or resilience, and facilitating adaptation actions and processes to climate variability and change for

the fishing communities would require multifaceted measures. Global climate change mitigation is essential over the longer term to reduce exposure, overcome the limits to adaptation and build resilience, because adaptive capacity may be limited to only lower levels of climate change ( $\leq 2 - 3^{\circ}\text{C}$ ) (IPCC, 2007a). Improved weather forecasting, warning and evacuation systems can reduce exposure to extreme events both in inland and at sea. Investment here would clearly impact on those that have no choice but to go to sea. In addition, investment in hard infrastructure such as concrete sea-walls surrounding the communities could protect them from storm surge, sea level rise and land erosion. However, given Bangladesh's limited economic resources, investment in hard infrastructure is unlikely in the near future.

Reducing exposure needs to be complemented with reducing sensitivity, increasing adaptive capacity and supporting adaptation processes through planned adaptation. Ensuring improved livelihood outcomes of fishing communities by augmenting their livelihood assets and improving access to them, and helping to diversify livelihood strategies could be helpful in this regard. Modernisation of fishing technology (such as improved quality fishing boats) and radio signalling could not only help save lives in the sea but could also reduce the damage to fishing assets particularly from cyclones. Modernisation of fish drying technology (such as more use of solar tent driers) will also be required in future to adapt the fish drying process to increased variations in temperature and rainfall. Access to less expensive financial credit through institutional reform could help transform fishing and fish drying technologies, build human capital, facilitate necessary migration, assist diversification of livelihoods and prevent maladaptation (by helping to build comparatively expensive robust fishing boats) in the fishing business. This institutional reform would include provision for flexible collateral, flexible credit repayment schemes, and easing the application process so that less educated/uneducated people could apply for credit easily and they would not need to have special knowledge of the credit systems or pre-existing relationships with credit providers to get credit. Institutional reform is also required to improve enforcement of maritime laws (such as through increasing the capacity of law enforcing members and removing corruption amongst them) and access to fish markets (such as through reducing middlemen in the marketing chain and reducing the charge for selling fish in the auction market) to help reduce the overall costs of the fishing business. Enforcement of fishing regulations and provision of insurance would increase the safety of fishermen.

Building human capital, such as through investment in education and skills development, could particularly help to diversify livelihoods which in turn would help individuals and associated households to become less reliant on climate-sensitive marine fisheries. The fisheries systems could also be made less-climate sensitive by conserving fisheries resources to ensure sustainable fish stocks and incomes for the future. Protection of near shore fish stocks is a priority given the lack of fish reported in this area – this would also divert the offshore fishermen into near shore areas where it is easier to respond to cyclones.

However, caution should be maintained as some adaptation strategies may exacerbate existing problems or may be maladaptive to other systems. For example, the construction of sea-walls to protect the communities, proposed above, may change the offshore sediment balance and increase erosion in adjacent coastal areas (Eriksen et al., 2007). Black et al. (2011b) have warned that the condition of the people who are unable or unwilling to migrate to address climate impacts may be exacerbated by maladaptive policies designed to prevent migration. To ensure that existing problems are not exacerbated, Fazey et al. (2009, p. 414) suggest that adaptation must: address both human-induced and biophysical drivers of change, maintain a diversity of future response options, and nurture the kinds of human capacities that enable the uptake of those response options. It is also necessary to ensure that adaptation does not lead to greater disparity and inequity between households or social groups, especially to achieve sustainable development. Thus, rather than adopting more radical options, mainstreaming of adaptation within a wider development arena is often preferred (e.g., Stringer et al., 2009; Brown, 2011).

### **8.3 Limitations and Future Research Directions**

To draw together detailed insights into vulnerability and adaptation of fishing communities to climate variability and change, this research has focussed on the local scale in three case studies. In order to draw general lessons more confidently by scaling-up conclusions on vulnerability and adaptation to climate variability and change a broader range of in-depth case studies complemented by finer scale climate data would be required. On the regional and global scale, climate change predictions suffer from important knowledge gaps and uncertainties which need to be overcome. Quantitative modelling of the quantification of fish stock should be complemented with robust

climate change data particularly for the Bay of Bengal. These data have important implications for social impacts, adaptation and vulnerability studies for fishery-dependent people. Since vulnerability, impacts and adaptation are context specific, finer scale climate data are necessary to complement this research. The assessment of vulnerability further highlights the need to develop a more robust means of understanding the impacts of climate change on livelihoods within the context of broader systems dynamics.

While assessing migration as a response to climate change, this research highlights that migration is a complex and contextual phenomenon. To establish with more confidence that migration can be a viable adaptation strategy to climate change, more evidence is needed on its merits from other contexts. It is necessary to do more research on how migration will affect other systems or types of social change, as also suggested by Black et al. (2011b). The current research further highlights that given the dependence on policies and politics, there may be limits to generalising about migration in response to climate change when it comes to millions of people needing to resettle. To build a strong scientific basis, more research is needed to accurately identify, measure and characterise climate-induced migrants, as also suggested by Warner et al. (2008).

In assessing limits and barriers to adaptation, this study finds cross-scale interdependencies and combined influences of many barriers that can constrain adaptation to cyclones in communities. Future research should focus on the better understanding of diversity, interconnections, cross-scale and temporal dynamics of limits and barriers to adaptation in order to develop robust means for overcoming them and enabling adaptation.

This thesis focuses mainly on the households and community scale. Taking into account the intra-household variability may provide some new insights into vulnerability and adaptation. Wider scale (district and country) studies on these issues may help generalise the findings. Cross nation comparative case-studies may also help countries learn from each other.

Research also needs to look at how the implications suggested in this study fit into the wider development arena. For example, this study has highlighted a need for alternative

non-climate sensitive livelihood activities in order that fishing communities can diversify their livelihoods. More study is needed at multiple scales and sectors to find these alternatives in the context of wider development.

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## Appendices

### Appendix A – Structured Household Questionnaire

#### STRUCTURED HOUSEHOLD QUESTIONNAIRE

(Interviewer: do not ask the respondent the words or sentences with font Colonna MT. These are either instructions for the interviewer or will be filled after finishing a questionnaire).

A. Introduction and explanation of ethical issues

B. IDENTIFICATION

1. Name of the village:
2. Random number:
3. **Household ID:**
4. Date:
5. Name of Interviewee:
6. Relation to the household head:
7. Name of Household head (if not the interviewee):
8. Phone (if any):
9. **Religion: Islam (1)/Hindu (2)/ Others.....(3)**

D. COMPOSITION OF HOUSEHOLD AND HUMAN CAPITAL

1. Household member (who?) (including absent members who contribute to the household)	2. Currently present (P) or absent (A)	3. Gender (male -1, female -2)	4. Age (years)	5. Marital status (married -1, unmarried-2, others .....3)	6. Education level		7. Condition of health		8. Technical skills have (such as training)	
					a. Total years of schooling completed	b. Highest level of academic qualification (no education-0, primary-1, secondary-2, higher secondary or technical-3, bachelor-4, master-5)	a. No. of days in past 12 months this person was sick	b. Number of days in past 12 months unable to carry out livelihood activities	a. Name	b. Number
<b>Household head (HH)</b>										
.....of HH										
.....of HH										
.....of HH										
.....of HH										
.....of HH										
<b>HH size</b>	Observations/notes:		Mean age		Mean education		Observations/notes:	Observations/notes:		

E. PHYSICAL AND NATURAL CAPITAL

1. Does your household own any fisheries related assets (physical capital) e.g. boat/net/drying plant/fish trading asset such as 'arot' or truck/others?

Yes (1)/ No (0)

2. If yes, please give details in the following table:

Name of fisheries related physical capital	Quantity	Size (very big - 4, big - 3, moderate - 2, small - 1, very small - 0)	Value at current market price (TK)	Observations/notes
Boat				
Net				
Drying plant				
'Arot'				
Truck				
Other.....				
<i>Total</i>	<i>a.</i>		<i>b.</i>	

If your household is involved with fishing/fish processing/fish trading/fish farming/shrimp PL collecting (interviewer: please tick; if the respondent is not involved with these please write not applicable and go straight to Q7) then please answer the following:

3. *How much fish is caught/traded/processed by your household this year?*.....
4. What is the trend in fish production? Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)
5. What are the reasons for this trend? (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc) and how)

6. How does the production of fish vary throughout the year?

Months of a year when harvested or processed	Species of fish	Variation in the quantity of fish caught/ traded/dried (no fish caught/ traded/dried -0, did less -1, did more -2)	Reasons for variations across months in the recent year (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc.) and how)	Observations/notes
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

7. *How much fish or other seafood does your household consume/month?.....kg*
8. What is the trend in fish consumption? Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)
9. What are the reasons for this trend? (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc) and how)
10. How does the consumption of fish vary throughout the year?

Months of a year	Variation in current year (no consumption-0, less consumption -1, more consumption -2)	Reasons for variations across months in the recent year (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc) and how)	Observations/notes
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

**11. Does your household own a house? Yes (1)/ No (0)**

12. If yes what is the *value* at current market price (TK).....

13. Also please give details in the following table:

Instruction to interviewer	Questions	Response	Observations/notes
Interviewer: Do not ask but observe and fill in	What is the structural condition of house?	Dilapidated(1)/Average (2)/Good(3)	
	What is the size of house?	Small (1)/Medium (2)/Large (3)	
	What is the quality of exterior walls of house?	Poor (1)/Average (2)/Good(3)	
Interviewer: Ask these questions	How many rooms does the dwelling have? (Interviewer: Include detached rooms in same compound if same household. Exclude bathrooms, toilets and kitchen)		
	What type of roofing material is used in house?	Leaves or straw and bamboo (1)/ Leaves or straw and wood(2)/ Bamboo and tile(3)/CI sheet (corrugated tin)(4)/ brick with cement casting(5)	
	What type of exterior walls does the house have?	Leaves or straw (1)/mud (2)//Bamboo(3)/ wood (4)/CI sheet (corrugated tin)(5)/ brick with cement casting (6)	
	What type of flooring does the house have?	Dirt(1)/Wood (2)/Brick/ (3)/brick with cement casting(4)	

**14. Does your household possess any other land besides homestead? Yes (1)/ No (0)**

**15. If yes, please give details**

Types	Area (decimal)	Value at current market price (TK)	Observations/notes
Agricultural farming land			
<i>Total</i>	<i>a.</i>	<i>b.</i>	

**16. Does the household cultivate agricultural crops? Yes (1)/ No (0)**

**17. If yes please give details**

Types	Quantity	Value at current market price (TK)	Observations/notes
<i>Total</i>	<i>a.</i>	<i>b.</i>	

**18. Does your household have farm assets? Yes (1)/ No (0)**

**19. If yes please give details**

Types	Quantity	Value at current market price (TK)	Observations/notes
Motor tiller			
Wooden plough			
Tube well for irrigation			
Manual husking machine			
<i>Total</i>	<i>a.</i>	<i>b.</i>	



**20. Does your household possess trees? Yes (1)/ No (0)**

**21. If yes please give details**

Types	Quantity	Value at current market price (TK)	Observations/notes
<i>Total</i>	<i>a.</i>	<i>b.</i>	

**22. Does your household use a sanitary toilet? Yes (1)/ No (0)**

**23. Does your household use a phone? Yes (1)/ No (0)**

**24. If yes please give details**

Types	Quantity	Value at current market price (TK)	Observations/notes
<i>Total</i>	<i>a.</i>	<i>b.</i>	

**25. Does your household use the internet? Yes (1)/ No (0)**

**26. Does your household own non-motorised transportation? Yes (1)/ No (0)**

*If yes please give details*

Types	Quantity	Value at current market price (TK)	Observations/notes
<i>Total</i>	<i>a.</i>	<i>b.</i>	

**27. Does your household own motorised transportation? Yes (1)/ No (0)**

*If yes please give details*

Types	Quantity	Value at current market price (TK)	Observations/notes
<i>Total</i>	<i>a.</i>	<i>b.</i>	

F. HOUSEHOLD ACTIVITIES AND ASSOCIATED FINANCIAL CAPITAL (interviewer: this section may be very sensitive to the respondents. Build trust again by explaining the objective of this survey)

a) Cash income generating activities for the household:

Household member (Who?) (including absent members who contribute to the household)	Source of income	Estimate of time invested (days /year)	Estimate of income level (TK/ year)	Observations/notes
	<b>1. Fisheries related activities</b>			
	Crew/fisherman			
	Labour in other fisheries activities such as in fish drying, net making, boat repairing etc.			
	Crew leader/chief fisherman in others boat			
	Boat owner/renting (income will be calculated after deducting expenses)			
	Operating self-owned boat (income will be calculated after deducting expenses)			
	Fish drying (income will be calculated after deducting expenses)			
	Fish trading (income will be calculated after deducting expenses)			
	Net making or mending (income will be calculated after deducting expenses)			
	Shrimp PL collecting (income will be calculated after deducting expenses)			
	Fish/shrimp farming (income will be calculated after deducting expenses)			
	OTHER fisheries related activities			
	<b>1. Sub-total-1</b>	<b>a.</b>	<b>b.</b>	

Household member (Who?) (including absent members who contribute to the household)	Source of income	Estimate of time invested (days /year)	Estimate of income level (TK/ year)	Observations/notes
	<b>2. Non-fisheries related activities</b>			
	Agriculture (income will be calculated after deducting expenses)			
	Agriculture labourer			
	Cattle/poultry rearing (after deducting expenses)			
	Business (income will be calculated after deducting expenses)			
	Job			
	Selling firewood (income will be calculated after deducting expenses)			
	<b>2. Sub-total-2</b>	<b>a.</b>	<b>b.</b>	
	<b>3. Grand total -1 (Sub-total-1 + Sub-total-2)</b>	<b>a.</b>	<b>b.</b>	
	<b>3. Others</b>			
	Interest from deposited money (e.g., savings account, FDR or DPS)			
	Interest from money lending			
	Rents (after deducting expenses)			
	<i>Dadon</i>			
	Government donation			
	Old age benefit			
	Donor/NGO donation			
	Pension			
	Remittance			
	'Fitra'			
	'Jakat'			
	Others (relatives, donation etc.)			
	<b>4. Sub-total-3 (others):</b>	<b>a.</b>	<b>b.</b>	
	<b>5. GRAND TOTAL-2 (Grand total -1 + Sub-total-3):</b>	<b>a.</b>	<b>b.</b>	

1. What is the trend in income from fisheries sources: Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)
2. What are the reasons for this trend? (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc) and how)

3. How does the income from fisheries sources vary throughout the year?

Months of a year	Variation in current year (no income-0, less income-1, more income-2)	Reasons for variations across months in the recent year (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc) and how)	Observations/notes
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

4. What is the trend in income from non-fisheries sources: Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)
5. What are the reasons for this trend? (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc) and how)

6. How does the income from non-fisheries sources vary throughout the year?

Months of a year	Variation in current year (no income-0, less income-1, more inome-2)	Reasons for variations across months in the recent year (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone etc) and how)	Observations/notes
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

**7. Number of activities the household involved at a time** (do not ask the respondent; need to calculate later):

**8. What is your household's total income (per month)?..... (TK)**

b) Other financial capital

9. How much money does your household have as savings (e.g., bank deposit)?.....

Observations/notes:

10. How much money has your household currently invested in local informal loan such as *dadon*?.....

What is the condition?

Observations/notes:

11. How much money does your household have in any other source (such as DPS, insurance)?.....

Observations/notes:

**12. Total savings** (do not ask the respondent; need to calculate later) = ..... **(TK)**

**13. Does the household own livestock (including poultry)? Yes (1)/ No (0)**

Observations/notes:

**14. If yes please mention resale value of all the livestock at current market price (TK).....**

**15. Does the household own jewellery? Yes (1)/ No (0)**

16. *If yes please mention the resale value of all the jewelleries at current market price (TK).....*

17. *Does the household have food stored in the house or anywhere? Yes (1)/ No (0)*

18. *If yes please give details*

Name of stored food	Quantity	Value at current market price (TK)	Observations/notes:
<i>Total</i>	<i>a.</i>	<i>b.</i>	



19. Other (such as possessions); please specify name and quantity:

Name	Quantity	Resale value at current market price (TK)	Observations/notes
Radio			
Television			
Modern furniture			
Solar panel that produce electricity			
Others ...			
<i>Total</i>	<i>a.</i>	<i>b.</i>	

20. Have your taken loan from any source? Yes (1)/ No (0)

21. If yes please then what is the total amount..... and rate of interest.....

22. What is the monthly total expenses of your household?.....TK/month

G. SOCIAL CAPITAL (interviewer: respondent may underestimate this section. Please keep patience and explain clearly)

**1. Does your household have relatives in the village? Yes (1)/ No (0)**

**2. Do you support each other especially during adverse climatic condition? Yes (1)/ No (0)**

If yes, how?

3. What is the trend in support? Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)

What are the reasons for this trend?

- 4. Does your household have contacts (such as friends, colleagues, acquaintances, good neighbourhood etc.) in the village? Yes (1)/ No (0)**

- 5. Do you support each other especially during adverse climatic condition? Yes (1)/ No (0)**

If yes, how?

6. What is the trend in help? Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)

What are the reasons for this trend?

- 7. Does your household have relatives outside the village (including abroad)? Yes (1)/ No (0)**

- 8. Do you support each other especially during adverse climatic condition? Yes (1)/ No (0)**

If yes, how?

9. What is the trend in help? Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)

What are the reasons for this trend?

**10. Does your household have (such as friends, colleagues, acquaintances etc.) outside the village (including abroad)? Yes (1)/ No (0)**

**11. Do you support each other especially during adverse weather condition? Yes (1)/ No (0)**

If yes, how?

12. What is the trend in support? Increasing rapidly (1)/ increasing moderately (2)/ increasing slowly (3)/ constant (4) / decreasing slowly (5)/ decreasing moderately (6)/ decreasing rapidly (7)

What are the reasons for this trend?

13. How many types of support did your household receive in the past month from any of the above people? .....

14. How many types of support did your household give in the past month to any of the above people? .....

15. How much money did your household borrow in the past month from any of the above people?.....

16. How much money did your household lend in the past month to any of the above people?.....

**17. Do any of your household members participate in a social organisation (for example BJMSS/ CBO/ Credit group/agri/business/religious)? Yes (1)/ No (0)**

If yes; which ones?

**18. Did your participation in a group support your household to face cyclone or tidal surge or other climatic hazard? Yes (1)/ No (0)/Do not know**

If yes, how?

**19. Do any of your household members have membership in political parties? Yes (1)/ No (0)**

**20. Did your membership support your household to face cyclone or tidal surge or other climatic hazard? Yes (1)/ No (0)/Do not know**

If yes, how?

**21. Can your eligible household members cast vote in local and general election? Yes (1)/ No (0)**

**22. Does the household have any insurance? Yes (1)/ No (0)**

If yes, which one(s)?

**H. Do you have any other assets not mentioned above? Yes (1)/ No (0)**

If yes which ones?

I. ACCESS TO LIVELIHOOD ENTITLEMENTS /ASSETS/SERVICES (Interviewer: please explain the concept of *opportunity in practice to use*)

a) Does your household have the opportunity in practice to use the following when you need them?	Yes (1)				No (0)	Do not know/not applicable	b) Distance (km and minutes) from the nearest asset or service	Support gets	Support expects but does not get	Observations/notes
	Very good opportunity (4)	Good opportunity (3)	Moderate opportunity (2)	Bad opportunity (1)						
1. Cyclone shelter(s)							....			
2. Sources of safe drinking water							....			
3. Sanitation										
4. Electricity										
5. Market							...			
6. Fish landing facilities							...			
7. Land (roads, rail etc) or water transports that connects nearest town							...			
8. Local Union Parisad office/service							...			
9. Forest							...			





C. HOUSEHOLD HISTORY

1. Is the above address household head's birth place? Yes (1)/ No (0)

If no go question 2; if yes go question 4.

2. When have your household migrated?

3. From where have you come here? (Village:                      Union:                      Upazila:                      )

4. Why did your household move to this village?

5. When did your own household start?



6. Please mention all the previous economic activities of your household.

Year (from..to.. )	Previous economic activities	Reasons for changing occupation/activities (Interviewer: first let the respondent explain then ask whether there is any climatic reason (temperature, rainfall, water current, cyclone, flood etc) and how)	Observations/notes

J. Any particular observation/notes for this household?

K. Name of the Interviewer

## **Appendix B – Checklists for Oral History Interviews**

### **Aim**

Oral history interviews were used to gather in-depth information on impacts, responses (both short- and long-term) and constraints to responses to climatic shocks and stresses of households and their livelihoods in each community.

### **Common checklists for the households of all three study communities**

How climatic shocks and stresses impact your household (negatively or positively) both inland and at sea?

Shocks and stresses include:

- cyclones
- floods
- sea level changes
- land erosion, and
- variations in temperature and rainfall
- others

Impacts on

- livelihood capital assets,
- infrastructure, social services, markets, transforming structures and processes,
- livelihood activities and strategies (fisheries or non-fisheries related) and
- overall livelihoods.

How you tackle these, both in the short-term and in the longer-term?

What things facilitate or constrain while tackling these?

What things help most while tackling these and how?

What things constrain most while tackling these and how?

What are the trends (both frequency and intensity) in the above shocks and stresses?

What have you learned from the above? In future how are you going to tackle these?

How can others, outside your households, help tackle these?

**Additional checklists for the households of Kutubdia Para**

Why and how did your household migrate?

Why did you migrate to Kutubdia Para? Why did you not migrate to other places?

Which factors influenced you to move?

Was there any support from non-government sources?

Was there any support from government?

How did migration impact your life?

What things and how helped or constrained you continuing or improving your life here?

Can you say whether migration is/was a successful or unsuccessful strategy?

How is your life going to be here in future?

**Additional checklists for the households of Kutubdia Island**

Could you talk about the history of your settlement here?

Why did your household not migrate?

Which factors influenced your household not to move from Kutubdia Island to Kutubdia Para or to other mainland areas?

What have been the impacts of not moving on livelihoods / trajectories / transitions taking place?

Do you think that your household has taken the right decision not to migrate? Is your household more or less successful in relation to livelihood than the households who have migrated?

What are your household's future plans – migration or staying on the island? If staying, then how will your household tackle future climatic stresses and shocks? How could your current livelihoods be improved? If migration, then how will your household overcome the restrictions of migration? How can others, outside your family help you in migration?