Climate change and resilience in industrial aquaculture : a study of community capitals in the shrimp-farming zone in Bangladesh

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**CLIMATE CHANGE AND RESILIENCE IN INDUSTRIAL
AQUACULTURE: A STUDY OF COMMUNITY CAPITALS IN THE
SHRIMP-FARMING ZONE IN BANGLADESH**

A thesis submitted to the Nanyang Technological University in partial fulfilment
of the requirements for the degree of Doctor of Philosophy in Sociology

By

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February 2018

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SHAIKH MOHAMMAD KAIS

Dedication

I humbly dedicate this work to the memory of my parents Sekendar Hossain Shaikh (late) and Alekjan (late), both of whom – being my first and best teachers – always encouraged and supported me in my learning endeavours.

بسم الله الرحمن الرحيم

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List of abbreviations and glossary

<i>Bagda</i>	Brackish-water marine shrimp, <i>Penaeus monodon</i>
<i>Bagdi</i>	A traditional fishing community, lower caste Hindu by religion
<i>Bawali</i>	Wood collector
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BDT	Taka (Bangladeshi currency)
<i>Bheri</i>	A system of shrimp production by capture
BIWTA	Bangladesh Inland Water Transport Authority
BMP	Better management practice
C	Celsius
CBA	Community based adaptation
CEP	Coastal Embankment Project
CO ₂	Carbon dioxide
CZPo	Coastal Zone Policy 2005
<i>dadandar</i>	Local money-lender
DFO	District Fisheries Officer
DO	Dissolved Oxygen
DoF	Department of Fisheries
dS/m	Deci-Siemens per metre
ENSO	El Niño Southern Oscillation
EU	European Union
FAO	Food and Agricultural Organization
<i>faria</i>	Local level shrimp and fry trader
GBM	Ganges-Brahmaputra-Meghna
GCC	Global Commodity Chain
GCM	General Circulation Model
<i>Gher</i>	Shrimp farm
GHG	Green-house gas
<i>Golda</i>	Fresh-water giant prawn, <i>Macrobrachium rosenbergii</i>
ha	Hectare
HACCP	Hazard Analysis Critical Control Point
HSC	Higher Secondary Certificate
ICZM	Integrated coastal zone management

IPCC	Intergovernmental Panel on Climate Change
kcal	Kilo-calorie
kg	Kilogram
<i>Khas jamin</i>	Government-owned land
<i>killas</i>	Wooden shelters
km	Kilometre
<i>Kolu</i>	A person who grounds oil from sesame and mustard seeds
LAPA	Local adaptation plan of action
LECZ	Low elevation coastal zone
LEDARS	Local Environment Development and Agricultural Research Society
m	Metre
ma	Million years ago
mm	Millimetre
<i>mohajan</i>	Rich man
<i>Mouali</i>	Honey extractor
MSL	Mean sea level
mt	Metric tonne
<i>Munda</i>	An ethnic minority group in south-western Bangladesh
NAPA	National Adaptation Programme of Action
NGO	Non-governmental organization
O & M	Operation and maintenance
PL	Post-larvae
ppm	Part per million
ppt	Part per thousand
RCPs	Representative Concentration Pathways
<i>Rishi</i>	A trader of leather and leather products
<i>Salish</i>	Arbitration
<i>Samaj</i>	Community
SES	Social ecological system
SLR	Sea-level rise
SPo	National Shrimp Policy 2014
SSOQ	Shrimp Seal of Quality

SST	Sea surface temperature
TPC	Third-party certifier
TV	Television
UFO	Upazila (Sub-district) Fisheries Office(r)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
<i>Upazila</i>	Sub-district
USA	United States of America
USAID	United States Agency for International Development
USD	Dollar (Currency of the USA)
WSD	White Spot Disease
WSSV	White Spot Syndrome Virus
yr	Year

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Abstract

While industrial aquaculture is one of the key components in sociology of global agro-food systems, climate change vulnerabilities and resilience at community levels are a growing concern in the twenty-first century environmental sociology. Aquaculture is one of the fastest growing industries in the world; however, its growth trajectory is confronted with various challenges including climate disruptions. Since both aquaculture and climate change have regional variations, comprehensive understanding of their complex interconnections requires systematic investigation. In various parts of the world, especially in the Global South, aquacultural countries are assessing these interconnections and devising resilience-enhancing programmes for development of the sector. Using a conceptual thread comprised of global climate change and community resilience, this thesis critically examines how the shrimp aquaculture industry in Bangladesh is affected by climate disruptions and how the shrimp farming communities address these challenges. A triangulation of methods – incorporating content analysis of secondary sources, ethnography, and qualitative interview – was adopted in collecting data on the commercial shrimp farming in Bangladesh. All collected data were analysed qualitatively. The findings from this research suggest that there is a clearly visible resilience gradient in the shrimp aquaculture industry in Bangladesh: individual shrimp farmers and households play a central role in resilience enhancement, while other stakeholders including community, state, and civil society organizations have moderate-to-little involvement in aiding resilience in the sector. Finally, this research aims to expand sociological knowledge by applying a community resilience framework to adaptation, which incorporates community capitals and architecture of entitlements as the working ground of

climate change and resilience dimensions, in aquaculture communities in the global South. In specific terms, this study contributes to sociology of climate change and resilience by providing thick qualitative narratives on local community-level dynamics of actions and transformations from a site where climate change is a day-to-day reality. Additionally, this research contributes to sociology of aquaculture by providing some fascinating insights into a specific aquaculture-based livelihood sector, i.e. industrial shrimping in Bangladesh.

CHAPTER ONE

INTRODUCTION

1.1 Global aquaculture and climate change: A critical intersection

Against the backdrop of an increasing certainty that human contribution to global warming is decisive, it is now apprehended that the current trajectories of climate anomalies will exacerbate existing vulnerabilities and may have striking repercussions for natural and social systems around the globe. Through its intense and unsettling consequences in different regions and sectors, climate change affects human communities in many ways – the majority of which are compound, indirect, and ambiguous (Pelling 2011). With its mounting role in the world economy and food security in the context of the exhaustion of marine fisheries, global aquaculture commands considerable scholarly attention. Aquaculture is profoundly affected by social and environmental perturbations, including climate variations and extremes. In the changing conditions, aquaculture communities throughout the world espouse their own coping strategies. Comprehensive scientific explorations of the intersections between climate change vulnerability and resilience from sociological perspectives can provide a detailed understanding of the problems.

From economic crises to climate-induced hazards, the challenges for humanity today are varied and interlinked (FAO 2012). Climate change is no longer a vague and indefinite future problem but an unavoidable event that is damaging the planet at an alarming pace, an outcome of 200 years of enormous green-house gas (GHG) emissions from the burning of fossil fuels for energy generation, transportation, industries and intensive agriculture (IPCC 2007a,

Williams and Rota 2013). The scientific community now warns that global climate change will have unprecedented repercussions on the natural setting of the earth as experienced through global warming, rising sea-levels, sea-bed landslides, changes in rainfall regimes leading to floods and droughts, decline in freshwater quantity, etc.; flora and fauna experienced through changes in marine ecosystems, forestry damage, extinction or threat to animal and plant species, etc.; and human life and activities experienced through changes in human settlements and habitats, human health, agriculture, aquaculture, industry, food security, conflict, etc. (Islam 2013, MoEF 2009a, McKinnon 2012, Pelling 2011, UNEP 2010, World Bank 2013). The combined impacts of all these will have a huge implication on the aquaculture sector.

Thus, climate change variabilities and extremes act as external stresses and perturbations to social-ecological systems making them vulnerable. The vulnerability of a system is composed of three components: exposure to perturbation – the degree to which a system is in contact with the perturbation, sensitivity to perturbation – the degree to which a system is affected by a disturbance, and the capacity to adapt – a system’s ability to adjust to a disturbance (Gallopin 2006). Only a resilient system (discussed in details later on) can successfully overcome stresses including climate perturbations. Resilience is a “long-term capacity of a system to deal with change and continue to develop” (Stockholm Resilience Centre 2014), “capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation” (IPCC 2014:1772). Enhancing community resilience is a core

element of disaster management and risk reduction in a social system in the face of global climate change.

As climate change is a brute reality in the twenty first century world, every ecological, social and social-ecological system takes its own adaptive and resilience measures to address weather shocks and climate disruptions. Global industrial aquaculture serves as an excellent case in point to examine climate change vulnerability and resilience. Industrial aquaculture is a prime candidate for exploration because in addition to nutritional and other qualities of fish protein, this sector has evoked serious socio-economic, political, and environmental concerns around the globe. *Firstly*, fisheries and aquaculture contribute to the livelihoods of a significant portion of world's poor population. In addition to primary fish production sector, fisheries and aquaculture provide numerous jobs in secondary activities like processing, packaging, marketing and distribution, manufacturing of fish-processing equipment, boat construction and maintenance, net and gear making, ice production and supply, research and administration etc. (FAO 2012). Though aquaculture directly employs about 24 million people globally (Bush et al 2013:1067, FAO 2012), all of the above-mentioned direct and indirect employments, together with dependants of the employed, are estimated to support the livelihoods of 660–820 million people, or about 10–12% of the world's population (FAO 2012:10). Globally, total food fish consumption has been growing at a rate of 3.6% per year since 1961, while the world's population has been increasing at 1.8% per year (WHO 2003:22). Thus, opportunity for employment in the fishery sector is increasing significantly. The number of fishers in the world has grown by 400% since 1950, compared to a 35% increase in the number of agricultural workers over the same period (World Bank 2005:5), with

most of the growth occurring in small-scale fisheries in the developing world (Williams and Rota 2013). It is expected that negative impacts of climate change on agriculture and other sectors in the future will force more people to resort to fishing and other common-pool resources for their employment.

Secondly, the food security of many of the world's poor in developing nations depends on fisheries and aquaculture. In 2009, fish, half of which came from aquaculture, accounted for 16.6% of the world population's intake of animal protein and 6.5% of all protein consumed. Fish provides almost 20% of animal protein intake for about 3.0 billion people, and 15% of such protein intake for 4.3 billion people worldwide (FAO 2012:5).

Thirdly, the total yield of wild capture fisheries remained unchanged for the last two decades and has reached or exceeded its optimal limits, while aquaculture production is rising at about 8% per year (Boyd and McNevin 2012, FAO 2012, Natale et al 2013); a 50% increase in global aquaculture happened between 1997 and 2003, while capture fisheries declined by 5% at the same time (Yazdi and Shakouri 2010). Thus, aquaculture's share of the total global fish supply is increasing steadily. While in 2004, for example, aquaculture accounted for 32% of entire fish supply (Brander 2007:19709), it increased to 41% in 2011 (see FAO 2012:3). However, if fish meal fisheries and aquatic plants were excluded from capture fisheries, then aquaculture had already contributed nearly 50% in 2009; that is, aquaculture accounts for 50% of fisheries products for direct human consumption (Boyd and McNevin 2012:A-37). Moreover, if we look at the shrimp sector, about 70% of the shrimp now consumed globally is farmed (Nagothu et al 2012). While the trend in productivity gains for agriculture and

livestock yield after the ‘green revolution’¹ is declining, aquaculture has still to utilize its full potential productivity through the intensification of production systems (Natale et al 2013). Thus, the entire increase in future demand for fisheries products and a significant quota of the total global protein supply must come from aquaculture.

Fourthly, industrial aquaculture products, as part of fish and fishery products, are among the major high-valued transnational agro-food commodities (Islam 2014). Among all globally traded food items, fish and fishery products are ranked first, “accounting for about 10% of total agricultural exports and 1% of world merchandise trade” (FAO 2012:14), with a value of USD 125 billion (Bush et al 2013:1067). The share of total fishery production exported as various food and feed items increased from 25% in 1976 to about 38% (57 million tonnes) in 2010 (FAO 2012:15). In the same period, global trade in fish and fishery products increased substantially in value terms too, rising from USD 8 billion to USD 109 billion (FAO 2012:77). Thus, over the last three decades, industrial aquaculture, particularly shrimp aquaculture, has become a major global industry, termed as the “pinnacle of the Blue Revolution’s achievement” (see Islam 2014). For example, commercial shrimp, which accounted for about 15% of the total value of globally traded fishery products in 2010 as the largest single commodity in value terms (FAO 2012:77), dominates the industrial aquaculture in the Global South

¹ Green Revolution is a worldwide programme that emerged in response to food scarcity problem during the middle of the twentieth century. Green Revolution was originally a ‘technical package’ of agricultural technology, seed, equipments etc. that was applied at first to basic crops and later to ‘high-value-foods’ (Islam 2013). The agricultural transformation began in 1943 when the Rockefeller Foundation of Mexico came forward to introduce bio-engineered hybrid seed of wheat in Mexico. This initiative transformed Mexico from a wheat-importing country to a wheat-exporting country within only twenty years. With the transfer of agricultural technologies from the Global North to the Global South region, agricultural production in many countries experienced phenomenal growth. Thus, it was a success story, if we consider it from an agricultural production increase point of view.

with total annual production worth more than USD 14 billion at the farm gate and about USD 80 billion at the point of retail (Boyd and McNevin 2012, Islam 2014).

Fifthly, changing food habits in the Global North are driving the cultivation of particular aquaculture species in the Global South. For example, shrimp, treated as a luxury seafood item in the Global North, is the most popular seafood in North American consumer culture (Islam 2014).

Sixthly, industrial aquaculture has evoked fierce debates surrounding its sustainability. Several environmental groups claim that commercial aquaculture has negative environmental and social consequences on ocean ecology and local communities in such a degree that obviously offsets its benefits (Islam 2014). Thus, global industrial aquaculture, especially commercial shrimping, has generated the interest of a wide array of stakeholders around the globe.

Seventhly, aquaculture is one of the sectors that will undergo both positive and negative implications of climate change. Ambiguity in the extent and rate in climate change in future and in its likely biophysical effects on cultured species makes it difficult to gauge the impact of climate change on aquaculture production in socio-economic terms (Handisyde et al 2006). Climate change variability is one of multiple causative factors that affect industrial aquaculture around the globe. The climate change phenomena that are likely to impact on aquaculture and aquaculture related livelihoods include global warming, sea-level rise, ocean productivity, changes in monsoon and occurrence of extreme climate events such as cyclones and storm surges, water stress, changes in hydrological regimes in inland waters, El-Nino Southern oscillation, and droughts (Bernhardt and Leslie 2013, De Silva and Soto 2009, Handisyde et al 2006, Kam et al 2012, WorldFish Centre 2007). Climate change affects, positively or negatively, the survival,

growth, reproduction, and distribution of individuals of marine and freshwater fish species (Brander 2007, Yazdi and Shakouri 2010). The effects of climate variability and extremes on aquaculture will vary depending on regional and species variation of aquaculture, among others.

Finally, aquaculture sector is grappling with its own resilience and adaptation strategies in the face of climate change extremes. We can consider an aquaculture setup as a social-ecological system (SES). The concept of SES has emerged as a conceptual entity that gives social and ecological systems the same weight in analysis (Folke 2006). SES views people and nature as part of a linked system, emphasising that “humans must be seen as a part of, not apart from, nature – that the delineation between social and ecological systems is artificial and arbitrary” (Bahadur et al 2013:56). In aquaculture, aquatic species and humans create a relationship of functional dependency between them. Since cultured fish species are confined in demarcated spaces, they have limited scope for building their own resilience to climate change when compared to their counterparts in open waters. With their limited scope, cultured fish develop resilience through biophysical actions. The aquaculturists, on the other hand, have more room for building resilience to climate change with regard to their farm activities. The aquaculture farmers and respective governmental and other stakeholders in farming countries devise actions for resilience and adaptation to environmental and climate change threats. In designing the resilience action plans, the respective authorities need to take the aftermath of the projects into consideration, whether they are sustainable in long turn or could create new environmental and social problems.

1.2 Bangladesh as an appropriate site for exploration

Although Bangladesh contributes negligibly to global greenhouse gas emissions, it is one of the worst victims of climate turmoil. Similarly, commercial shrimping² in Bangladesh, as part of global industrial aquaculture, is deeply affected by climate change. Shrimp industry in Bangladesh is an important area for a sociological investigation. Sociological study of any social action, institution or phenomenon incorporates, among other things, the breakdown of that particular system or entity into multiple layers and levels of analysis. Commercial shrimping in Bangladesh is a sociological issue because it, like aquaculture sector around the globe, incorporates diverse organizational, economic, social, political, environmental and cultural factors and significance. Though commercial shrimp production apparently might seem just as an economic and business activity, if we have a deeper look into the sector, we find that this sector's emergence, sustenance, growth, and development are profoundly affected by host society's political, cultural, economic, social, religious, and environmental factors as well as by global drivers.

The shrimp industry in Bangladesh is interconnected at such an extent with diverse social and cultural norms and institutions in Bangladeshi society³ that various facets of this sector, including its resilience to climate change at the

²Coastal aquaculture in Bangladesh consists mainly of two shrimp species: (a) brackish-water marine shrimp, *Penaeus monodon* (tiger shrimp, locally called *Bagda chingri*) and (b) fresh-water giant prawn, *Macrobrachium rosenbergii* (locally called *Golda chingri*). There are about 16,237 marine shrimp farms covering 148,093 ha and 36,109 fresh water prawn farms covering 17,638 ha of coastal area in Bangladesh (Azad et al 2009:800).

In popular usages, government statistics and scholarly writings in Bangladesh frequently refer to both species as 'shrimp'.

The FAO convention is to call the marine and brackish-water species 'shrimp' and freshwater species 'prawn' (FAO 2008).

Since the empirical part of this study was conducted in brackish-water area, 'shrimp' is generally used to mean *Penaeus monodon* throughout the report; but, to make it comprehensive, this term includes *Macrobrachium rosenbergii* and other penaeid species when referring to previous studies and statistics on shrimp (such as in the literature review section).

³ See the literature review on the shrimp industry in Bangladesh in the fourth chapter.

community level, require comprehensive explorations from sociological perspectives. This study will be a significant addition to environmental sociology, a sub-field of sociology that studies the interaction between ecological and social systems. Taking ‘community resilience’ as a sociological lens, this study seeks to offer a sociological understanding of shrimp aquaculture in Bangladesh.

Commercial shrimp, locally known as ‘white gold’ (Islam 2008c) because of its high transnational value, has turned into a ‘multimillion dollar industry in Bangladesh’ (Ahmed 2013). Bangladesh is the sixth contributor in global aquaculture (Paul and Vogl 2011), supplying about 5% of global shrimp production (Islam 2010:45). This sector benefits nearly 4.8 million poor people while providing subsistence directly to 1.2 million people in Bangladesh (USAID 2006). In order to boost aquaculture production in Bangladesh as part of promoting the Blue Revolution, the ‘development trilogy’ – consisting of three main external sources of international development banks, bilateral aid agencies, and multilateral development assistance agencies – provided a total loan amount of USD 115.49 million between 1976 and 1990 (Islam 2014:84). Additionally, starting in the 1990s, some donor-funded projects were undertaken in promoting inland prawn culture. The above-mentioned initiatives brought about significant positive changes to shrimp production and increased foreign currency earnings.

Though Bangladesh has been earning a significant amount of foreign currency from shrimp exports, Bangladesh lags behind other Asian countries by a wide margin if we compare shrimp production per unit of land in the region (see Table 6.1 in Chapter Six). The major causes behind this, among others, are its under-capacity operation, exposure to climate change vulnerability and lack of appropriate degree of resilience. Coastal Bangladesh, where shrimp is cultured, is

frequently affected by extreme climate events like cyclones and storm surges that severely damage the entire coastal aquaculture. Bangladesh, as a whole, is one of the most vulnerable countries in the world to climate risks, a fact that made it a hotspot⁴ in the world (World Bank 2013). Climate change vulnerability of the country lies in the fact that two-thirds of the nation is less than 5 meters above sea level (World Bank Group 2010:2) and is projected to lose 17.5% of its land if sea level rises about 1 meter (Mohanty et al 2010:121), thereby displacing millions of people. Based on data from the 1980-2000 period, Bangladesh was identified by the United Nations Development Programme (UNDP) as the most vulnerable country in the world to tropical cyclones (UNDP 2004:38) and the sixth most vulnerable country to floods (MoEF 2008:4). Every three years on average, a severe cyclone hits the coastal Bangladesh (MoEF 2009a, World Bank Group 2010). Cyclone *Sidr* alone resulted, mostly in the coastal region, in damages and losses of USD 1.7 billion, or 2.6% of the GDP in 2007 (World Bank Group 2010:17). The same cyclone washed away about 54,000 shrimp farms and hatcheries in the coastal districts (Siddiqui and Billah 2014:123). Bangladesh accounted for more than 60% of the registered deaths associated with tropical cyclones worldwide between 1980 and 2000 (UNDP 2004:37).

In order to address the above-mentioned and other climate extremes, and to increase the resilience of Bangladesh to climate hazards, the government of Bangladesh has invested USD 10 billion since the sixties (MoEF 2008:1, MoEF 2009a:1, World Bank Group 2010:xi) on structural and non-structural disaster reduction measures. Because of those initiatives, deaths, injuries and other forms of damage and losses have reduced remarkably (World Bank Group 2010). Since

⁴The term 'hotspots' refers to the regions which are already vulnerable to climate variability and are likely to suffer significant impacts in future from climate change, with the additional presence of poverty and other vulnerability characteristics (World Bank 2013).

climate change has severely affected coastal aquaculture, the Bangladeshi government recently adopted a number of programmes and policies to make coastal Bangladesh more resilient to climate extremes, these include the National Adaptation Programme of Action (NAPA) in 2005, the Coastal Zone Policy in 2005, and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2009 (World Bank Group 2010). Although the implementation of government-led resilience programmes earned Bangladesh a worldwide reputation as an “early leader in state-sponsored adaptation planning that acknowledges the centrality of governance” (Pelling 2011:167), recent studies show that they are not enough. No community can become adequately resilient to external perturbations like climate stimuli without developing its own ways of resolving problems and challenges that it encounters. Though the above-mentioned and other government and NGO initiatives can serve as ‘outside intervention’ to building resilience in shrimp communities, only a balanced and well-developed combination of the communities’ own social, economic, and natural capitals can ensure and enhance their resilience against catastrophic and gradual climate change related disturbances.

The above discussions signify the importance of studying resilience to climate change at the community level with regard to global industrial aquaculture and with a special focus on the shrimp industry in Bangladesh.

1.3 Research questions and objectives

The following two objectives and related research questions guided this investigation of the intersections between global climate change vulnerability and resilience in global aquaculture and the Bangladeshi shrimp industry.

1. To assess the vulnerabilities and resilience of global aquaculture to climate change.
 - What is the critical intersection between climate change and aquaculture?
 - What are the major climate change events that affect the aquaculture sector? How do they affect?
 - What are the major state and community-level resilience strategies that aquaculture adopts when facing climate change disturbances?
2. To examine the intersections between global climate change and resilience in the shrimp farming communities in Bangladesh.
 - What are the specific climate change events that affect the shrimp industry in Bangladesh? How do they affect?
 - How resilient has commercial shrimping in Bangladesh become to climate effects through the deployment of economic, social and environmental capitals in the shrimp farming communities?
 - What lessons can Bangladesh learn from, or provide to, the resilience efforts of other countries?

1.4 Rationale and scope of this research

A scrutiny of the existing literature on the complex interconnections between climate change and resilience with regard to the shrimp industry in Bangladesh (more in Chapter Four) reveals that there remains a knowledge gap in current research, which rationalizes the undertaking of this project. In the case of shrimp-farming community in Bangladesh, no significant sociological study has yet been conducted on the intersections between climate change vulnerability and

resilience at the community level. This study aims at contributing to knowledge by adopting a community resilience approach, which is not focused adequately in the existing literature. Table 1.1 summarizes how this project can expand knowledge on the Bangladeshi shrimp industry by applying community resilience approach, which is different from existing research works.

Table 1.1: Scope of this study for contributing to knowledge on shrimp sector in Bangladesh

Study topic /approach	Existing Literature	This Project
<i>Resilience approach</i>	Sociological study on ‘resilience’ in Bangladesh is scant.	Focuses on ‘community resilience’.
<i>Challenges for shrimp-farming community in Bangladesh</i>	Focused mainly on socio-political, quality control and governance challenges, anti-shrimp environmental movements, trade barriers, diseases etc. Very little focus on climate change challenges.	Primary focus is on, among other things, climate change disturbances and challenges.
<i>Solution to existing challenges</i>	Industrial, organizational, and governmental initiatives. Solutions are largely simplistic, and ignore the inherent relationship between social system and ecological system.	‘Community capacity’ in response to climate change disturbances – showing an inherent intersection between social and ecological system. Governmental and civil society initiatives are viewed as ‘outside assistance’.
<i>Community capitals in shrimp communities</i>	No sociological study on social, economic, or natural capitals in shrimp communities in Bangladesh.	Critical intersections of social, economic, built and natural capitals are examined to assess community resilience.
<i>Relationship between shrimp and environment</i>	How the cultivation of industrial shrimp affects the surrounding environment largely dominates the literature.	How the environment (esp. climate change) affects shrimp farming community, a study that is rare in the literature.

1.5 Central themes and organization of chapters

Recent extreme climate phenomena throughout the world such as intense 2010 heat-waves in Europe and Russia, cyclones Sidr (2007) and Aila (2009) in Bangladesh, 2002 ENSO and 2004 tsunami in Southeast Asia, and Hurricane Katrina (2005) and Sandy (2012) in North America caused increased attention of governments, aid organizations and development agencies to the question of how to adapt to climate change vulnerability. The study of adaptation as a social process has a shifting focus from impact-led research towards a better comprehension of social processes that trigger the capacity of societies to cope with the consequences brought about by climate change (Juhola et al 2016). Consequently, clarifying how climate hazards affect households and communities in local contexts and assessing the current processes of responses of households, communities and other institutions are a first-step towards proposing practical adaptation solutions (O'Donnell and Wodon 2015). Aquaculture, especially Bangladeshi shrimp farming, communities' vulnerability towards weather shocks and changing climate and the processes of their resilience – how aquaculture communities become resilient to climate extremes and shocks through community resources and capitals – are the central themes of this research.

Following this introduction, this thesis consists of seven chapters, which are briefly introduced here. Chapter Two aims to place the conceptual and theoretical frameworks adopted in this study. The main conceptual lenses for this study are aquaculture, climate change vulnerability and community resilience. The chapter discusses how the concept of resilience, moving from physical-ecological point of origin to social-cultural and community analysis, has become a crucial tool in assessing adaptive strategies at the community level. It also develops and

defines specific metrics through which community resilience can be gauged in aquaculture-dependent human societies.

Chapter Three discusses methodological issues. This study was conducted through a triangulation of methods combining content analysis of secondary sources, ethnography and qualitative interview. This chapter also briefly introduces the research areas and sampling of respondents, data collection and analysis techniques. Chapter Four outlines the background and literature review for this study. A robust review of the literature on shrimp culture in Bangladesh suggests that critical intersections between historical trajectories, socio-economic impacts and environmental concerns drew significant scholarly interest. However, there is a dearth of academic exploration of climate vulnerabilities and impacts as well as community-level adaptation in shrimp farming zone in Bangladesh.

Chapter Five introduces the socio-environmental setting in the southwestern Bangladesh where the empirical part of this study was conducted. Chapter Six focuses on the impacts of climate change on Bangladeshi shrimp cultivation. The chapter shows that weather shocks and climate changes have a range of negative repercussions on the growth, reproduction and survival of cultured shrimp, and on the economic and social organizations of the shrimp farming communities.

Chapter Seven looks at the resilience initiatives taken by households, community, and outside institutions including governmental and NGO interventions. The chapter outlines a resilience gradient, which clarifies the relative role of household, community, governmental and non-governmental organizations in creating adaptability to climate change in the shrimp-farming

community. The Eighth and final chapter concludes the report with few policy recommendations.

CHAPTER TWO

CONCEPTUAL FRAMEWORKS

2.1 Conceptual framework

Three conceptual lenses – climate change vulnerability, resilience, and aquaculture – frame this research. Climate change acts as an external perturbation that affects aquaculture production around the globe, while resilience is the response of aquaculture communities to the negative impacts of climate disruptions.

2.1.1 Aquaculture

Aquaculture means the farming of any species of aquatic organism. Farming denotes some form of interpolation in the rearing process to increase production, such as regular stocking, feeding, protection from predators etc. (FAO 2014). Most aquaculture of freshwater fish, marine shrimp, and milkfish is done in ponds (Boyd and McNevin 2012). There are an estimated 8,750,000 ha of freshwater fish ponds and 2,330,000 ha of brackish water aquaculture ponds worldwide (Boyd and McNevin 2012:A-43). Other forms of aquaculture include ‘cage culture’ and ‘culture in *raceways*’⁵ (Boyd and McNevin 2012).

Capture fisheries is an age-old practice, which does not have any significant negative social or ecological consequences. However, over the recent decades, with the decline of capture fisheries, and with the financial aid from international donor agencies, the massive growth of industrial aquaculture – hailed as the ‘Blue Revolution’ – has been integrating the aquaculture regions in the Global South with the world’s food network. This Revolution has strong

⁵ Raceways are long narrow channels through which water flows continuously; raceways are suitable for cold-water fish culture (Boyd and McNevin 2012).

repercussions on society and environment in the producing countries around the Global South.

The shrimp industry, which experienced a phenomenal growth and productivity under the Blue Revolution, is a contested arena of economic development in the Global South because this sector has gained significant attention from various stakeholders for its transnational commercial value and for its negative impacts on local ecology and environment. Nevertheless, industrial shrimp farming, conversely, is susceptible to numerous challenges from society and nature. Climate change issues are one of them.

2.1.2 Climate change vulnerability

The Intergovernmental Panel on Climate Change (IPCC) defined climate change as “a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer” (IPCC 2012:557). Climate change is explained through two associated phenomena: climate variability and climate extremes. “Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate at all spatial and temporal scales beyond that of individual weather events. Climate extreme refers to the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable” (IPCC 2012:557).

From a meteorological point of view, the climate of the earth is defined “in terms of the means and variability of the insolation, temperature, precipitation-evaporation balance, winds, and other relevant quantities that characterize the

structure and behaviour of the atmosphere, hydrosphere (oceans, seas, lakes, and rivers), and the cryosphere (ice and snow)” (Hay 2013:142). Climate change – global warming, dimming and cooling – is a natural event of the earth. Several physical, geological and cosmic factors – including variation in the sun’s energy production, distance between the earth and the sun, differences in angles at which solar radiation reaches to different parts of the earth, changes in the earth’s atmospheric and oceanic flows, changes in the insolation, albedo and reradiation rates of the earth, and volcanic eruptions – contribute to this (Hay 2013, Baer 2012).

Scientists delineate a geological memory lane consisting of four major climate regimes (see Table 2.1) of the earth’s history. *Snowball Earth*: The earth was completely covered with ice in a series of episodes during the late Proterozoic time that caused the planetary thermostat failure. The planet earth became uninhabitable for any sort of life in these extreme climate conditions. The youngest episode of the Snowball Earth episodes took place between 750 and 580 million years ago (ma), before the evolution of any higher form of life (Hay 2013:150-51). *Icehouse*: In the icehouse stage, polar and high latitude regions were covered by glacial ice. The last shift from greenhouse to icehouse climate phase occurred at the end of the Eocene, about 34 ma (Baer 2012, Hay 2013). Each icehouse period consists of longer glacial and shorter interglacial phases. The previous interglacial was about 110,000 years ago, which was followed by a glacial age that lasted about 80,000 years. We are currently, since 8,000 years ago, in an interglacial state named Holocene which provided the earth with the longest period of climate stability in at least the last half million years (Hay 2013). Only this optimal climate interval supported the rise and growth of human civilization

with sedentary settlement, agricultural food production, complex division of labour, and available time for sections of people to engage in brain-labour. In other words, if this Holocene climate state is altered drastically, human civilization may be jeopardized. *Greenhouse state*: In the greenhouse state, ice was limited only to high mountains. From Phanerozoic era (540 ma), the earth spent 75% of its time in greenhouse state and about 25% in icehouse state (Hay 2013:173). Thus, greenhouse state is the normal condition of the earth – but this condition is not optimal for human civilization. *Hothouse*: Geologically short intervals of 10,000 – 100,000 years of extremely warm temperatures (Hay 2013). Scientists believe that during the hothouse intervals there was “an active deep-ocean circulation opposite to that of today, with very warm salty waters sinking in the tropics and returning to the surface in the Polar Regions” (Hay 2013:148). The hothouse climate phases were untenable for human living.

Table 2.1: Guesstimates of mean annual temperatures at sea level for the four climate states

Source: Hay (2013:149)

Climate episodes	Temperature (°C)		
	Tropics	Mid-latitudes	Polar
Snowball	-30	-40	-50
Icehouse	22	0	-30
Greenhouse	34	20	0
Hothouse	42	35	16

Despite the fact that climate change was a regular phenomenon throughout the history of the earth, the current strain of global climate change is unique on two grounds – “it is *man-made* and it is happening more *speedily* than any time in the last fifty million years” (McKinnon 2012:1). Although climate change is a severe global problem that will affect the entire humanity within very short period of time (and has already done so in different regions) with all its complexity, human beings have failed to effectively address the threat because of,

among other things, conflict of interests among them in respect to climate change issue. Stephen Gardiner (2006) attributed this conflict of interest to a 'perfect moral storm' which is conceptualized as the convergence of three storms: global storm – explaining climate change as a product of wealthy countries and as a burden on poor countries, intergenerational storm – explaining climate change as an event that is created by the present generation but will be experienced by future generations who have no role in creating the problem, and theoretical storm – explaining climate change threats as too unprecedented to be guided by existing moral theories for appropriate actions.

Despite the conflicts of interests, the scientific community is now overwhelmingly unanimous on the existence, causes and impacts of global climate change. Human intervention to global climate change lies in the fact that the earth experienced erratic climate shifts with faster speed since the dawn of the human civilization, especially since the Industrial Revolution. Humans have now become the most important 'geologic agents' which alter the geo-climatic formation of the planet. The following facts, adopted from Hay (2013), support this claim.

- Human activity is responsible for moving ten times more soil and rock than all rivers and glaciers combined.
- Modern average global surface temperature is 15°C , which was 9°C during the last glacial age. The average temperature increase for 10,000 years was $0.0006^{\circ}\text{C}/\text{year}$. But during the last half century, global average temperature increased at a rate of $0.012^{\circ}\text{C}/\text{year}$, which is 20 times higher than the previous rate.

- Average sea level rise during the last deglaciation was 1 mm/year, while in the 20th century this rate rose to 1.5 mm/year, though there is no natural episode of shifting from glaciations to de-glaciation stage.
- CO₂ addition in the atmosphere during deglaciation was 1 part per million (ppm)/century. Since the start of the Industrial Revolution it increased to 100 ppm/century, and is currently 195 ppm/century.
- Humans have so far altered 54% of Earth's land excluding inhospitable regions of the tundra, the taiga, the Tibetan Plateau, the remaining Amazonian rainforest, the Australian outback, the Sahara and Gobi deserts, and ice-covered Greenland and Antarctica (Hay 2013:311)

For acknowledging the extreme human effect on the environment of the planet earth, ecologist Eugene Stoermer and atmospheric scientist Paul Crutzen, in 2000, proposed a new geological Epoch in the earth's history, named *Antropocene*, which began in 1784 after the invention of steam engine during the Industrial Revolution (Hay 2013:66). Later, in 2003, Paul Ruddiman argued that the Anthropocene began with the first human intervention to atmospheric CO₂ content about 8,000 years ago. Nonetheless, 95% of all anthropogenic climate changes happened after the Industrial Revolution (Hay 2013:170).

CO₂ and other greenhouse gases (GHGs) contribute to global warming. Modern capitalist treadmill of production and consumption exacerbates greenhouse gas (GHG) emissions in atmosphere in numerous ways by producing and consuming energy in agricultural, industrial, commercial, transportation and other uses. Figure 2.1 shows sector-wise global CO₂ emissions in 2007.

Figure 2.1: Global CO₂ emissions in 2007

Source: Drawn from Table 3.2, Baer (2012:59)

An unequivocal warming of the earth's climate system has been in operation since the Industrial Revolution began. Indeed, the last decade (2001-2010) was the warmest in history. Ever since the mid-1970s, the average global temperature has increased about 0.6°C, almost 0.2°C per decade (Wright and Boorse 2014:451). The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) predicts that world surface temperature is very likely to rise by 1.8°C – 3.4°C by 2100, compared with 1980-2000 (Wright and Boorse 2014:460). The IPCC in its latest Assessment Report (AR5) declared with 95% certainty that humans are responsible for more than half of the observed global warming between 1951 and 2010 (IPCC 2013:v). Global fossil fuel burning is rising every year and if the trajectory continues the earth might become an unliveable planet by the year 2100 because of the consequences of global temperature rise including rising sea level, frequent heat waves, changing weather and seasonal patterns, frequent and prolonged droughts and floods, more tree deaths and insect damage, ocean acidification or decrease in pH in ocean water etc. The majority of the projected changes in global climate will affect the industrial aquaculture sector.

i) Connections between climate vulnerability and resilience

Recently, several social scientists ⁶ examined the relationship between vulnerability and resilience of a system or community with regard to environmental and social disturbances. We can trace three broad streams of relationships between the two sister concepts: the two are opposite to each other (Folke et al 2002, Wilson 2012a and 2012b), one is a subset of the other (Gallopín 2006, Paton and Johnston 2001), and the two are overlapping but separate concepts (Cutter et al 2008, Maru et al 2014). In their study on community resilience of Mississippi counties Sherrieb and colleagues (2010) found community resilience having significantly negative correlation with social vulnerability. Adger (2006) also places vulnerability and resilience in fairly opposing poles – vulnerability is a system’s ‘susceptibility to be harmed,’ while its resilience refers to ‘the magnitude of disturbance’ that it can absorb. Few authors, such as Wilson (2012a and 2012b) and Brand and Jax (2007), even conceptualize from a normative point of view and tag resilience as ‘good’ and vulnerability as ‘bad’. Community resilience is viewed as a ‘positive’ quality because this concept is associated with a human system’s ability to absorb hazardous impacts of disasters and to re-instate the community’s full function and/or structure. Community vulnerability, on the other hand, is treated as a ‘negative’ quality since it describes “exposure and sensitivity of a human system not able to cope with disturbances” (Wilson 2012b:1221, see also Adger 2000).

⁶ E.g. Adger 2006, Bergstrand et al 2015, Chandra et al 2013, Cutter et al. 2003, Cutter et al. 2008, Cutter et al 2014, Fieldman 2011, Gallopín 2006, Manyena et al 2011, Maru et al. 2014, Miller et al 2010, Nelson 2011, Nelson et al. 2007, Paton and Johnston 2001, Turner II 2010, Wilbanks and Kates 2010, Wilson 2012a and Wilson 2012b.

Thus, a community's resilience and vulnerability can be put at opposing poles of a continuum.

The second stream of scholarship views resilience as a part of vulnerability. With regard to climate change, the more a community (or, system) is exposed and sensitive to climate stimuli, the more vulnerable it is. Sensitivity denotes the degree to which a system can be affected, positively or negatively, by climate perturbations (Gallopín 2006, IPCC 2001), exposure means the degree, or duration in which a system is in contact with climate threats (Adger 2006, Gallopín 2006). A system's exposure and sensitivity to a particular threat are determined by the system's physical and social characteristics, the threat's attributes and the nature of relationship between the system and the threat. In addition to exposure and sensitivity, the third component of vulnerability is capacity of response (or, adaptive capacity) which means a system's "ability to adjust, moderate potential damage, take advantage of opportunities, and cope with the consequences of a transformation that occurs" (Gallopín 2006:296). Gallopín (2006) argues that vulnerability denotes the transformation of a system that may be external, internal, or both. Positive vulnerability leads the system to beneficial transformation; negative vulnerability is the system's harmful transformation. Resilience, on the other hand, is obviously related to adaptive capacity, which is one of the components of vulnerability. Thus, the resilience of a system (be it social or ecological) is only a subset of its vulnerability.

The third group of scholars hold the two concepts as separate but frequently linked. For them, vulnerability is a function of exposure and sensitivity of a system, which is an inherent quality that exists before hazards occur, resilience is the conditions that help a system to absorb, cope with, and adapt to

disturbances or threats (Bergstrand et al 2015, Cutter et al 2008, Cutter et al. 2014). Manyena (2006) points out the major constituent elements of disaster vulnerability and disaster resilience – elements of vulnerability are engineering and environmental sciences related, while the elements of resilience are more associated with medical and social sciences. The resilience approach contends that communities possess certain level of resilience built over long period. Local knowledge, culture, experiences, resources, social networks and relations all contribute to outline a community's resilience to hazards. The social vulnerability approach, on the other hand, emphasizes to resist the threat by means of more tangible resources of the community. Thus, while resilience focuses on the adaptation processes acquired through cultural heritage, vulnerability has engineering and institutional resistances at its heart. Table 2.2 lists the major constituent elements of vulnerability and resilience.

Table 2.2: Elements of vulnerability and resilience

Source: Manyena (2006:445)
(title modified)

Vulnerability	Resilience
Resistance	Recovery
Force bound	Time bound
Safety	Bounce back
Mitigation	Adaptation
Institutional	Community-based
System	Network
Engineering	Culture
Risk assessment	Vulnerability and capacity analysis
Outcome	Process
Standards	Institution

In addition to above theoretical streams, a few researchers, like Cannon and Muller-Mahn (2010), argue, opposing others, that a paradigm shift from vulnerability to resilience perspective is dangerous. According to them,

“vulnerability involves a clear, economically and politically induced condition that theorises the way that people are exposed to a lesser or greater degree of risk” (Cannon and Muller-Mahn 2010:632), while resilience, derived from natural or technological sciences and with a focus on systems (or ecosystems) approach, fails to grapple with the human system’s socio-economic components. They also hold that since economic and political allocation of resources can facilitate the reduction of vulnerability, policy requirements of a vulnerability approach are clear with a pro-poor grassroots level emphasis within this approach. By contrast, resilience thinking, with its ecosystem management approach, undermines socio-economic and political interventions and thus leaves the poor and vulnerable groups out of focus (Cannon and Muller-Mahn 2010).

The bottom-line is that while both approaches can be applied to rapid and gradual hazards and changes, the vulnerability framework is more appropriate for addressing rapid onset events like cyclones or earthquakes, whereas resilience perspective is more suitable for addressing slow onset transformations like drought, famine, long-term temperature shifts, and sea-level rise. Similarly, both concepts are overlapping in the sense that although a community can possess characteristics that can determine only its vulnerability or only its resilience, it can have multiple socio-economic characteristics that influence both its vulnerability and resilience (Cutter et al 2008). Moreover, central to vulnerability-reducing programmes is a top-down manner of service delivery from state organizations to local communities, whereas at the heart of resilience initiatives are the “bottom-up view of individual, organisational, and community capability and capacity” (Rogers 2013:392). Thus resilience, when compared to vulnerability, has great

potential to bring together cumulative, progressive and dynamic knowledge, insights and works in dealing with and learning from hazards and threats.

2.1.3 Resilience

Despite few limitations of the concept of resilience conceptualised by Cannon and Muller-Mahn, academic and policy attentions are now shifting from a vulnerability approach to a resilience perspective because the latter is viewed as “more proactive and positive expression of community engagement” (Cutter et al 2008:598), especially with regard to slow onset hazard reduction and climate change adaptation.

i) Conceptualizing resilience

The concept of resilience is unusually ‘plastic’ (Leichenko 2011), ‘highly ambiguous’ (Reid and Botterill 2013), or ‘vague and malleable’ (Brand and Jax 2007) and has taken a ‘promiscuous approach’ (Collins 2005 and Islam 2014 used this phrase in reference to commodity chain) in that it incorporates different meanings in different contexts. This is because of a blending of descriptive (what the case is) and normative aspects (what the case should be) within its conceptualization (Brand and Jax 2007).

Resilience as a descriptive concept, with precise definition and meaning and operationalized quantitatively, can be applied to hard systems in physical, ecological and meteorological *hard sciences*. Resilience, in this usage, can be dubbed as ecosystem resilience, ecological resilience, engineering resilience, or simply, resilience. Resilience as a normative concept, on the other hand, with inherent vagueness and malleability and with an opportunity to be operationalized

qualitatively, can be applied to trans-disciplinary analyses of soft systems like social, political, cultural systems. In this usage, resilience can be termed as ‘social resilience’, ‘cultural resilience’, ‘economic resilience’ or ‘community resilience’.

Resilience of a system (or community) incorporates both static and dynamic properties. On the one hand, resilience is conceptualised as an inherent or antecedent condition, state, or ‘outcome’ (Cutter et al. 2008, Reid and Botterill 2013, Rose 2004 & 2007, Kais and Islam 2016). Inherent resilience reflects ontological definition of resilience which focuses on the system’s ‘being’ (CARRI 2013, McCrea et al 2014), i.e. its ability to function well under normal circumstances in non-crisis periods and its ability to reinstate the pre-crisis stability (i.e. bounce back) if any catastrophe strikes it. In other words, inherent resilience can be thought of ‘as a snapshot in time or as a static state’ (Cutter et al. 2008:602), a system’s ‘latent attributes’ (Abramson et al. 2014). On the other hand, a system’s resilience is also its adaptive quality during and after a crisis – it is a ‘process’. This dimension is related with the phenomenological view that focuses on ‘becoming’ (CARRI 2013) or ‘doing’ (McCrea et al. 2014). In this view, resilience is not a fixed property of the system; rather, it incorporates the idea that a resilient system has flexibility in responding to hazards in that the system’s initial structure or function might undergo some necessary changes – resilience is viewed as “a quality, characteristic or result that is generated or developed by the processes that foster or promote it” (Manyena 2006:438). Dovers and Handmer (1992) view outcome vs. process dimensions of resilience as reactive and proactive resilience. At the centre of reactive resilience is the ‘quest for constancy or stability’, while proactive resilience “accepts the inevitability of change and tries to create a system that is capable of adapting to new conditions

and imperatives” (Handmer and Dovers 1996:494). Static and dynamic resilience can lead to differentiated community resilience programmes. For example, outcome-oriented resilience schemes tend to espouse ‘command and control styles’ which aim to retain the social status quo. Process-oriented disaster resilience schemes, on the other hand, focus on series of actions that enhances a community’s coping capacity over time.

ii) Evolution of the concept of resilience in academic discourses

The concept of resilience has its origin in the sciences of mathematics and physics (Bodin and Wiman 2004, Davidson 2010, Norris et al 2008, Reid and Botterill 2014), and ecology (Adger 2000, Folke 2006). In its original usage, the concept describes the ability of an object or system ‘to return to equilibrium after a displacement’ (Norris et al 2008). The English word ‘resilience’ has its origin in Latin ‘resiliens’ and its derivatives ‘resilio’ and ‘resilere’ (Klein et al. 2003, Manyena 2006, Rogers 2013). In essence, resilience translates to ‘recoil’ (see Rogers 2013) or ‘to jump back’ (Klein et al. 2003, Manyena 2006, Ranjan and Abenayeke 2014). The earliest English usage denoted the repercussive qualities of sound, namely ‘resilience of echoes’ (see Rogers 2013). Later the term was used in engineering science to mean obdurate quality of materials. In the twentieth century, ecologists grabbed the concept and during the last half century, it has been in use in various disciplines. Thus, ‘resilience’ has now, in its ‘third wave’ (Bodin and Wiman 2004), become a hot issue in sociology and other social sciences. Within the social and behavioural sciences, developmental psychology was the first discipline in which the study of resilience evolved (Abramson et al 2015, Masten 2001, Waller 2001). Currently, sociologists are contributing notably

in expanding the concept of resilience at social levels; this study is a part of that endeavour.

Wilson (2012a, 2012b) conceptualized the evolution of the resilience concept in the social sciences in three phases over the last five decades. ‘*Ecological resilience*’ was the focused notion during the late 1960s and early 1970s with an emphasis on descriptive and non-normative research on how ecosystems responded to disturbances. Later on, the resilience approach diffused in various social science researches, taking an extended ecological definition of resilience. From the late 1970s through the 1990s, social scientists deployed the resilience concept in ‘social-ecological systems’ study. At this phase, the notion of resilience emerged as a ‘boundary object’ between the natural and social sciences (Brand and Jax 2007, Wilson 2012b). Resilience was defined in this stream of research as ‘the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks – to have the same identity’ (Walker and Salt 2012:3). The conception of ‘*social-ecological resilience*’ was still burdened by its substantial reliance on “deterministic and positivist natural science-based behavioural assumptions” (Wilson 2012b:1220), which is not always applicable to human communities and systems. Social scientists began to feel discomfort in using this framework for social systems because a social system incorporates structural as well as agency variables within it, while an ecological system is primarily built on structural components. Thus, the concept of ‘social-ecological system resilience’ is incapable of conceptualizing the totality of the role of human agency factors in the resilience of a social system.

In order to overcome the inadequacy of ‘social-ecological resilience’, social scientists, after 1990s, began to use the third strand of research focusing solely on human groups and communities by deploying the new concept of ‘*social resilience*’ (Wilson 2012b). Social resilience has been defined as the ability of human communities to withstand external shocks to their social infrastructure, such as environmental variability or social, economic and political upheaval (see Adger 2000, Folke 2006). Traditionally, resilience theorists did not focus on power relations, politics and culture, their emphasis was on the structure and function of a system. Social resilient theorists brought about the question of policy, political, social, economic, psychological, and ethical parameters into the resilience spectrum (Adger 2000, Cumming et al 2005, Wilson 2012a & 2012b). Social scientists now engage a ‘bottom-up’ approach in comprehending human drivers and indicators at the community level, in which human–environment interactions are only one of many constituents. One of the differences between ecological resilience and social resilience is that while the former is linear and the latter is non-linear in the sense that due to social learning processes and social memory, social systems can never go back to its original status after a blow (but ecosystems may be able to do that). For a human community, social resilience can be both preventive to shocks through avoiding poor outcomes by developing adaptive mechanisms and curative for recovery after a traumatic or catastrophic disturbance (Wilson 2012b). Through its anticipatory nature, a social community may develop human adjustment processes that push the after-shock system to a new, and sometimes better, state – hence, at the heart of social resilience is ‘bouncing forward’ or ‘move on’, not ‘bouncing back’ (Cutter et al 2014, Manyena et al 2011). Thus the aim of adaptive capacity after a disruption would

not be to attempt merely to restore the initial state but to “use learning processes and social memory as a basis for the creation of a qualitatively different more resilient community” (Wilson 2012b:1221). So, in this view, social resilience is both an *outcome*, meaning an upgraded coping ability by communities, and a *process*, referring to community-level dynamic changes and learning to withstand shocks over time and to take responsibility and control of their development trajectories (Chaskin 2008, Davoudi 2012, Wilson 2014 & 2012b).

iii) Community resilience: the focused level

Every level of human institutions or organizations, from the individual/household to the global, shows resilience characteristics. In its multi-scalar dimension, resilience is more direct and tangible in the individual/household level and gradually takes on a more abstract and intangible form at larger spheres (Wilson 2012a & 2012b). Thus, it is imperative to researchers to have clear definition of resilience, identify the social level of which resilience is measured and elaborate the measuring methods. For example, as a global problem, decisions and initiatives regarding climate change actions come from the larger global, regional or national strata, but those actions are tangibly implemented at household or community levels. Communities are particularly important in conceptualizing social resilience because this level is at the intersection of micro-individual-household and macro-national-global levels and which can be downscaled or up-scaled (Cutter et al. 2008, Wilson 2012b).

a) What is a community?

The notion of ‘community’ is fluid and is a social construct that needs to be defined by a case-by-case basis (Mohan and Stokke 2000, Sherrieb et al. 2010) focusing on the specific area of interest of investigation. A community can be viewed as “an affective unity of belonging and identity”, “a functional unit of production and exchange”, “a network of relations” among individuals, or “a unit of collective action” (Chaskin 2008:67). Communities are composed of compositional (i.e. characteristics of individuals living in an area), contextual (i.e. characteristics of the area where certain group of people live in), and functional (i.e. mechanisms and processes through which a community functions) components (Chaskin 2008, Sherrieb et al. 2010). In community resilience studies, the term ‘community’ has been defined variously, including the totality of social system interactions, i.e. an affective unit of belonging and identity and a network of relations, usually within a defined geographical space (Wilson 2012b, 2013); any group of individuals that share common interests, identify with one another, have a common culture, and participate in shared activities (Fellin 1995, Ungar 2011); a group of people living within the territorial boundaries of an administrative unit (Allen 2006); and a place-bound neighbourhood as well as an interest or kinship-based social unit (Murphy 2007). A community’s most significant feature, in the context of resilience to climate changes, is its capacity “to collectively identify problems, take decisions and act on them and to allocate resources” (Dynes 1998:113, cited in Allen 2006:84).

Communities can be conceived of as locality-based ‘closed entities’ with geographical boundaries like village, neighbourhood, town or city as well as relation-based ‘open and unbounded systems’ (Kloos et al. 2012, Wilson 2012b)

that transcend geographical identities, like mutual help groups, student clubs, faith-based communities or internet-based virtual communities. While in the geographically-bound communities interpersonal relations are built upon by geographical proximity, people build interpersonal ties by choice in relational communities (Kloos et al. 2012). Though it is possible to view communities in various levels of size and length from a tiny area of a village to a global community, generally social resilience researchers locate community at an intermediary level in terms of a nested hierarchy of geographical scale, in which the local community is placed above household level and below regional level (see Wilson 2012b). In this usage, a community displays few distinct characteristics that include (1) community members interact on a somewhat regular basis, (2) this interaction is not mediated by the state and (3) members have some degree of shared preferences or beliefs (Flora 1998). Further, attributes of communities like community boundaries, membership, and perceptions can change over time both as a reaction to their own internal dynamics as well as to external influences (Murphy 2007).

b) Characterising a climate-resilient community:

Community resilience, or ‘regional resilience’ (Yamamoto and Yamamoto 2013) has been defined by social scientists in various ways including “those features of a community [including the development of material, physical, socio-political, socio-cultural, and psychological resources] that in general promote the safety of its residents and serve as a specific buffer against injury and violence risks, and more generally, adversity” (Ahmed et al 2004:391); “a community’s ability to maintain, renew, or reorganize social system functions and ecological functions”

(Verghese et al. 2006:508); “a process linking a set of networked adaptive capacities to a positive trajectory of functioning and adaptation in constituent populations after a disturbance” (Norries et al. 2008:131); “the existence, development, and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability, and surprise” (Magis 2010:401); and “[a community’s] social capital, physical infrastructure, and culturally embedded patterns of interdependence that give it the potential to recover from dramatic change, sustain its adaptability, and support new growth that integrates the lessons learned during a time of crisis” (Ungar 2011:1742).

In previous literatures on community resilience (e.g. IFRC 2012, Magis 2010, Norries et al. 2008, Rivera and Settembrino 2013, Skerrant 2013, Ungar 2011, Wilson 2013), we find the following characteristics of a resilient or ‘viable’ (Elms 2015) community, especially in terms of both rapid and slow onset socio-economic, environmental and climate changes.

- A resilient community takes intentional action to enhance the personal and collective capacity of its members and institutions to respond to, and influence the course of social and economic change.
- A resilient community is organized. It has the capacity to recognize problems, institute priorities, and act.
- A resilient community fosters the factors that enhance community resilience by improving community members’ capabilities, e.g. learning to live with change and uncertainty, nurturing diversity for reorganization and renewal, combining different kinds of knowledge, and creating opportunity for self-organization.

- A resilient community adapts to constant changes, it does not treat shocks and disturbances only as episodic, but regards many of them as constant and gradual threats.
- A resilient community builds its resilience through cumulative mechanisms and pathways over time. It is knowledgeable and skillful in assessing, managing, and monitoring its risks. It can learn new skills and build on past experiences.
- Community resilience is multi-scalar; it acts at the individual, community and regional levels.
- A resilient community deploys its internal as well externally-networked resources in tackling and coping to adversaries.
- A resilient community assists its members to navigate to resources as well as to negotiate for the resources they need.
- A resilient community is relatively autonomous and self-sufficient in relation to economic decision-making. It has wider economic diversities with a broader range of employment options, income and financial services (economic capital). It is flexible, resourceful, and has the capacity to accept uncertainty and respond proactively to change.
- A resilient community is rich in community capitals including economic, social, built, political, and environmental capitals.
- A resilient community is capable of clearly identifying its barriers (e.g. pre-disaster vulnerabilities, social class, mistrust, race and ethnicity, gender) and facilitators (e.g. access to community resources, local community civic and faith-based groups, and bonding-bridging-linking social capitals).

- A resilient community is connected to external actors (including family friends, religious groups, and government) who deliver a wider supportive environment and supply goods and services when needed (linking social capital).
- A resilient community has physical infrastructures and services (built capital) that include resilient housing, transport, and power, water, and sanitation systems. It has the ability to retain, repair, and renovate them.
- A resilient community can manage its natural assets (environmental capital). It recognizes their value and has the ability to protect, enhance, and maintain them.

c) Community capitals, architecture of entitlements and resilience to climate change

From the above discussion, it is clear that a climate resilient community has sufficient assets and resources that facilitate its coping capacity with long-term changes. A balanced combination of various ‘community capitals’ (Magis 2010) – sometimes variously termed as community resources (Elms 2015, McCrea et al 2014), community energy (Elms 2015), or community capacities (McCrea et al 2014) – enhances resilience of a community to disturbances including climate change disruptions. Community capitals are resources of a community that are invested for the collective wellbeing of the entire community. Social scientists frequently mention human capital (i.e. an individual’s innate and acquired personal attributes such as work skill, education, knowledge, and health which contribute to ability to earn a living and strengthening the community), cultural capital (i.e. community’s worldview, values and norms), financial or economic

capital (i.e. material property, wealth and other financial sources available to be invested for business development, civic and social enterprises), physical or built capital (i.e. physical infrastructure of a community including machinery, homes, factories, water, roads, transport, shelter and energy), political capital (i.e. community members' access to resources, power and power brokers), environmental or natural capital (i.e. availability and sustainable use of natural resources for human consumption), and social capital (i.e. the extent of social networks) (Magis 2010, McCrea et al. 2014, Murphy 2007, Norris et al. 2008, Poortinga 2012, Sherrieb et al. 2010, Ungar 2011, Wilson 2012b, 2013). 'Social capital' is an 'umbrella term' (Wilson 2012a, 2012b) that can incorporate the cultural and political capitals of a community. Social capital may further be divided into bonding capital (i.e. close 'inward looking' horizontal ties of social network that build cohesion within a community), bridging capital (referring to loose horizontal ties of 'outward looking' social networks across various social and ethnic groups), and linking capital (referring to vertical relationships across power or authority gradients) (Magis 2010, Poortinga 2012).

According to Geoff A Wilson, a community's resilience can be conceptualized on the basis of how well the 'critical triangle' of three major community capitals – economic, social and environmental capital – are developed in a certain community and how these capitals interact (Wilson 2012b). A community is strongly resilient when all three capitals are well developed in it, while it is weakly resilient when only one or no capital is well developed in it, and furthermore, a community is moderately resilient when two capitals are well developed. However, community capitals are neither equally distributed among community members nor are they available to a community as group – often some

capitals are under the capacity of particular individuals or groups of individuals. For example, human capital varies from individual to individual, and economic and political capitals may vary from class to class. Nevertheless, all the capitals available to a community can mutually support and enhance each other if they are utilised optimally by the community members. Climate events can have variegated impacts on geographically-bounded communities. They can negatively influence one form of capital but can facilitate other forms. For example, sudden changes like floods can destroy physical infrastructures in a community but they can improve natural capital and are likely to attract financial influx through governmental and other rebuilding and rehabilitation schemes. By contrast, slow onset changes, such as sea-level rise or drought, can destroy financial and environmental capital of a locality but do not attract support from outside (McCrea et al. 2014).

Resilience of a people or community is determined not only by how much the community is rich of various capitals or resources, but the distribution of those resources are more crucial in defining the overall vulnerability or adaptability of the community. The availability of resources in a community and the entitlement of individuals or groups to these resources define the vulnerability or resilience context of a people (Adger and Kelly 1999, Adger 1999). Resilience is a socially constructed phenomenon influenced by biophysical and socio-economic dynamics. Thus, it is crucial to understand the factors that determine the vulnerability or resilience of a particular community in the face of weather shocks as well as a changing climate. Adger and Kelly (1999) termed the process through which the pattern of access to resources in a people is constructed as ‘architecture of entitlements’. Social vulnerability is assessed within the framework of

‘architecture of entitlements’ at three levels. (1) At the individual level by direct analysis of material sources of entitlements, (2) at the community level by distribution of those entitlements across social strata, and (3) the institutional context within which the entitlements are shaped, contested and distributed over time and among groups (Adger and Kelly 1999).

Overall resilience of a place-based community is located at the intersection of the community’s resilience dimensions, community capitals, and the level of climate disruptions (Kais and Islam 2016). A community’s resilience depends on how much rich the community is in terms of various capitals, the pattern of entitlements to the resources, how quickly and well the community recovers from the losses through effective use of resources and capitals, how the whole community works as a unified team, how committed and persevering its members are, how well it identifies its barriers and facilitators, how well it is horizontally and vertically connected to other groups and institutions and how well it uses these connections, and how dynamic and strategic are its community leaders. We can term all the above characteristics of a community as its resilience dimensions (McCrea et al. 2014). Thus, it can be concluded that although climate change phenomena can have indirect positive consequences on social, economic and other community capitals, generally climate variability and extremes have immediate and direct negative impact on community resources through destabilizing or destroying them. Community resilience dimensions, on the other hand, have short-term and long-term direct positive influences on community resources and capitals through recovering and reinstating the community strength. Community capitals and architecture of entitlements serve as working ground for both climate change impacts and resilience dimensions – either positively or negatively. Figure 2.2

presents schematic relations among climate change impacts, community capitals and community resilience.

Figure 2.2: A conceptual model for climate change, community resilience and community capitals

Source: Partially based on McCrea et al (2014:278)

2.3 Operationalization and measurement of resilience in this study

In this study, resilience of global aquaculture and shrimp farming community in Bangladesh has been explored. Here ‘*community*’ means the shrimp-farming areas in southern Bangladesh, which is a geographical entity that possesses the three characteristics mentioned by Flora (1998) (see above). By ‘*shrimp-farming community*’, I mean any geographically demarcated specific rural area in which at least half of the population’s principal subsistence comes from shrimp cultivation or shrimp related activities. The word ‘*resilience*’ (as well as ‘*community*’

resilience’) is used to mean the ability of a social system (here, commercial shrimp farming community in Bangladesh) to respond to and recover from climate-induced disasters. Climate change is defined as external *source of shocks* and climate change events like tropical cyclones, storm surges, salinity ingress and sea-level rise are defined as ‘*external shocks and disturbances*’. Though measuring community resilience has been a challenge in the contemporary disasters science as there is no standard yardstick of common indicators or frameworks for the community resilience appraisal (Cutter et al 2010, Ainuddin and Rautray 2012), the resilience of the shrimp-farming community is conceptualized and analyzed based on the critical intersections between different community capitals. Appropriate metrics, taking insights from Magis (2010), have been applied to measure social, economic, built and environmental capitals in the shrimp communities in Bangladesh. Table 2.3 shows a simple list of community dimensions and metrics that are used in exploring the resilience of the shrimp farming community in Bangladesh.

Table 2.3: Community resilience (CR) in the Bangladeshi shrimp industry

CR components (community capitals)	CR dimensions	Sample metrics
Social capital Economic capital Environmental/ natural capital Built capital	Community resources (natural, human, social, cultural, financial, built)	How community members identify the resources. To what extent the members of shrimp-farming communities are linked to one another. To what extent shrimp communities are connected to other groups. How the community leaders are networked with outside resources.
	Development of community resources (growth and expansion of resources)	The level of the development of community resources over the last decade. New employment opportunities created. The alternative work opportunities in a changing or emergency situation, if shrimp farming faces sudden drastic calamities.
	Active agents (community stakeholders’ leadership role in community development)	Shrimp farmers’ belief in their ability to impact the community’s well-being. How active the community members are in collective work. Community members’ engagement in different groups and events related to the development

		of shrimp. Shrimp-farming community's self-reliance in addressing any outside perturbation including climate disturbances.
	Collective action (participation of community members in community works)	The role of community leaders in augmenting collaboration in works on community objectives. How far various stakeholders groups collaborate in addressing climate challenges in the community.
	Strategic action (planning, implementation, and learning)	How the community action plans are devised and implemented. Community members' commitment level to implement action plans. Community leaders' search for outside support in devising and implementing the plans.

Thus, the current study focuses on the *resilience of shrimp farming communities* in southern Bangladesh, which is examined through a thorough investigation of the critical intersections of the major community capitals. Since community resilience building involves strong interdependence between communities and governmental and non-governmental institutions and organizations (see Murphy 2007), in this study, the assets, resources and initiatives taken by shrimp communities are defined as *community capacity* (IFRC 2012), which is at the core of community resilience, and adaptation measures taken by the Bangladeshi government and NGOs are defined as *outside assistance and resources* (IFRC 2012). In order to explore the resilience of aquaculture in general, the adaptation strategies that various aquaculture communities around the globe have taken in addressing climate change shocks was examined.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter deals with the techniques of measuring community resilience to climate change in global aquaculture in general and shrimp farming in Bangladesh in particular. Here, I present the methodology applied for exploring the specific research objectives of this project.

Notwithstanding the significant implications of global climate change, there is a marked discrepancy between the importance placed on the impacts of and resilience to climate change by the scientific community, national governments and local communities. Similarly, there are disagreements between different stakeholders on how global climate change impacts aquaculture and what measures local communities need to adopt in order to adapt to climate change. The current study focuses on the *resilience of shrimp farming communities* in southern Bangladesh, which is examined through a thorough investigation of the critical intersections of the major community capitals in the localities. Since community resilience involves strong interdependence between communities and governmental and non-governmental institutions and organizations (see Murphy 2007), in this study, the assets, resources and initiatives taken by shrimp communities are defined as *community capacity* (IFRC 2012), which is at the core of community resilience, and adaptation measures taken by the Bangladesh government and NGOs are defined as *outside assistance and resources* (IFRC 2012).

In order to explore the resilience of aquaculture, I conducted a case-based systematic document analysis (Olsen 2012) of the resilience of global aquaculture

to climate changes. I examined the adaptation strategies, which various aquaculture communities around the globe have taken in addressing climate change shocks. For my case study in Bangladesh, I used primary data substantiated by secondary sources. The details are explained below.

3.1 Methods of data collection and analysis

To explore objective 1 of this study (assessing the vulnerabilities and resilience of global aquaculture to climate change), I have resorted to textual or archival research that incorporates collection of information and data from secondary sources including scholarly published books and journal articles as well as ‘gray literature’ like newsletters, newspaper reports and articles, consultancy and NGO reports, official statistics, governmental policy documents, laws, ordinances, unpublished theses and dissertations, periodicals of different domestic and international agencies, meeting minutes, working papers, brochures, notes etc. I visited libraries and public offices in Singapore and Bangladesh where related archives are placed. In addition to above mentioned printed sources and materials, I consulted internet materials from websites of concerned organizations including the World Bank, FAO, UNEP, IPCC, Network of Aquaculture Centres in Asia-Pacific (NACA), Centre for Policy Dialogue (CPD) etc. I adopted qualitative content analysis method to comprehend and analyse the documents and data. Since objective 1 serves only as a background of the objective 2 and I put more emphasis on empirical case-study of Bangladesh shrimp industry, I limited my analysis of global aquaculture in the background chapter (Chapter Four).

In order to explore objective 2 (examining the intersections between global climate change and resilience of the shrimp farming communities in Bangladesh),

I conducted a field-level investigation in Bangladesh from March 2014 to July 2014. A triangulation of methods – incorporating content analysis of secondary sources, ethnography and qualitative interview – was adopted in collecting data. In qualitative research, triangulation of methods, ‘the combination of methodologies in the study of the same phenomena’ (Denzin 1970:270), is an effective approach because what is observed by means of one method may not be perceived by another, and vice versa (Flick 2007). The whole subject of climate change vulnerabilities and resilience mechanisms in Bangladesh context is so complex and diverse that I had to apply all the above-mentioned methods in order to acquire complete insight into the sector.

3.1.1 Content analysis

In order to get a comprehensive picture of the historical as well as current scenario of the climate change and resilience in Bangladesh, at first I conducted an ‘unobtrusive’ or ‘nonreactive’ (Babbie 2013) research based on content analysis of existing secondary documents in Bangladesh. After mapping out the entire project – I searched for the potential resource persons and institutions from which I could gather relevant materials and data. Then I contacted those persons and institutions and conducted the content analysis of secondary materials from institutions including both academic and gray literatures. I searched libraries of various institutions and organizations in Dhaka, Khulna, Satkhira and Bagerhat including District Fisheries Offices, Bangladesh Centre for Advanced Studies (BCAS), Bangladesh Unnayan Parishad (BUP), Bangladesh Disaster Preparedness Centre (BPDC), Centre for Environment and Geographic Information Services (CEGIS), Climate Change Cell of Department of Environment (DoE), Department

of Fisheries (DoF) under the Ministry of Fisheries and Livestock, Coastal Development Partnership (CDP), Bangladesh Institute of Development Studies (BIDS), Bangladesh Frozen Foods Exporters Association (BFFEA), the World Bank Country Office, Bangladesh Bureau of Statistics (BBS), Institute of Disaster Management and Vulnerability Studies (IDMVS) at the University of Dhaka, Shrimp Research Station of Bangladesh Fisheries Research Institute (BFRI) etc. This phase of content analysis helped me to become familiarize with the whole set up of shrimp industry, climate change vulnerabilities, and resilience or adaptation strategies and programmes that are currently on going or planned for future realization in Bangladesh.

3.1.2 Ethnography

At the next phase of data collection, I was engaged in ethnographic study in the shrimp farming areas in southwestern Bangladesh. As a data collection method, ethnography involves the researcher “participating, overtly or covertly, in people’s daily lives for an extended period of time, watching what happens, listening to what is said, and/or asking questions through informal and formal interviews, collecting documents and artifacts – in fact, gathering whatever data are available to throw light on the issues that are the emerging focus of inquiry” (Hammersley and Atkinson 2007:3). Ethnographic inquiry involves a ‘prolonged, systematic, first-hand and direct encounter’ (Payne and Payne 2004) with the people concerned in their own cultural ‘settings’ (Warren and Karner 2015) through their lived experiences (Bernard 2013). The main aim of the ethnographer is the ‘thick description’ (Fetterman 2009, Tracy 2013, Babbie 2013) as well as ‘interpretation’

(Payne and Payne 2004:73) of the observed pattern of human activities (Van Maanen 1979).

In order to grasp the local dynamics of shrimp cultivation, climate issues, and resilience mechanisms I conducted three ethnographic visits in my three research fields in Bagerhat, Khulna and Satkhira districts in southwestern coast of Bangladesh, staying for two weeks in each of the sites (details in upcoming sections). Taking three shrimp-producing villages, namely Haldibunia, Gazipara and Ghar Kumarpur, as specific communities or socio-cultural systems, I talked to and interacted with local people, and observed the whole scenario. I selected three persons, one from each research area, as the key informants who are well versed in the social dynamics of their localities. They helped me in gaining knowledge about the history, growth trajectory and socio-economic and political repercussions of commercial shrimp farming in the areas. They also helped me in gaining access to various sites and people concerned. Since they were previously known to me, two of the key informants acted as ‘gatekeepers’ (Warren and Karner 2015:69) in the formal and informal settings of my research who made my way smooth in different situations and connections.

In this phase, I particularly focused on the total complex intersections of shrimp farming and resilience to climate change in the locality. In doing this, among other things, I had a keen observation on the local supply chain of shrimp culture incorporating different stakeholders including wild fry collectors, nursery pond workers, fry *farias*, fry *aratdars*, fry commission agents, shrimp farmers, shrimp *farias*, shrimp *aratdars*, shrimp commission agents, shrimp retailers, shrimp processors, shrimp exporters etc, on the environmental and social implications of shrimp in farming areas, on the modes and efficacy of resilience

etc. In the ethnographic phase, I also tried to understand and know about the positives and negatives of commercial shrimp cultivation in the communities. I particularly focused on a set of questions to enquire which includes: Who are the main stakeholders? What do they specifically do? Why did shrimp farming emerge in the localities? What were the contributing factors? What are the social, political, and environmental implications of commercial shrimping in the communities? How is commercial shrimping affected by environmental and climate problems? How is the commercial shrimp adapting or becoming resilient to global climate change? How the communities make use of their natural, physical, economic, and social capitals in building community resilience to climate variations and extremes? Who opposes commercial shrimp farming? Why? What are the roles of government and NGO bodies? In this phase, I also collected information on community capitals in the research areas. This ethnography helped me to know about the history and growth trajectory of shrimp cultivation in my research areas. The intensive ethnography also provided many data that are relevant to the study.

3.1.3 Semi-structured and in-depth interviews

At the final stage, after having a clear understanding of the local dynamics, I interviewed a section of informed group in order to complement the ethnographic data. I conducted the interviews after getting approval from the Institutional Review Board at the Nanyang Technological University. I made separate interview schedules for the different stakeholders of the shrimp-farming community. As the researcher, I personally conducted the interviews. I contacted each respondent prior to the interview in order to explain the nature of the

research, seek informed consent of the respondent and set an appointment for the interview. I also informed the respondents prior to the actual interviewing that their participation was voluntary and anonymous, and that they would not be harmed in any way for participating in the study. I also established rapport, an open and trusting relationship, with the respondents in order to find out the truth. Generally, ‘under-rapport’ might lead to untruths, refusal to answer, or short ‘yes-no’ responses, while ‘over-rapport’ might lead to the respondent trying to please the interviewer with ‘socially desirable answers’ rather than ‘true answers’ (Warren and Karner 2015). For this reason, I was conscious about the intensity of the rapport built – tried to avoid both under-rapport and over-rapport. In most of the cases, I conducted guided interviews by employing a ‘general set of questions and format’ to ‘use with all participants’ of a given group of stakeholders (Lichtman 2014). I conducted an unstructured, in-depth qualitative interview with a government officer not using any specific set of structured or semi-structured interview questions; our discussion remained unobtrusive and was going on in a non-directive manner.

For conducting the guided interviews, I developed open-ended interview scripts based on my research questions and objectives. I also got insights from existing literature and internet materials. Moreover, in order to refine my interview schedules, I tested the pilot questionnaires by interviewing one respondent from each category. Thus, my interview questions contained both emic and etic assumptions about my research questions. In the actual interview sessions, I let the discussions continue until the patterns of answers indicated a ‘saturation point’ so that I could get complete information. Our discussions took conversation forms, and as the interviewer, I established the general direction for

the conversation and pursued specific topics raised by the respondents. Each interview session took 1 to 6 hours of time depending on the category of respondent (see sampling of respondents below).

I conducted the interviews at times and places chosen by the respondents – in general government officials, NGO officials, processing plant owners and workers were interviewed in their offices or workplaces; shrimp farmers and fry collectors were interviewed either at their homes or at public places like outdoor courtyards, nearby cafes or market areas; shrimp and fry traders were interviewed in their business centres; and one District Fisheries Officer was interviewed outside office hours in another office building. Some interviews also took the form of ‘transect walks’ during which the respondents (especially shrimp cultivators) showed me their shrimp farms which allowed me to learn more details about the physical and environmental features of the farms.

The interview questions contained a number of sections each focusing on different topics to discuss on. The interview schedule for shrimp farmers, for example, was divided into five parts. Part A contained basic demographic questions about the respondent, Part B focused on shrimp cultivation, Part C dealt with the respondent’s observation on and knowledge about local weather and climate change, Part D focused on the social, physical, finance, and natural capitals of the community, and Part E was based on the outside assistance that the community gets.⁷ Since Bangla is the official language of Bangladesh and almost all people speak in Bangla, I conducted my interviews in Bangla. In order to increase accuracy of both my delivery of question and understanding of answers, I often repeated my questions to the respondents who struggled to grasp them first

⁷ See Appendix for a sample questionnaire used for shrimp farmers.

time. In addition, I requested the respondents to clarify the local terms and phrases they used, which were previously unknown to me.

I followed the seven stages in the complete interviewing process that include thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting (Kvale 1996, Babbie 2013). I recorded the interviews with digital recorders with the consent of the respondents. It allowed me to focus on listening to the respondents and pay attention to unspoken signals. I also took field-notes during my interview sessions.

Figure 3.1: Map of shrimp aquaculture zone in Bangladesh

(The blue-marked areas are the shrimp farming zone in Bangladesh).

3.1.4 Site selection

The present study was conducted in three districts of southwestern Bangladesh namely Bagerhat, Khulna and Satkhira. These districts were selected purposively because they fit best for the research problem. First, these three districts comprise about 80% of total shrimp farms in Bangladesh (Pokrant and Reeves 2003, Alam

et al 2005, Islam 2008). Second, these areas are most vulnerable to climate change events like tropical cyclones, sea-level rise, salinity intrusion, and storm surges (Ali 1996 & 1999, Ahmed et al 2013, Ahmed 2013, MoEF 2008). Finally, adaptation initiatives by the Bangladeshi government and NGOs are being taken in these areas in order to face climate change vulnerabilities (MoEF 2008). For my study, only those sites in these districts were selected where shrimp farms are more prone to climate change perturbations.

Source: Google Maps

For close observation of the critical intersections of social, built, economic and natural capitals, three shrimp farming villages – namely Haldibunia of Mogla Upazila in Bagerhat, Gazi Para of Koyra Upazila in Khulna and Ghar Kumarpur of Shyamnagar in Satkhira – were randomly selected (see Figure 3.2). All the three upazilas (sub-districts) that I selected for my field investigation are situated

in the coastal regions where brackish-water shrimp cultivation is the main source of livelihood of the inhabitants. There were 5,480 brackish water shrimp farms in Mongla Upazila in 2013 (DFO, Bagerhat 2014), 15,158 in Shyamnagar Upazila in 2014 (DFO, Satkhira), and 4,200 in Koyra upazila in 2013 (Upazila Parishad, Koyra 2014). Vast majority of the inhabitants of the selected villages are engaged in shrimp farming and shrimp related activities. According to the Bangladesh Bureau of Statistics (BBS), 79.43% of employed males in Haldibunia of Mongla are engaged in agriculture (BBS defined shrimp cultivation as an agricultural activity) (BBS 2012a:C-11:31), 95.65% in Gazi Para of Koyra (BBS 2012b:C-11:39), and 80.67% in Ghar Kumarpur of Shyamnagar (BBS 2012c:C-11:53).

4.1.5 Sampling for interview

Forty-five people from different stakeholders of shrimp-farming community in Bangladesh were interviewed in order to have a clear and detailed picture of the current state of the sector. As this is a qualitative research project, I used purposive sampling technique in order to select respondents. In sociology, purposive or judgmental sampling is used to select units of observation “on the basis of researcher’s judgment about which ones will be the most useful or representative” (Babbie 2013:128).

Table 3.1: Selection of samples

Participants		Area				T
		Bagerhat	Khulna	Satkhira	Dhaka	
Shrimp-farming Community (N=29)	Fry collector	3	3	3		9
	Shrimp farmer	4	4	4		12
	Local shrimp trader	2	2	2		6
	Plant owner		2			2
Government Officials (N=7)	DFO	1	1	1		3
	UFO	1	1	1		3
	DoF Officer				1	1
NGO officials (N=9)		3	3	3		9
Total		14	16	14	1	45

As mentioned above, to know more intensively about the farmers and villagers, I took the help of one key informant from each research area. The mentioned numbers of research subjects were selected to ensure a fair geographical share among the three districts (Table 3.1). While collected data from ethnography and interview of shrimp-farming community reveal both the *community capacity* and the *outside assistance* (see above section on ‘operationalization and measurement’ in Chapter Two), data from governmental and NGO officials supplement information on *outside assistance* that the shrimp communities get in enhancing their resilience to climate change disturbances.

Selection criteria for respondents: In order to conduct an in-depth qualitative study I set specific selection criteria for the respondents that prioritized experienced participants who have the greater depth of understanding and knowledge of shrimp aquaculture and local climate change.

Shrimp cultivators: (1) Residing in the village or locality since their birth, (2) Spent at least 10 years in shrimp farming, and (3) Experienced at least one major climate extreme in their lifetime.

Postlarvae collectors: (1) Residing in the village or locality since their birth, (2) Spent at least 10 years in shrimp fry catching, and (3) Experienced at least one major climate extreme in their lifetime.

Shrimp/PL trader: (1) spent at least 10 years in shrimp or fry trading, and (2) experienced at least one major climate extreme during their business years.

NGO Officials: (1) The NGOs operating in the area at least for five years, (2) Directly or indirectly address, support or oppose commercial shrimp farming through their projects and activities, and/or (3) Directly or indirectly address climate change in the area.

Shrimp processing plant owners: (1) the plants operating at least for 10 years.

Government officials: (1) Current office-holders.

3.1.6 Data analysis techniques

I have analyzed the data collected from field observation by using ‘qualitative analysis’ technique in which data are examined and interpreted non-numerically (Babbie 2013) through a narrative approach (Lichtman 2014) and analytic description (Warren and Karner 2015). A large quantity of thickly descriptive data, good organizational skills and interpretative ability are the requirements of qualitative analysis (Warren and Karner 2015). My fieldwork produced a high volume of unstructured, cumbersome and rich qualitative data which I tried to reduce through document summaries and thematic patterns. Soon after completing my data collection, I transcribed each interview into MS Word document. I went through each transcript carefully to acquire an extensive understanding of its content. Then I made a document summary of every transcript that encompassed general information about the contents and relevance of the transcript in relation to my research questions. Once the interviews were transcribed and document summaries were created, I started to construct a cohesive representation of the data through finding out the themes, patterns, categories, relationships etc that emerged out of the transcripts and field notes. I particularly focused on patterns and themes⁸. Finally, I analyzed the data, incorporating the emerged patterns and themes, through concept mapping and narrative means.

⁸ In qualitative data analysis, ‘pattern’ refers to a descriptive finding and ‘theme’ refers to a more categorical or topical form (see Patton 2015)

3.2 Limitations of the data collection methods

Since I was engaged in qualitative interviewing for collecting my field data, I faced a number of deficiencies while conducting my fieldwork in Bangladesh. First, although I tried to secure the highest-level accuracy in questions in terms of their content, structure and presentation, some questions might have produced biasness due to their poor construction or delivery. Second, narrow demographic representation and relatively small size of the respondents might not produce sufficient data and conclusion that can be quite generalizable in greater global context of the research problem. Third, despite my efforts of building the required degree of rapport with the respondents, I assume that there were some problems of reactivity (Babbie 2013) in that some respondents might have altered their answers and opinions, at least with regard to few questions or topics, since they were aware that they were being studied. Finally, in-depth qualitative interviewing is a rigorous and time-consuming endeavour to which I could not do justice aptly because of the time constraint that I encountered during my data collection phase.

CHAPTER FOUR

BACKGROUND AND LITERATURE REVIEW

4.1 Introduction

It is now widely recognized that climate change will be, and somewhere is, affecting fisheries and aquaculture throughout the globe. Sea surface temperature (SST), sea-level rise (SLR), changing atmospheric and water temperature in rivers and lakes, variability in the amount of rainfall, water and soil salinity, cyclone, droughts, storm surges, floods, ocean acidity, earthquake and tsunamis – are all significant drivers of climate change that will affect coastal, inland and marine environments in various degrees in different regions of the world, resulting into changes in fish habitats, stocks and species distribution (FAO 2011). However, comparing to other primary production sectors, fisheries and aquaculture obtained only ‘scant attention’ (De Silva and Soto 2009) in mainstream climate change impact research. The intersections between climate change impact, adaptation, and aquaculture has drawn considerable scholarly interest⁹ in recent years. In the first part of this chapter, I look into specific issues on how aquaculture is, and might be being, affected by anthropogenic global warming and associated changes in other climate parameters and phenomena. I also delve into the issues of adaptation and resilience in aquaculture sector. The first part, thus, is a broad survey of global aquaculture. I present a comprehensive review of literature on the industrial shrimp production in Bangladesh in the second part of this chapter. Finally, this chapter points out the knowledge gap in existing literature and hence justifies the commencement of this project.

⁹ E.g. De Silva and Soto 2009, Brander 2007, Handyside et al 2006, Chand et al 2012, Williams and Rota 2013, FAO 2009, 2011, Brugere 2015, Mills et al 2011, Khan et al 2012, Frost et al 2012, Young et al 2012, Shelton 2014, Edwards 2015, Kam et al 2012, Nagothu et al 2012.

4.2 Climate change and resilience in global aquaculture

4.2.1 Impact of climate change on global aquaculture

Since climate change has a regional dimension, affecting different geographical areas in different degrees (IPCC 2014, 2015) and since aquaculture is not practised evenly across the globe (De Silva and Soto 2009), geographical and climate distribution of aquaculture is a crucial factor that determines how aquaculture can be affected by climate disruptions. De Silva and Soto (2009) reported that aquaculture is practised in three basic environments – fresh water, marine water and brackish water. In the three major climate regimes of the world, tropical regions are the areas where the most aquaculture productions take place, followed by sub-tropical and temperate regions. The continent of Asia dominates in aquaculture production by an extremely wide margin. Asia supplies about 90% of total global aquaculture production (De Silva and Soto 2009, World Ocean Review 2013), with about 65% of total production from tropical and sub-tropical Asia (De Silva and Soto 2009). Thus, climate change variability and extremes in Asia – the epicentre of global aquaculture (De Silva and Soto 2009) – will affect the global aquaculture most. The geographic and environmental variation in aquaculture concentration entails diverse and region-specific mitigation and adaptive strategies.

Climate change related threats to aquaculture arise from “(i) stress due to increased temperature and oxygen demand and decreased pH, (ii) uncertain future water supply, (iii) extreme weather events, (iv) increased frequency of diseases and toxic events, (v) sea level rise and conflict of interest with coastal defences, and (vi) an uncertain future supply of fishmeal and oils from capture fisheries”

(Brander 2007:19711). Predicted climate changes such as rise in water temperature, precipitation, sea level rise, extreme events like cyclones and tidal surges, soil erosion, climate variability and ocean currents will cause physiological (growth, reproduction, disease etc), ecological (organic and inorganic cycles, predation, ecosystem services etc) and operational (species and site selection etc) changes (Handisyde et al 2006). All these changes will have direct impact on aquaculture production and aquaculture dependent livelihoods and indirect influences on aquaculture through fishmeal and fish oil availability (Handisyde et al 2006, De Silva and Soto 2009, FAO 2011, Chand et al 2012). In the context of aquatic species, “direct effects act on physiology and behaviour and alter growth, development, reproductive capacity, mortality, and distribution. Indirect effects alter the productivity, structure, and composition of the ecosystems on which fish depend for food and shelter” (Brander 2007:19710). The direct effects of climate change on aquaculture are summarized in Table 4.1.

Table 4.1: Ways in which climate change may directly impact aquaculture production

Drivers	Biophysical effects	Implications for aquaculture
Changes in sea surface temperature	More frequent harmful algal blooms. Less dissolved oxygen. Increased incidence of disease and parasites. Altered local ecosystems with changes in competitors, predators and invasive species. Changes in plankton composition.	Changes in infrastructure and operating costs from worsened infestations of fouling organisms, pests, nuisance species and/or predators. Changes in production level.
	Longer growing seasons. Lower natural mortality in winter. Enhanced metabolic and growth rates.	Potential for increased production and profit
	Enhanced primary productivity.	Potential benefits for aquaculture but perhaps offset by changed species composition
	Changes in timing and success of migrations, spawning and	Impacts on seed availability for farming.

	peak abundance, as well as in sex ratios.	
	Change in the location and size of suitable range for particular species.	Aquaculture opportunities both lost and gained.
Rising sea level	Loss of land.	Reduced area available for freshwater aquaculture.
	Changes to estuary systems.	Shifts in species abundance, distribution and composition of fish stocks and aquaculture seed.
	Salt water infusion into groundwater.	Reduced freshwater availability for aquaculture and a shift to brackish water species.
	Loss of coastal ecosystems such as mangrove forests.	Reduced seed for aquaculture. Worsened exposure to waves and storm surges and risk that inland aquaculture become inundated.
Higher inland water temperatures	Raised metabolic rates increase feeding rates and growth if water quality, dissolved oxygen levels, and food supply are adequate, otherwise possibly reducing feeding and growth. Potential for enhanced primary productivity.	Possible benefits for aquaculture, especially intensive and semi-intensive pond systems.
	Shift in the location and size of the potential range for a given species.	Aquaculture opportunities both lost and gained.
	Reduced water quality, especially in terms of dissolved oxygen. Changes in the range and abundance of pathogens, predators and competitors. Invasive species introduced.	Altered culture species and possibly worsened losses to disease (and so higher operating costs) and possibly higher capital costs for aeration equipment or deeper ponds.
	Changes in timing and success of migrations, spawning and peak abundance.	Impacts on seed availability for aquaculture.
Changes in precipitation and water availability	Changes in fish migration and recruitment patterns and so in recruitment success.	Impacts on seed availability for aquaculture.
	Lower water availability for aquaculture. Lower water quality causing more disease. Increased competition with other water users.	Higher costs of maintaining pond water levels and from stock loss. Reduced production capacity. Conflict with other water users. Change of culture species.

	Altered and reduced freshwater supplies with greater risk of drought.	
Increase in frequency and/or intensity of storms	Large waves and storm surges. Inland flooding from intense precipitation. Salinity changes. Introduction of disease or predators into aquaculture facilities during flooding episodes.	Loss of aquaculture stock and damage to or loss of aquaculture facilities and fishing gear. Additional cost for designing new facilities. Increased insurance cost.
Drought	Lower water quality and availability for aquaculture. Salinity changes.	Loss of wild and cultured stock. Increased production costs. Loss of opportunity as production is limited.

Sources: Adopted from Handisyde et al (2006: 30-31) and WorldFish Centre (2007:3-4) (abridged)

Since aquaculture species are poikilothermic (De Silva and Soto 2009), physical metabolism and consequent rate of growth, production, reproduction and seasonality of them largely depend on the temperature of their habitats. Increasing atmospheric and water temperature caused by human-induced climate change may seriously affect the physiology of cultured aquatic species, especially brackish water species. Increased temperature affects pond evaporation rates (Nagothu et al 2012) and, as a result, increases the salinity level in water which decreases the amount of dissolved oxygen (DO) in the farm water, which, in turn, impedes metabolic activities in fish, especially in less saline-tolerant species leading to increased incidence of disease and parasites (FAO 2011). On the other hand, increased metabolic rates in aquaculture species due to temperature increase in water cause extra feeding for them. Culture species may be more vulnerable to diseases and so pushing up operating costs for farmers. Operation costs may also increase due to higher capital investment in aeration and other equipments and deeper ponds (FAO 2011). Again, since most ponds used for aquaculture are shallow (De Silva and Soto 2009), climate change induced temperature increase

affects water quality in source water bodies and aquaculture productivity, and in extreme cases, causes high mortality through an increase in the frequency and intensity of disease outbreaks (Vilchis et al 2005). This phenomenon is common in shrimp aquaculture in Bangladesh (see chapter six). In increased water temperature, food intake of mariculture species falls and feed utilization efficacy in fish reduces (De Silva and Soto 2009); this could be disastrous for fish growth, production, and reproduction.

Abrupt changes in wind and rainfall pattern could result in upwelling bringing deep/bottom O₂ depleted waters to the surface, which adversely affects cultured stocks. Because of this upwelling and resultant de-oxygenation problems cage cultures have already been reduced to one crop per year as opposed to earlier two crops per year (De Silva and Soto 2009). Floods caused by excessive rainfall may inundate aquaculture ponds resulting into escape of farmed species and economic loss to the farmers. Floods and other water related drivers of change may affect the abundance and composition of wild stock and seed of farmed species, cause damage to aquaculture facilities in some cases, affect water salinity in farms, and lead to the introduction of disease or predators into aquaculture ponds during flooding episodes (Handisyde et al 2006, FAO 2011). Like temperature increase and severe rainfall, droughts can have stern impacts on aquaculture. In extreme cases, fishponds may dry up and fishers need to harvest fishes prematurely, which can affect economic output for them. Water stress caused by decreased rainfall may limit aquaculture in some regions (Handisyde et al 2006), which in turn lead to increased risks and costs of aquaculture in affected areas.

Climate change might contribute to global acidification (IPCC 2007, Hughes et al 2003). Increased acidification might restrict calcareous shell formation in molluscs that can lead to reduced growth and production of mollusc species. One of the major setbacks comes from SLR and salinity ingress. SLR causes changes to estuary ecosystems, such as changes in mudflats and mangrove forests, which again results in variation in species abundance, distribution and formation of fish stocks and aquaculture seed (FAO 2011). SLR increases salinity intrusion further upstream, which causes reduced area of aquaculture and translocation of freshwater as well as brackish water aquaculture areas. A one-metre SLR, for example, can inundate up to 20,000 km² of land in Mekong Delta, Vietnam (De Silva and Soto 2009), causing massive displacement of coastal aquaculture.

Extreme climate events like cyclone, flood etc frequently causes havoc in tropical and subtropical countries. Increase in frequency and severity of extreme events induces damage to aquaculture infrastructure and stocks (Nagothu et al 2002, FAO 2011). In one instance of direct impact of climate change on fisheries and aquaculture, a smog cloud over Southeast Asia at the time of 2002 El Niño Southern Oscillation (ENSO) dropped sunlight and heat to the earth's surface by 10%, which caused dinoflagellate blooms that affected coastal aquaculture in the region and resulted damage to aquaculture worth of millions of US dollars (De Silva and Soto 2009, Swing 2003). During 1994-95, El Niño Chile devastated salmon industry and caused huge numbers to escape from sea-cage aquaculture farms (Soto, Jara and Moreno 2001). Extreme events in China caused a loss of about 0.5 million tonnes of cultured finfish. Similarly, Hurricane Mitch damaged large number of aquaculture farms in Nicaragua in 1998 (De Silva and Soto

2009). Extreme climate events are often accompanied by salinity changes in pond water or addition of predators or disease into aquaculture farms together with flooded water, which leads to production losses (Nagothu et al 2012).

Though there is not much convincing proof yet, few scientists hypothesize that climate change will dramatically increase the number of earthquakes, tsunamis, and volcanic eruptions (McGuire 2012a, 2012b, Renton 2015). McGuire (2102a, 2012b) argues that anthropogenic global warming, through swift melting of cryosphere, especially ice sheet on the lands of Greenland and Antarctica, shifts huge amount of weight from land to sea. Since the cryosphere and the hydrosphere (especially ocean) are the two major stabilizers (Hay 2013) of natural systems of the Planet Earth, this enormous transfer of weight – ‘giant’ in McGuire’s term – can cause a geologic imbalance and instability in the entire system. A lesser amount of weight can lead to a rebound effect on the earth, causing earthquakes. The extra weight on the ocean, on the other hand, can cause an increase in frequency and intensity of earthquakes, tsunamis and volcanic eruptions in the coastal belt (McGuire 2012a, 2012b, Renton 2015). The 2004 great Asian tsunami had a devastating impact on coastal aquaculture in Southeast Asian countries. It is estimated that only in coastal Aceh, Indonesia, for example, nearly half of the aquaculture ponds were severely damaged, which directly affected at least 40,000 peoples’ livelihoods (Philips and Budhiman 2005, Mills et al 2011).

In addition to above issues and problems, many fish diseases are associated with changes in weather parameters. Increased incidence of White Spot Disease (WSD) of shrimp, for example, a disease caused by White Spot Syndrome Virus (WSSV), is associated with fluctuations in water temperature, suboptimal

level of salinity and pH, heavy rainfall, and presence of carrier organisms in pond, water, or feed (Bush et al 2010).

Predicted indirect impacts of climate change on aquaculture includes impact on fishmeal and fish oil supplies, supply of non-aquatic feed ingredients used in aquaculture, trash fish / low-valued fish / forage fish supplies, impacts on fish diseases, and impact on biodiversity (De Silva and Soto 2009, Handisyde et al 2006, Brander 2007). The most noticeable indirect impact of climate change on aquaculture is related to fishmeal and fish oil supplies. In 2003, 2.94 million tonnes of fishmeal (53.2% of global fishmeal production) and 0.8 million tonnes of fish oil were consumed globally by aquaculture sector (Tacon, Hasan and Subasinghe 2006:v), considered to be equivalent to the consumption of 14.95 to 18.69 million tonnes of forage fish/trash fish/low-valued fish, primarily small pelagics (Tacon et al 2006:v, De Silva and Soto 2009:180). Due to climate change, global production of sardines, sand eel, capelin, Peruvian anchovy and other species that are used to make fishmeal and fish oil may decrease by 20% (De Silva and Soto 2009, Schmittner 2005). Trash fish captured mostly from small-scale artisanal, coastal fisheries are used directly or in combination with other ingredients to feed the cultured stocks in Asia. Climate variability could threaten the supply of trash fishes through decreased ocean productivity (Schmittner, 2005), eventually reducing the supply of an important feed ingredient in small-scale aquaculture (De Silva and Soto 2009). High El Niño temperature, due to climate change, in 1997 and 1998 led to coral bleaching (De Silva and Soto 2009) in the Pacific, which led to loss of biodiversity in the area. Biodiversity loss can indirectly affect the growth and survival of farmed species of fish.

Social impacts of climate change on aquaculture are the effects of climate disturbances on socio-economic conditions of the communities dependent on fish cultivation. Below is a summary, based on secondary literature, especially De Silva and Soto (2009) and Handyside et al (2006), of current and projected social consequences of climate change in aquaculture communities. Aquaculture communities' overall revenue from the sector might be affected negatively due to reduced rate of growth and production of farmed fish because of climate change. Damage to physical infrastructure during extreme events affects transportation and marketing systems, leading to financial loss to the farmers. Small-scale cluster farmers could suffer losses from farm damages in tropical and subtropical regions. Marine finfish producers in tropical regions are vulnerable to incur losses due to the projected increase of severe tropical cyclones in future. Saline water intrusion in far reaching inland areas can cost millions of people in coastal areas to alternate their mode of subsistence shifting from agriculture-base to aquaculture-base. An outbreak of diseases in aquaculture caused by climate change can have crucial social consequences on small-scale producers and workers (De Silva and Soto 2009). Outbreak of diseases in aquaculture species can affect negatively on employment opportunities at all levels of the sector, which in turn could have strong detrimental effects on the local economy.

In addition to general impacts of climate change on world aquaculture, results from six regional case studies on the impacts of climate change on fisheries and aquaculture conducted by the FAO in 2009 suggest that there are regional variations of climate factors and their consequences on fisheries, aquaculture and dependent people. Major climate-related drivers in the Caribbean, for example, are SLR, increased cyclones, temperature, volcanic eruptions, and tsunamis and

decreased wet-season rainfall (McConney, Charlery and Penna 2015); Lake Chad is vulnerable to drought and rainfall variations (Ovie and Belal 2012); SLR, salinity increase and floods are the major climate threats to fisheries and aquaculture in the Mekong Delta (Brugere 2015); the Pacific region is threatened by fluctuations in atmospheric temperature and SST, and increased rainfall (Bell et al 2011); and in Latin America the climate change drivers that impact most on aquaculture are SLR, increased SST and extreme events (Brugere 2015). The above drivers of change cause decrease in aquaculture production across the regions either directly or indirectly. They also lead the communities toward social conflicts and vulnerabilities.

4.2.3 Adaptation and resilience in aquaculture in global context

Only after a thorough analysis of contextual factors affecting exposure, sensitivity, and adaptive capacity of aquaculture communities and stakeholders, effective adaptation and resilience plans and actions can be devised for specific groups and communities. In addition to aquaculture species' biophysical and environmental influences, several socio-economic, networking and governance factors, as we noted in a previous section on facilitators and barriers, act as determinants of resilience for human communities dependent on aquaculture. Markets, for example, are an important determinant of adaptation for aquaculture communities, especially when other forms of governance are absent or weak. Markets provide adaptive opportunities for aquaculture through essential connections between supply and demand and access to inputs and support services such as information and insurance. In the Pacific, for example, according to a FAO study, markets play a crucial role, especially in the trading of highly valued commodities such as

tuna and pearls. Similarly, in the Mekong Delta, aquaculture producers rely on foreign demand and exports, while at the same time remain under pressure to meet standards. Similar market demand and pressure influence the Bangladeshi shrimp industry to be resilient to disease and disasters. On the other hand, when markets are not appropriately functional, and do not provide access to demand, inputs and services (as well as basic facilities), chances of adaptation are immediately decreased, as in the case of the Lake Chad Basin in FAO study (Burgere 2015). Governmental and civil society organizations, by formulating public policies (Tompkins et al 2010) and harnessing collective action (Agrawal and Perrin 2009), play key roles in determining a community's resilience to climate shocks. The FAO regional studies report that governments adopted a coordinating and regulatory role in the Pacific, a planning role in Latin America and an investing role in the Caribbean (Burgere 2015). In some communities, such as the Mekong Delta, the Lake Chad Basin and the Benguela Current, good governance of adaptation is affected by trans-boundary character of natural resource base on which aquaculture systems depend (Burgere 2015).

Modes of governance are another state and/or non-state component that affect an aquaculture community's resilience to climate change. Governance can be defined as 'the process of decision-making and the processes by which decisions are implemented (or not implemented' (UNESCAP 2016:1, quoted in Islam 2014:30). Governance is context-specific such as international, corporate, national, and local (i.e. community-level) governances (UNESCAP 2016). Governance can be 'good' or 'bad'. UNESCAP pinpoints eight key characteristics of good governance: it should be "participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive, and

[follow] the rule of law” (2016). Good governance should also incorporate features like corruption-minimization, consideration of the views of the minorities and the most vulnerable segments in society while decision-making, and responsiveness to the current and future needs of society (UNESCAP 2016). In terms of the intersections between the roles of community-level initiatives and national governments, few aquaculture systems, such as the Lake Chad communities in the FAO studies, entail ‘self-governance’ through “effective traditional fisheries-management and conflict-resolution mechanisms” (Burgere 2015:37); others (such as in the Pacific and the Caribbean communities) adopt community-state partnership in which governmental institutions work more closely with communities and non-state actors; and in still others (such as the FAO case studies on Latin America, Benguela Current and Mekong Delta), the governments take a regulatory approach through “command and control tools like legislation” (Burgere 2015:37). Good governance is crucial for successful adaptation. FAO (2011) suggests that initiatives need to be taken in order to mainstreaming fisheries and aquaculture within broader climate change strategies in aquaculture countries.

In addition to determinants, another important component that influences resilience of aquaculture is barriers to adaptation. Tompkins and Adger identified a few common barriers that impede adaptation to climate change in communities including threatened resources often being public-good resources, failure of collective decision-making, uncertainty in adaptation decisions, and a lack of clarity over who are responsible for action (Brugere 2015, Tompkins and Adger 2005).

Considering the determinants, facilitators¹⁰, and barriers of adaptation and resilience, few aquaculture communities have already started devising their coping strategies in addressing climate hazards. Moreover, scientists and researchers suggest a number of adaptation measures for aquaculture. In this section, we will discuss current and suggested resilience strategies that aquaculture communities can adopt to minimize adverse impacts.

Implementing the ecosystem approach to aquaculture can minimize losses from climate shocks. The ecosystem approach assimilates aquaculture within the larger ecosystem in a way that promotes sustainability of the total social-ecological systems (De Silva and Soto 2009, FAO 2011). The integrated rice-fish cultivation, which is already a traditional practice in rural China and other tropical Asian countries (De Silva and Soto 2009), can be a resilience alternative for Asia and Africa. This system, through natural production of zoo- and phyto-plankton and benthos (De Silva and Soto 2009), can increase rice production and reduce the needs for fertilizers and pesticides (Williams and Rota 2013), leading to enhanced food security for the community.

In devising threat-specific measures, exchange of water in aquaculture ponds and raceways can be an adaptive strategy to avoid, or at least soften, negative impacts of increased water temperature. One adaptation strategy could be the introduction of the culture of brackish-water fish species, like shrimp, in the coastal areas where salinity intrusion could become a severe problem for agriculture and fresh-water aquaculture. The culture of carnivorous fish species need to be discouraged as the wild fishes used as feed for these species will decline. Alternatively, non-carnivorous, carbon-sequestering species like seaweed

¹⁰As discussed in a previous chapter, facilitators include, among others, access to community resources, local community civic and faith-based groups, and bonding-bridging-linking social capitals.

and shellfish can be cultivated, instead (FAO 2009, Williams and Rota 2013). Further scientific research is required to develop new varieties among fish species that could be more tolerant to saline and poor quality water. Research on new fish diseases and treatments, the search for new and better-adapted species, on better feeds and feeding practices can enhance coping abilities of aquaculture (De Silva and Soto 2009).

Some of the other proposed adaptation measures include institutional, policy and planning measures including aquaculture insurance, research and technology transfer, using lessons from the expansion of farming species outside their natural range of distribution, aquaculture diversification and aquaculture zoning and monitoring (De Silva and Soto 2009). Suitable insurance schemes help aquaculture farmers to recover from losses from weather shocks and climate extremes. Governments could make aquaculture insurance mandatory for all farmers (De Silva and Soto 2009). Improved governance and management of aquaculture operations was viewed as an effective strategy to reduce vulnerability and increase resilience in all the six aquaculture communities in the FAO regional case studies (Brugere 2015). Proposed resilience strategies also include stronger bridging connections and partnerships including outside aquaculture communities (Caribbean region), improved management of environment (Mekong Delta), introducing new legislative mechanisms (Caribbean, Benguela Current, and Pacific), creation and dissemination of climate and adaptive knowledge and information (all six regions), capacity building of stakeholders from schools to ministries (Caribbean, Latin America, and Pacific), investment in climate proof infrastructures (Caribbean), development and financing of action plans (Lake Chad, Benguela Current, Pacific, and Latin America), economic incentives such

as insurance (Mekong Delta) and promotion of aquaculture development in national and international climate change strategies (Lake Chad, Caribbean, Pacific, and Latin America) (Brugere 2015).

Optimization of employment opportunities in aquaculture and diversification is a recommended adaptive option by the FAO studies in the Pacific and Lake Chad Basin regions (Brugere 2015). Livelihood diversification can lead to income generation from non-climate-sensitive sectors (FAO 2011) which could reduce vulnerability of aquaculture people in the exposed regions. Diversification of aquaculture species itself can act as insurance for the sector. If one species become affected or vulnerable to a particular climate threat, other species can act as backups for the farmers. Diversity provides better chances for natural selection as well as adaptation to strenuous conditions. Farmers in China became successful in adapting better to climate changes through diversification of aquaculture – Chinese aquaculturists increased the number of cultured species from 13 in 2000 to 34 in 2005 (De Silva and Soto).

In post-tsunami coastal Aceh, aquaculture communities rebuilt their livelihoods and infrastructure by using their savings or by selling productive assets like livestock and rice or liquidating savings like jewellery (Mills et al 2011). This capability was largely determined by income level prior to the tsunami. The pre-tsunami high earning cohort was the best segment who showed the highest level of post-tsunami resilience thanks to their asset-base. The tsunami affected aquaculture communities received external support from governmental and private organizations in various forms, which helped them to cope with the new situation. They received inputs subsidies in the form of high quality seeds, including hatchery produced fish fingerlings and shrimp PL. This helped them

significantly in rebuilding their livelihoods. The Aceh community also received training from field-level officers of fisheries division, which was crucial for post-tsunami recovery. These communities also adopted a scheme of collaboration among co-located farmers in order to recover from shocks quickly through making social bonds and strong cooperation.

The brief overview of climate-aquaculture interactions suggests that fisheries and aquaculture is a site where observed and projected climate change might have dire consequences. The hot and humid tropical regions, where the vast majority of global aquaculture production occurs, will be the worst affected due to anthropogenic climate change. Floods, cyclones, storm surges, SLR, salinity intrusion, temperature increase, erratic rainfall, and even earthquakes and tsunamis affect coastal, marine and inland aquaculture throughout the tropical, subtropical and temperate regions. These weather shocks and climate changes and extremes affect the physiology and growth of cultured fish as well as social organization of the aquaculture-dependent human communities. These communities will have to devise (few communities have already started) their own resilience mechanisms – reactive and proactive, spontaneous as well as planned – to avoid adverse impacts of climate disturbances.

4.3 Review of Literature on Bangladeshi shrimp industry

Up to now, a great deal of research works focused on different socio-economic and ecological aspects of shrimp aquaculture in Bangladesh, but only few dealt directly with the vulnerabilities and resilience of aquaculture to climate change. A thorough literature review on the Bangladeshi shrimp industry suggests that a

number of scholars, from home and abroad, critically investigated into social, environmental and economic aspects of shrimp aquaculture in Bangladesh.

4.3.1 Historical overview of shrimp cultivation in Bangladesh

Wild shrimp *capture* is a century-old phenomenon in coastal areas in Bangladesh, where people used to play tidal waters carrying shrimp post-larvae within paddy fields, which would grow for about six months. Farmers would use a single piece of land for cultivating both shrimp and rice by rotation – generally, they used the land for paddy culture after repeated flushing at the start of annual monsoon (Deb 1998). In this *bheri*-culture (as it was called locally), farmers would not use any modern technology or feed or fertilizer but they would get adequate quantities of shrimps and fin fishes as well as rice from the same piece of land. Though wild shrimp *capture* is a century-old phenomenon in coastal zone in Bangladesh, shrimp *culture* started in the late 1960s when several fish-freezing plants were established in Chittagong and Khulna (Islam 2008b). Fresh-water prawn farming took off around 1978 when a small number of wealthy farmers in Bagerhat district in southwest Bangladesh began to experiment with stocking prawn in carp ponds. They made a healthy profit by testing new techniques and technologies in their ponds including construction design, stocking, and feeding. Keramat Ali of Fakirhat *upazila* (sub-district) in Bagerhat district is frequently referred to as the ‘father of freshwater prawn farming’ in Bangladesh (Rutherford 1994, Ahmed et al 2008, Ahmed et al 2010).

With the immersion of the government and international donor agencies, the export-oriented shrimp industry in Bangladesh started in the early 1980s, “when large-scale shrimp aquaculture in higher-income East Asian countries such

as Thailand, Indonesia, China, the Philippines and Taiwan began to suffer from ecological, environmental and social damage. Against this background, the industry expanded to the less developed countries of South Asia, namely India and Bangladesh” (Ito 2002:49). Rising fishing demands on natural marine shrimp stocks and maximum harvesting in available areas enhanced the commencement of extensive shrimp cultivation in coastal areas (Azad et al 2009) around the Global South, including Bangladesh.

4.3.1.1. Historical factors contributing to commercial shrimp cultivation

The rise of the Bangladeshi shrimp industry was connected with few historical events. Farmers in coastal areas experimented with shrimp cultivation in the 1960s, when the Coastal Embankment Project (CEP) created permanent water logging with saltwater in coastal arable lands. Local farmers were compelled to involve in small-scale shrimp cultivation because rice production in saline fields was not possible (Swapan and Gavin 2011). After that, as soon as the shrimp price soared up in international market, a number of powerful elites from outside grabbed the sector and turned it into a large-scale commercial industry. Swapan and Gavin (2011) distinguished three historical developments (mainly economic in nature) that contributed to the emergence of industrial shrimp aquaculture in Bangladesh.

>> *Victim of a ‘Green Revolution’*

Green Revolution is a worldwide programme that emerged in response to global food scarcity during 1950s and 1960s. Green Revolution was originally a ‘technical package’ of agricultural technology, seed, equipment etc. that was

applied at first to basic crops and later to ‘high-value-foods’ (Islam 2013). In order to boost rice production through high yielding varieties (HYV) and to create a green revolution in agriculture for addressing a burgeoning price hike in global rice market in the 1960s, the then Pakistan government, with assistance from the World Bank, instituted the CEP in the south-western coastal region of East Pakistan (Swapan and Gavin 2011). This project aimed at turning coastal lands into a freshwater region permanently. A total of 5017 km of embankments (World Bank Group 2010) with 1039 sluice gates and regulators (Banglapedia 2015) were constructed, creating a huge system of saline-free lowered sections known as polders, separated by high embankments. Initially the polders were cut off from saltwater from the sea. However, in the course of a few years, silt deposition occurred on the riverbeds, forcing them to rise rapidly that in turn caused rivers overflowing the embankments, on the one hand. On the other hand, since sluice gates were blocked with silt, water from empoldered areas could not drain out. Thus, the polders became a permanently saltwater-logged area in which some farmers, finding no other way, first started shrimp cultivation (Swapan and Gavin 2011).

>> ***Price rise in the international market***

After that, shrimp culture was viewed viable in the region because of two factors – first, rice cultivation was not feasible in saline water and, second, the price of shrimp was high in global market within a few years comparing to that of rice. Thus, in the 1980s, the practice of brackish water *bagda* shrimp cultivation spread rapidly with cheap land and labour, and with an abundance of wild shrimp PL (post-larvae) (Swapan and Gavin 2011).

>> *Response to global demand*

Global demand of cultured shrimp continued to rise in the face of shortage of captured fisheries. The Bangladeshi Government, realizing the potential of the sector, recognized shrimp as an ‘industrial production’ under the Second Five-Year Plan (1980-85). Thus, commercial shrimp culture in Bangladesh was shifted from an inward-looking development strategy to a more outward-looking strategy of export-led growth. A World Bank/UNDP investment of USD 30 million in technology and infrastructure in the shrimp industry in Bangladesh provided a significant breakthrough for the sector during the late 1980s and early 1990s. The Bangladeshi government also facilitated the growth of the shrimp industry through various incentives including amendments to the land-lease laws, subsidized credits, a nine-year tax holiday, and others (Toufique 2001).

4.3.1.2. Phases of commercial shrimp farming in Bangladesh

Islam (2008c) observed that environmental issues forced commercial shrimp cultivation in Bangladesh to go through three phases: an era of resistance (from 1960s to mid-1990s), an era of ambivalence (from mid-1990s to 2003), and an era of normalization (2003 onwards). During its nascent stage, highly unregulated shrimp cultivation – and the resulting socio-environmental problems like overfishing, loss of shellfish and finfish, destruction of mangrove ecosystems, soil acidity and salt incursion – incurred social resistance from villagers, landholders and radical NGOs. In the second phase authorities in Bangladesh, realizing shrimp culture’s economic value, initiated a ‘pro-shrimp campaign’ after instituting a number of environmental agendas and policies. In this phase, many mainstream NGOs joined the government and international donors in promoting the campaign.

At the present phase, local people more widely accepted the shifting of their principal subsistence from rice to shrimp and began to cope with the new consumption patterns and labour arrangements. Among other reasons, this happened because of the fact that foreign cash galvanized the local economy. Now shrimp producers instead of reverting back to rice regime, focus on traceability and quality of shrimps as required by international buyers (Islam 2008c). Thus a shift from traditional rice cultivation to shrimp farming also indicates a gradual shift from a focus on preservation of environment and tradition to a focus on economic gain.

The phenomenal growth of shrimp production in a relatively short period in south-western Bangladesh is generally regarded as linked to the ‘blue revolution’ (Ahmed et al 2010, Deb 1998, Ito 2004, Islam 2008a, Metcalfe 2003). Bailey (1985, cited in Ahmed et al 2010) first used the term ‘blue revolution’ as an aquatic counterpart of ‘green revolution’. This term refers to the introduction of modern technologies in fishery that enhanced the fishing capacity of developing countries.

In addition to its connection to the blue revolution, scholars have delineated a few revolutionary phases of the development of shrimp and prawn aquaculture in Bangladesh. The principal attributes of the revolutions – namely, green revolution, fake blue revolution, blue revolution, and blue-green revolution – are summarized in Table 4.2.

Table 4.2: Revolution of prawn and shrimp farming in Bangladesh.

Period	Revolution	Attributes
1970s	Green revolution	Rapid agricultural development in rural Bangladesh. Moved to coastal areas for agriculture. Started prawn and shrimp farming in rice fields. Shrimp culture initiated earlier than prawn.
1980s	Fake blue revolution	Unplanned and unregulated construction of shrimp farms. Environmental impacts of shrimp cultivation. Social costs of shrimp production. Economic benefits through export earnings.
1990s	Blue revolution	Widespread socioeconomic benefits from prawn culture. Livelihood opportunities for the coastal poor. Increased food production through prawn-fish-rice farming. Export earnings, significant contribution to the national economy.
2000s	Blue-green revolution	Diversification and intensification with fish and rice. Increased prawn and shrimp production. Economic growth through export earnings. Enhanced staple food supply (i.e. rice and fish).

Source: Ahmed (2013:35)

4.3.2 Suitability of shrimp farming in Bangladesh

Bangladesh holds an advantageous natural setting with tropical climate and a long coastal line that turns the country to be an important hub for commercial shrimp cultivation (Islam 2008a, Islam 2010). Bangladesh has a 710 km long coastline in the northern and north-eastern part of the Bay of Bengal (Azad et al 2009, Chandra et al 2010, Deb 1998). The country comprises about 25,000 km² coastal areas of which 250,000 ha of tidal lands are suitable for aquaculture (Deb 1998:64). The coastal area – divided into south-western, central, and south-eastern regions – is rich with wetlands, mangroves and coral reefs that create different coastal marine and brackish-water ecosystems supporting wide biodiversity (Azad et al 2009, Deb 1998). The south-western part of Bangladesh is particularly suitable for prawn and shrimp aquaculture because of the availability of wild fry, favourable resources and climate conditions, including low-lying rice fields, warm climate, fertile soil, and cheap and abundant labour (Ahmed et al 2008, Ahmed et

al 2010, Paul and Vogl 2011). For this reason, over 75% of prawn and shrimp farms (locally known as *gher*¹¹) are located in southwest Bangladesh, mainly in Bagerhat, Khulna and Satkhira districts (Ahmed 2013).

Salam et al (2003), using remote sensing, global positioning system (GPS) and geographical information systems (GIS), conducted an extensive survey on the suitability of brackish water aquaculture in an area of 1400 km² in six districts (Jessore, Narail, Gopalganj, Bagerhat, Khulna, and Satkhira) in south-western Bangladesh. In order to identify and prioritize the most suitable areas for brackish water shrimp and crab farming, they developed nine GIS sub-models including soil chemistry, water chemistry, land use, market potentiality, risk factors, support, inputs, water availability etc. They calculated weighted suitability by analyzing favourable factors as well as constraints. The study concluded that based on actual intensity of rice and other crop farming systems, about 43% of the land was found as very suitable for brackish water shrimp and crab culture, while a further 5%, 49%, and 3% were classified as moderately suitable, marginally suitable and unsuitable, respectively (Salam et al 2003:486). They found that because of the presence of optimum water quality – including appropriate level of salinity and tidal water flow – the southern parts of the region are very suitable for both brackish water shrimp and crab farming. These areas have added advantages of easy access to road transportation and markets and high agglomeration potential. All of the current shrimp *ghers* are located either in very suitable or in moderately suitable areas – “among the 287 known farm locations, 158 were exactly matched with the very suitable model output and 129 falls within moderately suitable output” (Salam et al 2003:489). Some discrepancies are

¹¹*Gher* is a Bangladeshi local term, meaning enclosure, for modified rice fields or ponds located beside canals or rivers that are used to cultivate shrimp and fin fish (Ahmed et al 2008, Chandra et al 2010, Paul and Vogl 2011 and 2012).

observed between the predicted and the actual sites of shrimp farms because of the fact that the farms were not established using any systematic application of scientific knowledge, but rather on water availability and the influence of neighbouring farmers.

4.3.3 Prawn and shrimp farming methods

The most widely practised method of shrimp and prawn aquaculture is the integrated *gher* system that is primarily of traditional and extensive nature.

4.3.3.1. Monoculture vs. poly-culture

Monoculture is a method of aquaculture farming in which only one species of fish is cultivated in a specific piece of land. Among the three types of farming practices in Bangladesh (*bheri*, pond, and *gher* culture), pond culture is categorized as a purely monoculture system. Pond-system shrimp culture is practised in inland Mymensingh and coastal Noakhali regions in Bangladesh. In this system, the average stocking density of prawn postlarvae is around 10,000 postlarvae/ha (Ahmed et al 2008:809).

Poly-culture method, on the other hand, is a system in which various species of fish and crops are cultivated in a given piece of land. The traditional *bheri* culture and the modern *gher* culture are examples of poly-culture in shrimp cultivation in Bangladesh. The traditional coastal shrimp farming, known as *bheri* culture, involves the trapping and grow-out of shrimp in tidal and low-lying areas isolated by dikes. Traditional shrimp farming is believed to be started in 1829 in the Sundarbans area of Bangladesh (Azad et al 2009:801). In *bheri* culture, a *rotational* or *alternate* cropping practice of shrimp and rice is done in which

captured shrimp is allowed to grow in between January and July and *aman* rice is cultivated during the monsoon (Ahmed et al 2002). Generally, rice fields are used in *bheri* culture. It is difficult to predict the number of post-larvae (PL) in *bheri* culture.

Gher culture is a recently introduced integrated farming system. *Gher* farming can be considered as a method of combining aquaculture and agriculture on one plot. Shrimp farming takes a rotational form in some areas – rotation with salt production in the south-eastern region (Pokrant and Reeves 2003) and with rice cultivation in the south-western coastal areas (Ahmed et al 2008). In the south-western region, during the rainy season the whole water body is used for cultivation of shrimp and fish species like Indian major carps such as, catla (*Catla catla*), ruhi (*Labeorohita*) and mrigal (*Cirrhina cirrhosus*), as well as exotic carps, silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharynx godonidella*) and common carp (*Cyprinus carpio*). However, during dry seasons farmers cultivate rice in the central plot, while they use the trenches near the dikes for shrimp and fish culture (Chandra et al 2010, Ahmed et al 2008). They also use dikes for producing vegetables and fruits like carrot, tomato, onion, mustard, long yard bean, spinach, pea, potato, okra, sweet guard, cucumber, chilli, banana, papaya, and guava in different seasons throughout the year (Ahmed et al 2008). Thus, *gher* farming shows both rotational, or alternate, and integrated, or concurrent, forms of poly-culture. Integrated *gher* cultivation produces fish, rice, and dike crops and fruits for household consumption and the domestic market, while shrimp and prawn are produced mainly for the export market.

4.3.3.2. Extensive vs. intensive culture

Shrimp farming can be classified into four categories depending on the intensity of the culture pattern such as stocking density, inputs (feed, fertilizer) and water management. The categories are traditional, extensive, semi-intensive, and intensive (Deb 1998, Paul and Vogl 2011). The traditional system involves low stocking rate and uses no modern farm management measures. Sustainable production and profit in this system depend on the size (smaller farms) and management (household) of the farms (Paul and Vogl 2011). Extensive method, which is viewed as a modified version of traditional method, employs low stocking density (10,000-18000 postlarvae/ha/year) and low inputs (Ahmed et al 2008:809). Homemade feeds are generally used in extensive farming systems. The feeds include ingredients such as rice bran, wheat bran, oil cake and fishmeal. Intermediate levels of stocking (18,000-30,000 postlarvae/ha/year) and other inputs are employed in semi-intensive farms. These farms depend on commercially produced pelleted feeds for feeding the cultured shrimps. Intensive farming employs modern management practices with the highest density of stocking and inputs and commercially manufactured pelleted feeds. This system of culture, if maintained properly, can attain 50 times more production than traditional culture (Paul and Vogl 2011). Hussain (1994) found that 70% of the shrimp farms in Bangladesh use traditional and/or extensive, 25% semi-intensive, and 5% intensive culture techniques (cited in Paul and Vogl 2011:203-4). Table 4.3 shows the differences between four types of shrimp farming.

Table 4.3: Four different types of shrimp aquaculture practice

Criteria	Intensity of farming systems			
	Traditional	Extensive	Semi-intensive	Intensive
Pond (<i>gher</i>) size (ha)	5 – 10 or >	5 – 10 or >	1 – 10	<1
Stocking	Natural	Natural + artificial	Artificial	Artificial
Stocking density (seed/m ²)	1 – 1.5	2 – 10	20 – 40	40 – 60
Seed source	Wild	Wild	Wild + hatchery	Hatchery
Survival rate (%)	50 – 60	60 – 80	70 – 80	70 – 90
Feed used	Natural	Natural, little low cost feed	Natural and pelleted feed	Formulated complete feed
Water exchange	Tidal	Tidal, minimal pumping	Tidal, pumping	Pumping, reservoir, filter
Aeration	No	No or little	Yes	Yes
Yield (t/ha/yr)	0.1 – 0.5	0.6 – 1.5	2 – 6	7 – 15
Production cost (USD/kg)	No data	1 – 3	2 – 6	4 – 8
No. of crops /year	1 – 2	1 – 2	2 – 3	2 – 3
Diversity of species	Poly-culture	Poly-culture	Monoculture	Monoculture
Lime used (kg/ha/yr)	No or little	< 100	250 – 400	500 +
Fertilizer used (kg/ha/yr)	No or little	Cow dung – 500, no or little urea/TSP	Cow dung-2000+, Urea-300+, TSP-100+	Cow dung-4000+, Urea- 500+, TSP-200+
Chemicals used	No	No or little	Used	Widely used
Employment (persons/ha)	No data	< 7	1 – 3	1
Disease problems	Rare	Rare	Moderate or frequent	Frequent
Operational costs	No or little	Low	Moderate to high	Extremely high
Development costs	No or little	Low	Moderate to high	Extremely high
Environmental impact	No or little	Relatively little	Moderate to high	Extremely high
Social implications	No or little	Relatively little	Moderate to high	Extremely high
Economic proliferation	Subsistence	Subsistence	Commercial	Entrepreneurial
Sustainability concerns	High	High to moderate	Moderate to low	Relatively low

Source: Paul and Vogl (2011:204)

4.3.3.3. Prawn and shrimp mixed culture

Generally, shrimp (*Penaeus monodon*) grows in saline water in the coastal areas, while prawn (*Macrobrachium rosenbergii*) grows in fresh-water in the inland areas. Nevertheless, in recent times, experiments have been done on mixed culture of prawn and shrimp species in coastal areas. Some farmers adopted a shrimp-prawn mixed farming system in order to address the impacts of water and soil salinity due to climate change. According to Nesar Ahmed (2013), because of its higher economic returns, mixed culture of prawn and shrimp is gaining importance in the coastal brackish-water ecosystem.

4.3.4 Global connection of the Bangladeshi shrimp industry

“Globalization of the agro-food system has led developing nations to orient their production to meet global markets. Consequently, local agricultural systems are increasingly linked to global commodity networks, and generate complex intersections and sometimes tensions” (Islam 2008a:209). Most of the items that we consume now have global origins. Even when a product has a domestic ‘Made in ...’ label, its journey to market might have combined components and labour from production and assembly lines around the world (McMichael 2008). The shrimp industry in Bangladesh has a profound connection with the neoliberal globalization project of development. Starting in 1980s, commercial shrimp cultivation in Bangladesh has now been treated as a 100% export oriented industry (Ahmed et al 2002). Again, technological developments in aquaculture have fuelled the globalization of the shrimp supply chain. Since the 1980s, Western markets have received an increasing share of their shrimp from Asian and Latin American producers, including Bangladesh.

4.3.4.1. Global commodity chain (GCC)

Today, producers and buyers around the world are connected together by a tapestry of networks of commodity exchanges. A series of production and manufacturing stages are the parts of a network. In these stages, diverse labour and material inputs are provided by diverse actors from different countries and places contributing to the creation of a final product (McMichael 2008). This network, which connects households, enterprises and states to one another within the world-economy, is called the global commodity chain. The GCC approach explores how the production, distribution, and consumption of products are globally interconnected along the GCC (see Islam 2008b:214). The stakeholders in a commodity chain have diverse power relations that shape the nature of the chain. In addition, some actors who are not directly a part of a commodity chain, like environmental groups, now have an influence on the chain, making it complex (see Islam 2008b). Like in other commodities, large corporations have become global players in agro-food sector. Now, countries specialize to produce agro-food items for global market (McMichael 2008). The global shrimp commodity chain can be viewed as having the characteristics of a buyer-driven commodity chain as well as a twin-driven commodity chain.

>> *Buyer-driven commodity chain*

Some authors, including Gamage et al (2006) and Islam (2008a) opined that Bangladeshi commercial shrimp network shows ‘several characteristics of a buyer-driven commodity chain’ (Islam 2008a:217). In a buyer-driven commodity chain, buyers and consumers including large retailers, marketers, or brand-name

companies play the essential role in controlling the production and distribution of commodities around the world (Dolan and Humphrey 2000, Islam 2008b). The global shrimp commodity chain is an example of buyer-driven commodity chain in which producing countries, like Bangladesh, cultivate shrimp for its consumption in the rich Northern countries like Japan, the European Union, and the USA. Major importing firms in these countries control the commodity chain by defining what should be produced under what conditions.

>> *Twin-driven commodity chain*

After critically examining the roles, activities, and influences of every directly or indirectly engaged stakeholders in industrial shrimp commodity chain of Bangladesh, Islam (2008a) concluded that the shrimp commodity chain is moving towards a Twin-Driven Commodity Chain in which buyers (i.e. lead firms) govern the supply network, while environmental groups and third-party certifiers outline and manage the regulatory aspects of the aquaculture – sometimes both working in an overlapping manner. This is a new type of commodity chain that goes beyond the traditional uni-linear buyer-driven one in which production, supply and distribution of a commodity are solely defined and governed by lead farms (Islam 2008a). He argued that though environmental, consumer and human rights based NGOs were treated as external agents in the traditional dichotomy, the increasing awareness about risk, safety, and quality issues in the global agro-food chains is putting the NGOs and third party certifiers (TPCs) within the commodity chains. Thus, these groups are becoming an essential part of the commodity chains by their growing influences in shaping the production and process frameworks of present-day global agro-food system. Islam (2008a) argued that in marked

contrast to the exclusive role of the powerful buyers (lead farms) in a buyer-driven commodity chain, the Bangladeshi shrimp production and consumption is mostly governed by a network of diverse international environmental groups¹², local labour rights and environmental NGOs and groups¹³, and the governmental Department of Fisheries (DoF). This network defines the quantity, quality and production conditions of aquaculture. Overall, all of these environmental and labour rights groups focus on sustainability of shrimp aquaculture in common, though they frequently hold diverse opinions on specific environmental and labour issues and questions (Islam 2008a).

4.3.4.2. Quality control, governance and certification

While in the industrial capitalism product price and quantity were the primary criteria for characterizing production, present consumerism emphasizes quality as the basis for economic competition. The quality of a commodity incorporates specific attributes of the commodity itself (like safety and nutritional specification) as well as labelling or branding of the commodity (Busch and Bain 2004). The term ‘quality’ includes “both ‘experience’ characteristics such as freshness or taste that can be detected directly by consumers after purchase and ‘credence’ or nonmaterial characteristics that cannot be detected by consumers such as the environmental and ethical conditions of production” (Islam 2008c:76, see also Vandergeest 2007). In the current global agro-food system, food retailers compete on quality of their food items mostly based on private food safety and

¹² Some of the international environmental groups are Aquacultural Certification Council (ACC), Environmental Justice Foundation (EJF), Global Aquaculture Alliance (GAA), World Wildlife Fund (WWF)

¹³ Like Coastal Development Partnership (CDP), Centre for Policy Dialogue (CPD), Bangladesh Shrimp and Fish Foundation (BSFF), Bangladesh Shrimp Farmers Association (BSFA)

quality standards, branding, contracts, certification, and agreements (Busch and Bain 2004).

As Bangladeshi shrimp is a commodity that is produced solely for consumption in the Global North including Europe, USA and Japan, Bangladeshi producers need to conform to the quality standards that are set by buyers in the wealthy countries. Thus, Bangladesh industrial shrimp production is always under supervision for quality maintenance.

>> *The governmental regime*

Shrimp aquaculture governance in Bangladesh has passed through three major phases. At the first age of regulation before the HACCP regime (Hazard Analysis Critical Control Point) of 1998, the Bangladeshi government, as a representative of the nation-state, was “the sole agency to make environmental and social regulations and implement them using its own capacity” (Islam 2008a:219). At the beginning, the Ministry of Commerce was in charge of issuing the quality assurance certificate for fish and fish products exported from Bangladesh.

In 1974, the DoF took the charge of certifying for exportable fish and fish products including shrimp (Ahmed et al 2002). Later, in 1979, a quality control unit in the DoF was instituted in order to supervise the quality of fish and fish products and afterward the government enacted the Fish and Fish Products (Inspection and Quality Control) Ordinance in 1983. Since then, the Bangladeshi government enacted various ordinances, acts, rules, and policies in order to ensure the quality and safety of aquaculture products (see Table 4.4).

Table 4.4: Relevant fishery policies, laws, rules, acts and ordinances in Bangladesh.

Title of policy/law/rule/act/ordinance	Aspects covered
The Protection and Conservation of Fish Act, 1950	Conservation of fisheries resources as a whole
Embankment and Drainage Act, 1952	Protecting crops, not allowing cuts in embankments (to produce shrimp)
Bangladesh Water and Power Development Board Ordinance, 1972	Develop water management infrastructure for shrimp farming
Territorial Water and Maritime Zone Act, 1974	Conservation of marine fisheries
Marine fisheries ordinance, 1983	Conservation of marine fisheries
Fish and fish product (Inspection and quality control) ordinance, 1983	Quality control of fish and shrimp, mainly targeting export
Fisheries Rules, 1985	Framing rules for enforcement of various provisions of Fish Act 1950
Manual for Land Management, 1990	Allocate unused state (<i>Khas</i>) land to the landless on a permanent or temporary basis
Shrimp Estate (<i>mohal</i>) Management Ordinance, 1992	Allocate suitable state (<i>khas</i>) land for shrimp culture
Shrimp farm taxation law, 1992	Imposing higher tax on shrimp land to cover cost of polder infrastructure
Bangladesh environment conservation act, 1995	Conservation of natural resources and ensure eco-friendly development
Bangladesh environment conservation rules, 1997	Conservation of natural resources and ensure eco-friendly development
Fish and fish product (quality control) rules, 1997	Quality control of fish and shrimp, mainly targeting export
National Fisheries Policy, 1998	Conservation, management, exploitation, marketing, quality control and institutional development
Fish and Animal Food Act, 2010	Safe fish and animal feed production, processing, quality control, import, export, marketing and transportation
Hatchery Act, 2010	Sustainable hatchery development to ensure quality fish and shrimp seed
National Shrimp Policy, 2014	Promotion of sustainable shrimp aquaculture

Source: Paul and Vogl (2011), MoFL (2014)

The core features of the ordinance and the rules are:

- Fish or shrimp cannot be processed without a DoF license. Only the licensed factories will be responsible for the processing of aquaculture products according to set hygienic principles and norms.
- In the transporting of aquaculture products, the set hygienic conditions are to be followed.

- Exportable fish and fish products will be inspected and tested for quality and safeness, and health certificates are to be given. Without a health certificate, no fish and fish products can be exported.
- Any breach of the existing laws is punishable and any licenses in possession are liable to be revoked (Ahmed et al 2002).

In that period, the government acted as a ‘container’ (in Ulrich Beck’s term) for the country’s economic activities through the enactment of laws and regulations that are primarily focused on domestic production and consumption.

>> *The HACCP regime*

However, since the foreign buyers were not happy with the governmental rules and regulations in regards to quality and safety assurance, they imposed stricter controls. The Hazard Analysis Critical Control Points (HACCP) is a new system of quality control for aquaculture products introduced by the European Union (EU) countries. Under the HACCP guidelines, producers and distributors need to ensure the quality and safety standards at every step of marketing from the first production places to the last retail points. In other words, the HACCP is “a preventive system of hazard control rather than one of reaction or inspection to decrease a hazard” (Pokrant and Reeves 2003:361). Food processors can use HACCP to identify, monitor and prevent physical, biological, chemical and environmental hazards. HACCP is based on seven principles: “(1) conduct hazard analysis and identify preventative measures; (2) identify critical control points (CCP); (3) establish critical limits; (4) monitor each CCP; (5) establish corrective action to be undertaken when a critical limit deviation occurs; (6) establish a

record keeping system; (7) establish verification procedures” (Pokrant and Reeves 2003:361, see also Islam 2010).

Based on the report of an EU inspection team that shrimp processing plants in Bangladesh were not complying with the EU quality guidelines, the EU enforced an embargo on the entry of frozen foods from Bangladesh to Europe in September 1997 (Toufique 2001). Four major issues were identified by the EU inspection team that led them to impose the ban. The factors were “1) unskilled and unhygienic labourers; 2) unhygienic way of shrimp transportation and preservation; 3) irregularity and unhealthy composition for acquiring shrimp; and 4) corrupt practices for making excess profit” (Toufique 2001:195, numbering added). As a reaction to the EU ban, in March 1998, the government of Bangladesh forced the shrimp processing plants to follow the HACCP guidelines mandatorily at every stage of procurement and processing. In this context, the EU finally lifted the embargo in July 1998 (Toufique 2001). From then, the second regulatory period of HACCP regime started. The HACCP regime transformed the role of Bangladesh government from a position of ‘regulation maker’ to that of a ‘regulation implementer’, because now the government cannot make rules and regulations independently but it just implements the HACCP principles (see Islam 2008a).

>> *Third party certifiers’ regime*

The Bangladeshi shrimp sector has entered into the final age of governance since the early 2000s. At this stage, the Bangladeshi government has lost its classical nation-state like role as the sole regulator. Through a process of the problematization of commercial shrimp, third-party certifiers (TPCs) have entered

into the scene. Saidul Islam noted that in order to fulfil the shrimp quality demands of the buyers, “the Shrimp Seal of Quality (SSOQ) – a private certification agency – was established in Bangladesh in 2002 with the help of USAID, and in February 2005, it began certifying the shrimp processors and hatcheries for the first time in Bangladesh. The SSOQ aims at certifying shrimp on the basis of five factors: (a) food safety and quality assurance, (b) traceability, (c) environmental sustainability, (d) labour practices and (e) social responsibility. All are among the key issues of concern for the buyers, such as Wal-Mart, Darden, and Lyons” (Islam 2008b:215, 2010:48).

After that, international aquaculture regulatory organizations have erected a number of regulatory and certification guidelines, including BAP certification, Global GAP, ASC certification, ISO certification etc. A number of transnational organizations are in charge of inspecting and supervising the enactment of the guidelines to commercial shrimp projects. Comparing to the governmental regulations, the third party certification is generally treated as a “product of scientific and technical practices and therefore, is regarded as objective and unbiased” (Hatanaka 2010:708). In Bangladesh, the SSOQ aimed at intervening in the shrimp sector by introducing the ‘better management practices’ (BMP) approach and by improving the quality of shrimp post-larvae (Islam 2010). In this latest phase of governance, the Bangladeshi government has virtually lost its control over the shrimp industry and turned to be an aide to the TPCs (Islam, Kais and Wu 2015).

4.3.5 Role of NGOs

Since the role of shrimp is crucial in export earnings for producing countries and since it has significant repercussions on environment, various environmental and human rights organizations and groups are actively involved in this industry both promoting and opposing the growth of this sector (Islam 2008a). Previous literatures on the issue have analyzed the position of NGOs by categorizing them as either mainstream or radical NGOs. Mainstream NGOs have taken a pro-shrimp farming position, while the radical NGOs are treated as an anti-industrial shrimp farming camp.

4.3.5.1. Mainstream NGOs

A number of NGOs, including CARE, Caritas, BRAC, and Grameen Bank, working with the Bangladeshi government and international donor agencies, push for better economic, social, technological and environmental management of the shrimp industry. Starting in 1990s, mainstream NGOs implemented some donor-funded projects in promoting inland prawn culture, for example, the CARE-supported Greater Options for Local Development through Aquaculture (GOLDA) project, Greater Noakhali Aquaculture Extension Project (GNAEP) and the Agro-based industries and Technology Development Project (ATDP) (Ahmed et al 2008). Taking a BMP approach to shrimp aquaculture, they concentrate mainly on “the improvement of shrimp farmer(s’) performance, financial and technical assistance to farmers, gender-based programmes aimed at raising women’s awareness of, and participation in, work opportunities in the non-domestic sphere, and assistance to fry collectors to improve their economic standing and protect the natural resources upon which they depend” (Pokrant and

Reeves 2003:384). Thus, their work is focused on the improvement of the industrial shrimp production by upgrading the technological and management system.

4.3.5.2. Radical NGOs

Influenced by the political ecology school of discourse on shrimp industry, the radical environmental NGOs in Bangladesh, starting in the early 1990s, view commercial shrimp farming as socially and ecologically disruptive for the cultivation area. They argued that industrial shrimp aquaculture has generated ‘severe ecological damage, social dislocation, and environmental destruction’ (Islam 2010). The most serious environmental problems caused by the shrimp industry include the destruction of coastal wetlands, disruption of hydrological systems, water pollution, and introduction of exotic species, damage of mangrove forest, and depletion and salinization of aquifers (Islam 2010). According to the environmental NGOs, severe social implications from the shrimp industry include the dislocation of local people, conflict and violence between local peasants and outsider land grabbers, decreased food security, and threatened human health. Against this backdrop, a number of NGOs, including Nijera Kori, Coastal Development Partnership (CDP), and UBINIG, conducted awareness building programs in the shrimp farming communities. They argue that the conditions of the poor involved in the shrimp sector can be improved through a shift from industrialized aquaculture to “more environmentally benign forms of farming based on organic farming methods, double rice cropping, community control of resources and a de-commodified exchange system which is local and regional in spread” (Pokrant and Reeves 2003:384).

Previous literatures on the Bangladeshi shrimp industry report a number of occurrences of conflicting encounter between the proponents and opponents of shrimp culture. The NGO-inspired resistance movements frequently led to violent confrontations between the two parties, the outcomes of which were serious breakdown of law and order situation, fighting, human rights violation, and even deaths (Islam 2010).

4.3.6 Positive impacts of shrimp cultivation

The industrial aquaculture is cherished globally because of its crucial role in ‘food security, nutritional supply, poverty reduction and economic development’ (Paul and Vogl 2011). Shrimp farming contributes heavily to expanding and advancing the economy of Bangladesh by earning significant amount of foreign exchange, increasing food production and widening employment options for local people. The ‘blue revolution’ has engendered extensive social and economic benefits especially in southwest Bangladesh. In particular, the integrated farming of shrimp, fish and rice has great potential returns.

4.3.6.1. Export earnings for Bangladesh

Since the 1990s, shrimp – accounting for about 5% of total export income – has become the country’s second largest export item after ready-made garments (RMG) (Ahmed 2013, Islam 2008a, Islam 2008c). Bangladeshi shrimp enjoys a bounteous demand in global market and the major importers are the EU countries (49%), the USA (35%), Japan (11%), and Southeast Asian countries (2.2%) (See Islam 2008a:214). Bangladesh earned as much as USD 454.93 million in the year 2012-13 by exporting shrimp (BFFEA 2014:95). In 2010-11, Bangladesh exported

54,891 tons of prawn and shrimp, of which 30% was contributed by prawn and the remainder (70%) by shrimp (Ahmed 2013:38).

4.3.6.2. Increased income for farmers

A shift from rice cultivation to shrimp production is not simply a change in the cropping system, more importantly it is a crucial transformation in the economy – from the production of a local staple food crop to an internationally profit-earning commodity (Ahmed et al 2010). The new production regime of industrial shrimp is characterized by “the sale of products in international markets and the increased flow of cash in the local economy” (Ito 2002:48). Export-oriented commercial shrimp production has infused extraordinary amounts of cash into the national economy. The local economy gains heavily through the circulation of this extra money that moves beyond shrimp and prawn farming communities. Increased profitability in shrimp and prawn cultivation and associated jobs – through noticeable quantitative and qualitative changes in the level of economic activity locally – has generated an opportunity for the local people to raise their income significantly. In their study, Ahmed et al (2010) estimated an average annual net income of USD 776 from integrated prawn farming (p. 567). Throughout the year, especially during the shrimp harvesting and marketing season, shrimp producers get sufficient amount of cash, a portion of which they can use as disposable money and purchase luxury items. This profitability and increased purchasing power brought about by shrimp farming has created additional job opportunities in newly created small markets in the locality (see section 4.3.6.5 below).

4.3.6.3. Food security

Shrimp and prawn farming contributes positively to food production and consumption in coastal regions in Bangladesh. According to Ahmed et al (2010), “before prawn farming a large number of farmers lived below the poverty line, and after converting their rice fields to prawn farms, they have increased their food consumption” (p. 568). Thus, a greater food security in the locality has been achieved through shrimp and prawn farming. Ahmed et al (2010) also noted that the quantity and quality of food consumed by the farmers have increased after the introduction of shrimp cultivation in the area. Integrated prawn and shrimp cultivation provides regular food supply of rice, fish and dike crops including vegetables and fruits. Increased food consumption positively influences the health of local people.

4.3.6.4. Increased social status

Ahmed et al (2010) concluded that people in southwest Bangladesh have raised their social status by shrimp farming because of their improved economic conditions such as increased standard of living and purchasing power. Most farmers used the profit they earned from shrimp farming in upgrading their housing conditions. Nowadays, the shrimp farmers replace their old mud and bamboo houses by new wood and tin ones. Introduction of shrimp farming has enhanced transport (increased number of motor vehicles), and recreational facilities (increased use of radio, television and mobile phones) in the locality as well as has contributed to improve the health status of the local people (improved drinking water supply through tube-wells). The above-mentioned indicators can be treated as markers of a more modern developing condition (Ahmed et al 2010).

4.3.6.5. New job opportunities

The commercial shrimp sector has generated a wide range of employment opportunities for rural households including marginal and small farmers and the landless poor. Shrimp culture increased employment opportunities from 10,000,000 man-days in 1983 to 22,600,000 man-days in 1990 (Deb 1998:66). All through the entire local supply from wild fry collectors to shrimp processing factories, about 15 million people earn their livelihood directly or indirectly from this sector (MoFL 2014:17098). The commercial shrimp sector provides different types of work on seasonal, temporary, contractual, or permanent basis including fry collection at postlarvae catching level; construction and maintenance of dykes and embankments, clearing and levelling of land, repairing of *ghers*, breaking the shells of mud snails, carrying and releasing of shrimp fry, guarding farms, and harvesting and post harvesting works like handling, cleaning, sorting, icing, transporting and marketing shrimp and fish at the farm level; packing and transporting of cultured fry at the shrimp hatchery level; and working as labourers at the processing factory level. Other employment opportunities include jobs in related sectors of transportation, ice making etc. (Ahmed et al 2010, Ahmed 2013, Ito 2002, Islam 2008a, 2008c, Pokrant and Reeves 2003).

4.3.6.6. Empowerment of women

In the previous rice irrigation regime, characterized by an explicit gendered division of labour, only male labourers used to do the outside jobs in rice fields, while the women were to do the household works. A breakthrough in the traditional division of labour took place after the introduction of shrimp and prawn

farming in the southwestern Bangladesh. Now a significant number of women are engaged in income-earning works outside of their homes (Islam 2008c). Women are involved in various facets of shrimp and prawn cultivation, including the collection of fry and snails, snail shell breaking, fishing net making, feeding of shrimps, making and cleaning shrimp ponds, farm supervision and management, dike cropping, shrimp harvesting and post-harvest sorting, grading and weighing, and working in the processing factories in cleaning, beheading, freezing and packaging of shrimps. In dike cropping, they involve mainly in sowing crops, planting saplings, fertilization, weeding, irrigation, harvesting and marketing. In the past, poor women had to migrate to town seeking jobs, but recently they have returned to find work as wage labourers in prawn farming activities (Ahmed et al 2010).

The increasing engagement of women in various shrimp farming related activities is an important marker of growing empowerment at both the household and the society levels (Islam 2008b, Ahmed et al 2010). According to Nesar Ahmed (2013), women's empowerment has not only given them greater equity, more authority, and social mobility but also reduced the incidents of domestic violence. Shrimp farming activities of women at the community level have strengthened their position within their families and in society in general. Their income has given them some financial independence. They are now able to play a stronger role in household decision making including those concerning education of children, attending social functions, inviting guests, accepting family planning methods, attending in religious functions, and advising sons and daughters on selection of spouses (Ahmed et al 2010).

However, some researchers doubted the women empowerment issue. For example, Ito observed, “low payment, long hours, and the intensity of labour all raise the question of whether or not poor rural women have in fact been empowered by the new economic activities associated with prawn cultivation” (2002:64).

From the above discussion, we find that there are ample positive consequences of industrial shrimp farming which are mainly economic in nature. If we take a critical look, we can find that the sector does not reward everyone equally. There is a class-dimension to the profit sharing. Only large-scale entrepreneurs and rich farmers get the lion’s share, while the marginal section of the people are engaged in the sector only to obtain the subsistence for living. Islam (2008a) clearly brought this fact into the fore. According to him, “Stakeholders like fry collectors, hatchery workers, depot workers, ice van operators, processing workers etc. are still in poverty and their incomes are not sufficient for their families though compared to their previous state in paddy regime, they are much better off. On the other hand, hatchery owners, large-scale farms owners, middlemen/traders, depot owners, processing plant owners, ice factory owners, exporters etc. are among the biggest beneficiaries” (Islam 2008a:216).

4.3.7 Negative impacts on the environment

Although shrimp cultivation has brought about some positive changes in Bangladesh, the ‘unregulated, uncontrolled and uncoordinated expansion’ (Metcalf 2003) of this sector poses some serious threats to the overall environmental and ecological set up of the locality and the entire country. Though

commercial shrimp culture brings about crucial economic benefit for the country, “the concomitant environmental degradation and marginalization of the coastal residents as a result of deprivation from traditional coastal resources have already become issues of growing concern” (Deb 1998:65). The following sections deal with the environmental consequences of commercial shrimping as delineated by the previous authors.

4.3.7.1. Destruction of mangrove forest

Mangrove forests, located at the intersections between land and sea, are distinct ecosystems developed under peculiar hydrodynamic and sedimentation conditions. The Sundarbans, the largest single block of mangrove ecosystem in the world (O'Donnell and Wodon 2015), is located in the south-western part of the Ganges basin covering an area of nearly 1 million hectares in India and Bangladesh (Hoq 2007:411). The Bangladesh part of the Sundarbans covers an area of 6017 km² (4143 km² of land and 1874 km² of water body) along its south-western coast (Hoq 2007:411). The Sundarbans has immense contribution to the national economy and to the livelihoods of the coastal people of Bangladesh. This forest provides tangible economic benefits by supplying housing materials, fuel, boat building timber, bridge construction timber, honey and wax, and industrial raw materials, among others. The Sundarbans plays the central role in preserving the rich biodiversity in the mangroves ecosystem. The Sundarbans serves as a ‘feeding, breeding, resting and roosting ground’ (Deb 1998) for numerous aquatic and terrestrial animals. It is the abode of a wide array of flora and fauna including 68 species of plants, 32 species of mammals (including world famous Royal

Bengal Tiger and spotted deer), 186 species of birds, 35 species of reptiles, and 8 species of amphibians (Deb 1998:73).

Commercial shrimp cultivation is referred to as the ‘silent destroyer’ (Deb 1998) of mangrove forests around the globe. It is estimated that about 30–70% of global (Ahmed 2013:36) and about 60% of Asian (Islam 2008a:216) mangrove areas has been lost because of the spread of shrimp farming. In shrimp aquaculture, the construction of ponds, dikes and canals leads to the destruction of natural mangrove vegetation and a permanent change in the hydrological features of the coastal areas (Deb 1998). About 9,734 ha of mangrove area in the Sundarbans has already been destroyed (Azad et al 2009). Similarly, the Chokoria Sundarban, a unique Mangrove forest of 8,000 ha in Cox’s Bazar has been completely destroyed (Ahmed 2013:36). In many areas, the forest density in the Sundarbans has degraded due to overexploitation of timber, extraction of fuel-wood and spread of infectious diseases (Azad et al 2009). The destruction of mangrove forests in Bangladesh is contributing negatively in the national economy, in the mangrove ecosystem and biodiversity, and in the traditional livelihood pattern of the surrounding people. In addition, the Sundarbans’ role as a protection wall against cyclones from the Bay of Bengal is diminishing day-by-day (Deb 1998).

4.3.7.2. Salinity intrusion

Gradual and rapid increase in soil and water salinity has become a major ecological concern in the coastal shrimp zones. Shrimp farms require continued supply and exchange of saline water throughout the growing phases. For each shrimp-growing season, on the one hand, farmers fulfil the demand for saltwater

by digging narrow canals from nearby river channels, an activity that dissipates saline water in the area. They meet the demand of freshwater, on the other hand, by launching deep tube-wells, which has negative impact on groundwater aquifers (Paul and Vogl 2011). The salinity level in surrounding agricultural plots increases due to the release of saltwater from shrimp farms. In the south-western Bangladesh, salinity ingress has lead to lower production of agricultural crops, poultry and fodders (Azad et al 2009).

4.3.7.3. Soil acidity

Soil acidity in shrimp farming zones is gradually increasing because of more exposure to air due to shrimp farming activities. “Long-term trapping of tidal water in shrimp ponds allows sulphur from the seawater to precipitate at the pond bottom. As the land dries out after shrimp harvest and is tilled for rice cultivation, the exposed sulphide deposits are oxidized and release sulphuric acid to soil and increase its acidity” (Ali 2006:427). Frequent attacks of diseases and deaths to the cultured species are linked to the stress caused by high levels of soil and water acidity. It is assumed that several disease outbreaks in shrimp farms in Bangladesh took place due to increased soil acidity (Azad et al 2009, Deb 1998).

4.3.7.4. Fry by-catch and destruction of aquatic species

Despite the easy availability of hatchery produced prawn and shrimp postlarvae (PL), wild fry is still the popular choice to the farmers. Every year fry catchers in Bangladesh collect about 2,000 million shrimp PL from wild sources. At least 90% of the total prawn PL and 50% of the shrimp fry are collected from rivers and the Bay (Azad et al 2009:803). As fry collection is an income earning source for

poor coastal people, the fry collectors use triangular push nets made of 1.05 mm mesh (minimum mesh size allowed by government is 30 mm) synthetic nets (Deb 1998:70), usually used for preventing mosquitoes, which virtually catches everything except water. Thus, during the collection of single PL about 12–551 postlarvae of other shrimps, 5–152 finfish postlarvae and 26–1636 other macro-zooplanktons are wasted (Hoq et al 2001:97). This leads to massive destruction of important coastal finfish and shellfish at larval stage that in turn destructs aquatic biodiversity.

4.3.7.5. Impacts of snail over-harvesting

Over-harvesting of snails in prawn-farming areas has harmful consequences on the environment. The meat of apple snail (*Pila globosa*) is one of the popular feed items for freshwater prawn in Bangladesh. Snails are harvested mostly in the monsoon season from natural water bodies like canals and wetlands. Approximately 365,849 m of snail was harvested in 1999 (Azad et al 2009:804). Because of over-extraction from wild sources, snail is disappearing rapidly from freshwater shrimp farming areas. The extinction of snail has negative impacts on aquatic environment. Removal of snail, for example, can lead to “an increase in the growth of at least some species of aquatic weeds which could reduce light penetration as well as photosynthesis and could lead to eutrophication of water bodies” (Ahmed et al 2010:571, Gain 1998). The dumping of a huge lot of snail shells also creates environmental pollution in the locality, causing blockage in canals where they are disposed generally (Ahmed et al 2010).

4.3.7.6. Water pollution

The shrimp industry often discharges toxic wastes and effluents directly to the environment without any treatment. This poses serious threat to water and soil in nearby areas. The intensive system of shrimp cultivation needs rigorous use of environmentally hazardous chemical and biological compounds and products for preparing and maintaining shrimp ponds. Farmers apply a wide range of toxic chemicals and fertilizers to the farms such as urea, dolomite, di-ammonium phosphate, and triple super phosphate (TSP). Since the farmers cannot bear the massive cost of scientific waste dumping measures, they generally dispose the harmful wastages into surrounding open places and water bodies. This practice pollutes water, decreases soil fertility, and damages freshwater fisheries, and plant and insect species (Swapan and Gavin 2011).

4.3.7.7. Loss of biodiversity

The impacts of shrimp aquaculture on biodiversity (the totality of genes, species and ecosystems in a region) in shrimp farming areas are multifarious. During construction works of shrimp ponds, shrimp farmers clear large sections of forest and mangrove area. Some local common animals like frogs, crabs are generally killed during the construction and processing of *ghers*. In addition, when collecting shrimp fry, a huge amount of other shrimp species, finfish and valuable aquatic organisms are destroyed. Increased water salinity due to shrimp cultivation can make water on surrounding lands toxic, which in turn can contaminate the aquatic habitat of the nearby rice fields. During field research at Damarpota of Satkhira in south-western Bangladesh, Abu Muhammad Shajaat Ali

found that 19 species¹⁴ of fresh water fish had become either extinct or pulled out by the farmers to protect shrimp and other saline water fish species (2006:433). Unplanned expansion of shrimp farming reduces open fields, open waters, and grazing lands that in turn reduce the population of livestock, goats and ducks in the locality. All the above conditions contribute to the loss of local ecological biodiversity.

4.3.7.8. Change in land-use pattern and visual pollution

The expansion of commercial shrimp farming over the last three decades has caused significant changes in land-use pattern in coastal rural areas in south-western Bangladesh. Swapan and Gavin (2011) reported in their study in Koyra sub-district of Khulna district that significant land-use changes occurred in key land-use categories such as human settlement, agriculture, fisheries and vegetation. They also identified that fishery land-use increased in one of their study villages by about 75% during 1990 – 2005 period, while agricultural and natural vegetation land-use decreased by 90% (Swapan and Gavin 2011:49). Farmers converted almost all of their agricultural fields into *bagda ghers*. In her study in three sub-districts in Satkhira and Bagerhat districts, Meghna Guhathakurta found from satellite data that mainly due to shrimp cultivation in her researched areas, land-use pattern was changed on an average of 15.62% of the total land area (2008:212).

In addition to having severe consequences on lives and livelihoods in the locality, this type of change in land-use pattern in an agricultural area can have

¹⁴ The species belong to the families of “*Cichlidae, Saccobanchidae, Clariidae, Schilbidae, Cobitidae, Cyprinodontidae, Cyprinidae, Notopteridae, Osteoglossinae, Channidae, Mastacembelidae, Synbranchidae, Afromandus, Sheljukoi, Nandidae, Belonidae, Trypanchenidae, Samaris, and Tetraodon*” (Ali 2006:433).

negative visual and aesthetic effect on people. The unspoiled nature and eye-catching beauty of the coastal line of Bangladesh have already disappeared with unplanned and haphazard expansion of shrimp ponds and *ghers*. Typical traditional village households with cattle and poultry, gardens and fishponds are rarely seen in the south-western coast of Bangladesh (Deb 1998).

4.3.8 Negative socioeconomic and cultural impacts

Though shrimp cultivation in Bangladesh is generally regarded as a profitable enterprise, it is not rewarding all stakeholders equally. A handful of rich investors are gaining the majority of economic benefits, while the bulk of poor people are being marginalized further by this sector. In this respect, environmentalist NGOs like Greenpeace argues that in the worldwide shrimp farming only a marginal fringe of investors receive the lion's share, while local populations are kept away from the profits and marginalized in a degraded environment (Bailly and Raux 2006). Beside economic issues, environmental preservation, the fight against poverty, institutional and market failings, culture change, quality control, certification and governance, gender issues and a number of other factors encourage unsustainable development and antagonisms in shrimp farming zone and beyond. Previous literature on the social impact of shrimp cultivation in southern Bangladesh profoundly underlines its negative aspects. The negative consequences include illegal land grabbing by outside investors, depeasantization, displacement, disruption of local networks of social security, local farmers' losing access to common property resources, local level violence and killings, increase in income inequality, decline in access to sharecropping opportunities, privatization of public lands, exploitation of women's labour etc.

4.3.8.1. Land grabbing and violence

National and multinational investors from outside control and operate most of the coastal land in Bangladesh (Deb 1998, Ito 2002, Paul and Vogl 2011). In the initial stages of shrimp farming, local power elites and intruders from outside, who can be called as ‘shrimp-lords’ (Ito 2002), captured legally or illegally the agricultural land of the poor and marginal farmers to establish shrimp farms. These investors, 85% of whom are outsiders, are highly influential persons or institutions including rich businessmen, bankers and bureaucrats, army officers, political leaders, journalists and NGOs (Deb 1998, Paul and Vogl 2011). Government-owned coastal lands are also leased out to these rich shrimp-lords. Though government-owned agricultural land should be leased out to the landless people as per the land reform act of 1989, in practice, only the ‘powerful few’ manage the lease from the government (Azad et al 2009). Additionally, in order to grab private lands, influential investors generally propose small landowners to sell or lease out their agricultural fields to them for shrimp cultivation. The powerful investors frequently submerge the adjacent rice fields with saltwater from their shrimp farms, if the owners of those plots of land refuse to comply with the investors’ proposals. In this situation, the petty landowners are forced either to accept the humiliating proposals or to migrate out of the locality. Through this process, many small landowners became landless and economically non-solvent and started fry catching and other shrimp related activities for rich farmers (Deb 1998).

As shrimp cultivation became a profitable enterprise for the rich entrepreneurs, the demand of suitable land has increased manifold, which in turn

has caused the increase of land price. Sanae Ito reported that land price skyrocketed in Bagerhat where it increased eighteen fold within a span of six year time between 1994 and 2000 (Ito 2002, Paul and Vogl 2011). Increasing land value is associated with increasing land disputes and agrarian conflicts (Ahmed 2013). Overtime, the deprived and angry local farmers and landholders started organizing themselves and launched protest movements against the land grabbers. In immediate reactions, the shrimp-lords took the path of violence in several occasions by hiring armed gunmen. Because of clashes between the two groups, a member of the landless women's group was murdered in a 1990 bomb blast (Ito 2002). In a reaction to this event, nationwide demonstration and protest movements took place, organized by various human rights and citizens' groups and supported by NGOs and the mass media. The outsider shrimp-lords resorted to abductions, harassment, legal actions, torture, and killings to suppress the protesters in different times. In another clash on July 29, 1998, criminals hired by land grabbers attacked villagers in Baburabad, Satkhira. As a result of the violent triangular fighting between villagers, thugs from outside and the police, two landless poor including a baby were killed and hundreds other were wounded. The local people, being ignited by this occurrence, organized violent protests in the area. The situation was overcome only after the head of the state had led the negotiations (Deb 1998).

The land grabbing incidents are a characteristic of brackish-water shrimp cultivation only and not of freshwater prawn farming. Ito identified two causes behind the fact why prawn farming has been controlled solely by the local farmers from the beginning (2004). Firstly, there is a difference in land ownership between the two farming zones. A major portion of the coastal land, where brackish-water

shrimp is cultured, is owned by the government and leased out to the elites. However, the local people privately own inland freshwater agricultural lands. So, it becomes difficult for an outsider to convince a large number of small landowners and to get their lands to form big farms. Secondly, farm size is another issue. While in brackish-water shrimp farming the entrepreneurs concentrate on larger size because of easy operation (e.g. flooding a large area with saline water at a single sweep), farm size is not such an important issue in freshwater prawn cultivation. Rather, smaller-sized farms can be maintained easily which are seasonally filled with rainwater. Thus, small landowners are encouraged to operate their own prawn farms (Ito 2004).

4.3.8.2. Depeasantization and forced migration

Local people are marginalised because of forceful grabbing and conversion of, and salinity intrusion into, their lands. The expansion of shrimp farms forced small landowning and landless sharecroppers and agricultural labours to be dislocated from their occupation and become jobless. Moreover, though commercial shrimp industry has created some new kinds of employment, traditional method of rice farming is more labour consuming than shrimp culture. In India, rice cultivation on 40 ha of land requires 50 labourers, but shrimp farming in the same area needs only 5 workers (Paul and Vogl 2011:207). In Bangladesh, the labour requirement in shrimp farms is only one-fourth to that in traditional agricultural activities (Deb 1998:81), rice farms need around 8 – 10 people all over the year whereas a large shrimp *gher* can be operated by 1 – 2 staffs (Swapan and Gavin 2011:50). It means that the introduction of commercial shrimp cultivation has constricted almost three-quarters of the agro-based labour

force in the region. Furthermore, the leaseholders from outside usually do not trust the local labourers and rather hire workforce from their own localities (Deb 1998). Thus, many of the poor who lost their agricultural job did not get any work in the shrimp cultivation sector. Swapan and Gavin were informed by their respondents in Koyra, Khulna that shrimp farms had employed only about 10% of the jobless people, who had lost their jobs because of the regime shift (2011:50).

In addition, the new shrimp regime has shrunk the scope for other classical dry season activities in the area, like duck raise, cattle grazing and homestead gardening. Due to the above factors and due to forceful land grabbing by the shrimp-lords, many previously small peasants have to look for work elsewhere, flee their homes and migrate to urban areas where they just contribute to making the 'planet of slums'. The forced occupation shift and migration place poor peasants from minority communities in a particularly vulnerable position. Sanae Ito (2002) reported a specific event from Mollahat, Bagerhat in which Hindu poor peasants whose lands were waterlogged did not dare to challenge the miscreants from the dominant Muslim community. Similarly, Nesar Ahmed and colleagues (2010) reported from Fakirhat, Bagerhat that some farmers from the minority Hindu community had to sell out their property and to migrate to India when they felt insecure after conflicts with Muslim perpetrators.

4.3.8.3. Food insecurity, malnutrition and health problems

Encroachment of paddy fields by shrimp farms has caused the reduction of agricultural land. In addition, rice cultivation is seriously hindered in the coastal region of Bangladesh during January-September period when shrimp is cultivated. Cultivation of the major rice crop (*aman*) is delayed from its normal time of

transplantation in June–July (Hoq 2007). Moreover, salinity intrusion in rice fields due to shrimp cultivation hampers the growth of paddy. The above factors jointly contribute to a decrease in rice production. Additionally, the introduction of commercial shrimp cultivation caused a massive decline of grazing and vegetation land. Thus, the scope of rearing cattle, poultry and duck, and growing vegetables and fruits has significantly decreased in shrimp farming areas. Poor people previously obtained milk, eggs, vegetables, fruits and other nutritious food from these activities. Furthermore, the institution of sharecropping, which guaranteed a fixed income for the landless poor, is disappearing due to the introduction of shrimp cultivation. All of the above issues cause greater food insecurity especially for the marginal section of people. Consequently, poor people began to suffer from malnutrition.

Shrimp farming and processing activities create such an environment in the locality that it is hazardous to human health. Labourers from poor families who work for long hours in saline, muddy, and fast moving water get skin diseases, colds, and hand and foot infections. Researchers found that proximity to and standing in saline water led humans to suffer more from malaria, diarrhoea, and some gastro-intestinal diseases (Rahman et al 2006). Nesar Ahmed and colleagues (2013) found in Mongla, Bagerhat that prawn fry catchers faced serious health problems with little or no medical support. Fishing families often suffered from diarrhoea, cholera, hepatitis, pneumonia, dysentery, eye infections, skin diseases, and mosquito-borne diseases such as dengue fever and malaria. They also found that insufficient food consumption had led to “birth defects, stunted growth of children, night blindness, and increases in miscarriages and maternal mortality” (Ahmed et al 2013:231).

4.3.8.4. Increase of poverty

In shrimp farming areas, the economic condition of a vast portion of people worsened after the institution of commercial shrimp cultivation. Though this ‘blue revolution’ significantly increased export earnings for the country, only a tiny section of people received a share of the profit. Forced dislocation, depeasantization, and migration caused marginal farmers to become more marginalized. Nesar Ahmed and colleagues (2013) found in Mongla, Bagerhat that the majority of fishers (78%) lost their income from rice cultivation and livestock rearing because of salinity ingress and the loss of pastures. Also, a decrease in snail availability, which is the major feed for ducks, has made duck rearing challenging for the local people, especially in the freshwater prawn farming zone. Due to salinity ingress in land and water, vegetation in the locality has declined and homestead gardening has been hampered significantly. All of the above factors have caused a decline in annual income of the villagers. Due to a loss of income, the socioeconomic conditions of local people remain poor and many of them have become even more impoverished (Ahmed et al 2013).

4.3.8.5. Social disruption

Shrimp farming has been associated with few social problems in shrimping zone. Workers hired from urban areas brought gambling, alcohol, drugs and prostitution with them. In addition, in a number of instances, cash wages on the shrimp farms drove children away from schools into employment, contributed to a decline in school enrolment and attendance (Ahmed et al 2002). An increased amount of cash flow has caused a rise in the risks and actual cases of hijacking, robbery,

extortion and theft. Occasionally, miscreants, out of jealousy, kill shrimps by applying poison at night into the shrimp ponds, causing huge loss to the farmers (Ahmed et al 2010). In a number of cases, villagers from different areas reported that *gher* employees attacked and burnt villages and abused women and children.

As mentioned earlier, a woman protester was killed in such an incident in 1990. At least 50 other people were wounded on that occasion when “a wealthy shrimp farm owner and his armed men opened fire with rifles and machine guns in an attack [against the resistance of local residents] in a zone that had been kept free of shrimp” (Ahmed et al 2002:18). However, nowadays this type of incidents has become rare since the local shrimp farmers have outnumbered the outsiders.

4.3.8.6. Derogatory condition of female workers

The interconnections between gender and the ideologies of work in the capitalist exploitative contexts generally identify women as non-workers and thus undervalue female labour (Guhathakurta 2008). In the industrial shrimp sector of Bangladesh, there is a clearly visible gendered division of labour in which poor women are employed in low-paid manual labour intensive jobs (see Islam 2008b for a detailed account). Women work as wage labourers, build embankments around shrimp ponds, maintain service roads, de-weed shrimp fields, collect shrimp fry, and clean and pack harvested shrimp (Rahman et al 2006). Comparing to their male counterparts, female workers, who can be called as ‘farm girls’ or ‘disposable labours’, have to work longer hours and to accept low wages (McMichael 2008). Islam (2008b) pointed out two basic reasons for which women have to accept the derogatory work conditions. “First, the supply is higher than the demand for female workers, giving employers an opportunity to exploit their

relatively cheap labour. Second, the absence of alternative income-generating activities is compelling women to work in the shrimp-processing factories. Because of these two reasons, one person's vulnerability becomes another's capital" (Islam 2008b: 227-228).

Women are more vulnerable in the work places. Poor fry collecting women are more vulnerable to be attacked by sharks and crocodiles and to be abducted and abused by robbers in the Sundarbans (Guhathakurta 2008). Some observers, including Ghafur et al (1999), report that guards of shrimp farms, in a number of cases, abused women physically or sexually. Women, whose husbands have migrated to urban areas for work, are particularly vulnerable to be abused. In the early era of resistance, women involved in organized movements against the expansion of shrimp cultivation were verbally or physically assaulted. A number of female protesters were killed in these attacks (Ahmed et al 2002).

4.3.8.7. Negative impact on women's life and work

Displacement of women from the sphere of agricultural production is one of the main consequences of the mushrooming of shrimp monoculture in south-western Bangladesh. Women played a crucial role in the production process in the previous agriculture regime. In the previous subsistence economy, a woman would engage in core production works after the harvesting of rice, the main crop of the regime. Her main jobs involved 'threshing, husking, and parboiling' of rice as well as processing and preserving of seeds for the following season (Guhathakurta 2008). In addition to regular time cycle and work rhythm, linked to lean and peak seasons of crop cultivation, an agricultural household had a lot of secondary jobs to perform including homestead gardening, cattle rearing and duck

and poultry farming – “which worked in synergy with agricultural production” (Guhathakurta 2008:215). The shrimp regime has upset the entire work structure for women folk. As rice cultivation has decreased sharply, coastal poor women have no other choice but to resort to the laborious and derogatory work of wild fry collection from rivers and the sea. This work squeezes all their time and energy. Table 4.5 is a list of changes that occurred at a village in Khulna district after commercial shrimp farming began.

Table 4.5: Change in daily activities of rural women after the introduction of shrimp cultivation.

Activities before the introduction of shrimp farming	Present activities after the introduction of shrimp farming
Preparing food in the morning	Preparing food in early morning
Drying rice in the sun/boiling and husking of rice	Working in shrimp ponds due to stopping of paddy production/collecting shrimp fry
Taking care of their children and other family members	Work in ponds all day long to maintain family, leaving no time left for family matters
Working in their own vegetable garden (source of income)	Vegetables cannot grow because of salinity
Maintaining hens and ducks and selling eggs (source of income)	No option for raising ducks as the owners of shrimp pond prevent to maintain ducks/high salinity
Selling hand-made mats prepared from tree leaves during their leisure period (source of income)	Trees are disappearing because of increasing salinity No leisure period after working in shrimp ponds

Source: Swapan and Gavin (2011:50)

4.3.8.8. Breakdown of traditional gender roles

The impact of shrimp farming on gender relations and in the realm of personal and family relationships is an area that is not well researched yet and hence

camouflaged (Guhathakurta 2008). The impact of shrimp farming on gender relations has generated a great deal of controversy both at the grassroots level and among the observers. Some observers treat the 'feminization of work' (see McMichael 2008) as a positive outcome and opine that this sector has provided an avenue to women for their income generation. Others have the view that shrimp farming has led to a loss of social status for many women and negatively affected male-female relationship. Women's work outside the home is still brought under the scrutiny of dominant patriarchal norms (Rahman et al 2006). New normative approaches have not yet come out which would offer social recognition and support to women's greater physical and economic mobility and freedom. Rahman and colleagues (2006) observe that working-women's social security in Bangladesh is still at risk as patriarchal norms and practices continue to control the public sphere strictly.

4.3.8.9. Child labour

Although children play a significant role in the shrimp industry, theirs is not documented properly in the literature. Most researchers have done work only on child fry collectors. Child labour across the industry as a whole is ignored in the literature and does not have the same public profile as in the garments industry. Children generally become engaged in the work early at the age of five (Ahmed 2002). Women and children from poorer families, hired as cheap labour to catch shrimp fry, need to work in cold and saline river water for about 8-10 hours a day, which makes them exposed to various diseases. Pokrant and Reeves (2003) reported that in the southeast coastal area of Bangladesh, children from poor family are sometimes forced to catch fry and their guardians think that children's

earning is a duty to their families and a means of fulfilling family obligations. In addition to working in extremely vulnerable conditions, the child fry collectors are deprived of the compulsory primary education and health and nutrition facilities.

4.3.8.10. Breakdown of rural power structure

Land is the principal means of production and hence one of the major sources of power in agrarian Bangladesh. Social and economic position and power of an individual or a household largely depends on the control and ownership of land. This traditional power-base was shattered in the initial stage of commercial shrimp cultivation when rich outsiders took control of the business. The shrimp elites were economically wealthy and politically influential being well connected with the local and the national political circles as well as with the administrative structure (Ahmed et al 2002). By using all their means and forces, they grabbed most of the agricultural land and converted those into big shrimp projects. In order to capture the lands, they also frequently adopted all types of violent means. Thus, these outsiders became more powerful by means of their wealth and force, though they were not traditional landlords in the locality. Hence, the launching of export-oriented shrimp industry in Bangladesh broke down the age-old rural power structure, which was primarily based on land ownership and kinship ties.

4.3.8.11. Culture conflict

Social and cultural milieu in rural Bangladesh changed significantly under the influence of the cash flow brought about by the Bangladeshi shrimp industry as a part of the global shrimp commodity chain (Islam 2008c). Economic benefits of the shrimp industry go to a minority of the shrimp farming population who have

adopted a more consumerist culture in the localities. They introduce colour television and other electronic media and video culture that are completely new to the villagers. This new form of entertainment, consisting of western and Hindi movies, has upset the traditional rural culture. The growth of direct and indirect influences from outside has led to an increase in the use of drugs, alcohol, gambling and prostitution. As a result, a noticeable breakdown of traditional family, community, and political relations has occurred which in turn is causing a great degree of social disintegration and social transformation (Rahman et al 2006). One noticeable impact was that the relationship of respect and honour between the landless and the landowners in the shrimp farming communities started to decline (Ahmed et al 2002).

4.3.8.12. Impact on religious institutions

The new regime brought about by the shrimp industry has repercussions on local economy, family, society, politics as well as on religious institutions.

>> *Impact on Islamic purdah system*

Though no research work is found focusing on the connection between shrimp and purdah and though Sanae Ito found that “Hindu women are more active participants in the new prawn economy than Muslim women” (2002:63), it can be assumed from several other studies (including Islam 2008b, Pokrant and Reeves 2003) that women’s engagement in working outside the home can expose them in public which can be a cause of breaching the *purdah*. Especially poor Muslim women’s work as shrimp fry collector in seawater clearly breaks Islamic norms.

>> *Impact on Hindu caste system*

Hindu caste system is a religious as well as occupational category. The shrimp regime is causing structural transformations in changing class and caste hierarchies in coastal Bangladesh. Before and after the Partition of 1947, the Sundarbans and its surrounding areas were mostly Hindu-dominated with the Hindu *zamindars* (landlords) controlling the lion's share of land-holding (Guhathakurta 2008). In this environmentally and naturally rich area – where fertile land, fish-rich rivers and water bodies, and wealthy forests provide sufficiently for subsistence consumption – people could contain with “a stratified system of caste-specific hierarchies” (Guhathakurta 2008:213) for ages. The caste-specific stratified system nurtured a fixed scheme of particular occupations such as *kolus* (people who ground oil from sesame and mustard seeds), *rishis* (traders of leather and leather products), *moualis* (honey extractors) and *bawalis* (wood extractors from the forests), weavers and fishermen. All of the above-mentioned and other secondary activities (including cattle rearing and poultry farming) are now in danger of extinction because of ecological degradation caused by the unplanned expansion of shrimp farming. Thus, shrimp cultivation caused large portion of people from these groups to change their occupation, some are benefitted with the cash economy induced by commercial shrimping. For example, *kolus*, “who used to grind mustard seeds to produce oil for the market, have merely changed into petty traders buying from the oil mills and selling the oil in the local bazaars, thus transforming a productive community into a trading one” (Guhathakurta 2008:213-14). Thus, with upward mobility of some groups in

terms of economic gain, the caste-oriented occupational boundaries in the Hindu community are eroding because of the industrial shrimping in Bangladesh.

4.3.8.13. Impact on marriage and family

Commercial shrimping has influence on the institutions of family and marriage. Unmarried women's engagement in works at open places like the forest and seawater can hamper their marriageability because of the social 'stigma of public work' (Pokrant and Reeves 2003). Furthermore, the cash flow to the local economy and the changing work and cultural patterns have caused an increase in dowry payment. Ahmed et al (2010) observed in Fakirhat, Bagerhat that families of bridegrooms that previously would get a bicycle from the bride's family, now claim motorcycles, large sum of cash, gold jewellery and wristwatches. Similarly, Shindaini and Baqui (2012) found in Bujbunia village in Khulna district that three-quarters of villagers felt that an increase in dowry demand and payment has occurred since the inception of commercial shrimp cultivation in the locality. About two-thirds of the villagers also reported an increase in family conflict due to occupational change brought by shrimp farming.

4.3.9 Climate change vulnerability in the Bangladeshi shrimp industry

Bangladesh is a disaster-prone country and ranked first among countries vulnerable to climate change (Ahmed et al 2013, Ahmed 2013). The country encounters one or more disasters every year, which damage life and property and shatter development activities. Though climate change phenomena are a growing concern for all of Bangladesh including its coastal aquaculture, very few

researches have been done on the current and projected negative impacts of climate change on the commercial shrimp sector of Bangladesh.

4.3.9.1. Vulnerability of Bangladesh to global climate change

The geographical location and geo-morphological conditions of Bangladesh have made it one of the most vulnerable countries to climate change in the world. With the mighty Bay of Bengal in the south and the great Himalayas to the north, Bangladesh is at the critical juncture of the two distinct environmental settings. Because of this unique geographical location, Bangladesh experiences both life-giving monsoons and shattering havoc of natural disasters (Ali 1996, 1999, Ahmed 2013). After synthesizing 16 General Circulation Models (GCMs) and 3 emissions scenarios, the Fourth Assessment Report of the IPCC concluded that an increase in temperature of 1–3° Celsius by 2050 is likely to take place in Bangladesh (Rawlani and Sovacool 2011:850). This increase in temperature will mainly cause problems associated with water: too much of it during the monsoons, and too little of it in the winter. The global warming of climate is likely to lead to an increase in sea-levels, river water levels, water logging, erosion, and flooding during the monsoon; and saline water intrusion and shortages of water for irrigation during the winter (Rawlani and Sovacool 2011).

4.3.9.2. Major climate change events that affect the shrimp sector in Bangladesh

Tropical cyclone is one of the most shattering natural disasters that affect shrimp aquaculture. Every year about 80 tropical storms (tropical cyclones with wind speed greater than or equal to 17 m/sec) form in the world's waters (Ali

1999:110). Though the coastal area of Bangladesh is hit by 0.93% of world's total cyclones, it is attacked by most severe cyclones in terms of death tolls. Between 1877 and 1995, Bangladesh was hit by 154 cyclones, including 43 severe cyclones and in every three years the country is hit by a severe cyclone (Ahmed et al 2013:225). The major severe cyclones during the last two decades include a severe cyclone in April 1991 that led to the loss of 138,000 lives, super cyclone Sidr that hit the coastal lines in November 2007 affecting livelihoods of around 8.9 million people with a death toll of 3406 and an estimated economic loss of USD 1.67 billion, cyclone Nargis that devastated coastal life in Bangladesh in May 2008, and cyclone Aila that hit coastal Bangladesh in May 2009. Cyclones are associated with storm surges, which cause severe damages to lives and property in coastal Bangladesh. Other environmental phenomena include coastal erosion, backwater effect, floods, droughts, sea level rise, water salinity increase, and storm surges in the Bay of Bengal (Ali 1996 and 1999, Ahmed 2013, Ahmed et al 2013).

4.3.9.3. Negative effects of climate change on the Bangladeshi shrimp industry

Cyclones reduce fishing days and catch rates, as well as causing fishermen to lose nets and gears. Severe cyclones have severe damaging effects on coastal aquaculture, for example, Saidul Islam reported that cyclone Sidr washed away about 6,000 shrimp farms and hatcheries in coastal areas (Islam 2010:55). In their study on the impacts of climate change events on prawn postlarvae fishing in Mongla, Bagerhat, Nesar Ahmed and colleagues (2013) observed that salinity increase in the Pasur River has both positive and negative impact on availability

of postlarvae. In an increased level of water salinity, prawn postlarvae become less available, while shrimp postlarvae become abundant. Sea level rise forces a number of fishers to change their fishing sites. Increased water temperature causes reduced availability of postlarvae. By causing increase of soil erosion and water turbidity, floods can reduce postlarvae availability. Prolonged drought increases water salinity that in turn reduces the availability of prawn postlarvae. Sea level rise, cyclones, tidal upsurges and other climate extremes severely damage the coastal ecosystem and biodiversity of the area.

According to Nesar Ahmed, “The potential impacts of climate change on prawn and shrimp farming could have severe effects on food production, export earnings, livelihoods of the coastal poor and their socioeconomic conditions. Declining rice and fish production could affect food security in coastal communities. Reducing prawn and shrimp production could lead to decrease export earnings that in turn undermine income and livelihoods of the coastal poor. Threatening this sector due to climate change could have dramatic consequences for the economy of Bangladesh” (Ahmed 2013:40).

4.3.9.4. Adaptation strategies

Ali (1999) and Ahmed (2013) pointed out a few possible adaptation strategies to climate change vulnerabilities for the coastal population in Bangladesh. The strategies (listed in Table 4.6) include generation of alternative livelihood opportunities, community awareness for disaster management to fight sea-level rise, construction of coastal embankments for cyclone protection, afforestation of greenbelt in coastal areas, construction of cyclone shelters, mixed culture of prawn-shrimp to fight salinity intrusion, building higher dikes around aquaculture

farms to fight floods, development of water irrigation facilities for coastal aquaculture to tackle draught situations etc.

Table 4.6: Possible adaptation strategies to climate change for coastal communities.

Event	Adaptation strategy
Sea level rise	<ul style="list-style-type: none"> • Community-based adaptation strategies must be developed • Alternative livelihood opportunities to be generated • Community awareness for disaster management
Cyclone	<ul style="list-style-type: none"> • Construction of coastal embankments for cyclone protection • Afforestation of greenbelt in coastal areas • Construction of cyclone shelters
Salinity intrusion	<ul style="list-style-type: none"> • Mixed culture of prawn-shrimp • Brackish-water fish culture • Introduce salt-tolerant rice varieties
Flood	<ul style="list-style-type: none"> • Building higher dikes around aquaculture farms • Construction of flood control dams • Using floodwater for irrigation and aquaculture
Drought	<ul style="list-style-type: none"> • Develop water irrigation facilities for coastal aquaculture • Introduce drought-resistant rice varieties • Plan for conservation and utilization of rainwater and floodwater

Source: Ahmed (2013:40)

Few researchers (Pouliotte et al 2009, Ahmed 2013) pointed to the cultivation of shrimp species as an adaptive measure to face the climate change problems. Since salt water intrusion in coastal areas is a result of global climate change and since rice cannot be cultured in saline water, coastal communities could adapt to the situation by farming shrimp and other brackish-water fish species.

4.4 Knowledge gap in existing literature on Bangladeshi shrimp industry

From the above literature review on the Bangladeshi shrimp industry we find that there remains a knowledge gap in research scholarships. Though vast majority of studies concentrated on the positive and negative socio-economic and environmental impacts of shrimp aquaculture in the south-western Bangladesh, no comprehensive study has so far been conducted from a reverse point of view i.e., on how environmental and climate hazards impede a sustainable growth of the industrial shrimp. Consequently, there is a lack of research on how households and communities in shrimp-dependent areas fight against, cope with or be resilient to climate change disruptions. In addition, there is virtually no significant scientific study on how the shrimp communities adapt to sudden weather shocks or slow on-set climate changes by means of social, economic, physical and environmental capitals they possess. This research is an endeavour in this regard. This research aims at contributing to knowledge expansion by unveiling community resilience to climate change in commercial aquaculture.

CHAPTER FIVE

THE SETTING: SOCIOECONOMIC, ENVIRONMENTAL AND CLIMATE PROFILE

5.1 Introduction

Since the empirical part of this study was undertaken in the south-western coastal zone of Bangladesh, before focusing on actual impacts of and resilience to climate change in shrimp farming communities in the next two chapters, in this chapter we will have a look into the socioeconomic, environmental and climate profile of the area. This discussion will reveal the vulnerability and resilience dimensions of the people living there.

Being located in the eastern part of the Indian subcontinent between 22°34′ and 26°33′ North latitudes and 88°01′ and 92°41′ East longitudes (BBS 2010) and between the Himalayan Mountains in the north and the Bay of Bengal in the south, Bangladesh embraces unique physiographic and climate settings with dynamic hydrological and morphological landscape (Kais 2017). Being part of the Bengal Basin, the largest geo-synclinals in the world (Karim and Mimura 2008), the ecological characteristics of this low-lying deltaic South Asian country are governed by three great river systems of the world – the Ganges, the Brahmaputra, and the Meghna. With a total area of 147,570 km² (BBS 2010:4, World Bank 2016a), Bangladesh is an extremely populated country with a total population of over 168 million (July 2015 estimate, CIA 2015), projecting to reach to 280 million by 2050 (Michaud 2009) – currently ranking 9th in the world with a density of 1,132 people/km². About 700 rivers and tributaries – with a total length of 24,140 km (Banglapedia 2016) – have crisscrossed the country before falling

into the Bay of Bengal, making it a land of rivers. Bangladesh is an attractive land rich with natural beauty and diversified cultural heritage. In terms of the World Bank scaling, Bangladesh is a lower middle income country with a total GDP of USD 172.9 billion in 2014 (World Bank 2016b). In Bangladesh, 47.4% of the employed persons aged 15 years and over are engaged in agriculture, forestry, and fisheries sector (BBS 2013:156). Once termed as ‘bottomless basket’ by some of its development partners (Siddiqui and Billah: 2014), Bangladesh advanced, thanks to hardworking people, quite significantly in a number of social and economic indicators including decrease in infant mortality (35 per 1,000 live births in 2011), maternal mortality ratio (2.09 in 2011), and illiteracy (literacy rate was 58.6% in 2010), and increase in life expectancy (71.6 in 2014) (BBS 2013, UNDP 2015:210). Economic progress of the country triggered since 1990 and annual GDP growth rate was between 5.3% and 6.7% during the last decade (Siddiqui and Billah 2014:120). Consequently, the Human Development Index of Bangladesh improved from 0.462 in 2005 to 0.570 in 2014 placing it in the list of countries with ‘medium human development’ (UNDP 2015:209, Siddiqui and Billah 2014). Despite considerable advancement in social and economic indicators, the growth potentiality of Bangladesh is retarded by a series of social and environmental impediments including the recent climate change threats.

5.2 Coastal Bangladesh

The Bangladesh landmass is connected to the Bay of Bengal in the south through a 710 km long coastline (Ahmed and de Wilde 2011:2). The coast is not a fixed, static line between land and sea; rather, it is intersected by a vast network of river systems, an ever-dynamic estuary, and a drainage basin through which a huge

amount of freshwater is discharged into the sea from Bangladesh, and parts of India, Nepal, Bhutan, and China. The Coastal Development Strategy of 2006 takes three physical criteria in defining the coastal area in Bangladesh: the limits of tidal fluctuation (difference of 0.3 meter between the high and low tide in a day), salinity intrusion (4 dS/m, 5 dS/m and 2 dS/m as threshold salinity level for soil, surface water and ground water respectively), and risk of cyclones and storm surges (among high risk, risk, wind risk, and no risk zones mapped by the Disaster Management Bureau, the first two are the coastal areas) (Ahmed and de Wilde 2011, Karim and Mimura 2008). In addition to land areas with above characteristics, exclusive economic zone (EEZ) as defined by the UN Convention on the Law of the Sea is a part of Bangladesh coastal area.

An *upazila* (sub-district) is considered to be ‘coastal’ (see Figure 5.1) if at least one of the defining parameters of coastal area is at the threshold level in the *upazila*. A district is termed as ‘coastal’ if it includes at least one coastal *upazila*. In Bangladesh, 133 *upazilas* under 19 districts¹⁵ are defined as coastal. In 48 *upazilas* in 11 districts all three indicators are above threshold level making them ‘exposed coastal zone’ (Ahmed and Wilde 2011), the remaining area is referred to as ‘interior coast’ (Rashid 2014). The exposed coastal districts are defined as ‘southern region of Bangladesh’ in a Master Plan of the Bangladesh Government (MoA and FAO 2013). In total, the coastal zone covers an area of 47,201 km², 32% of the total landmass of Bangladesh (Rashid 2014:59), and is home to 46 million people (Sarwar 2013:218).

¹⁵ The districts are Bagerhat, Barguna, Barisal, Bhola, Chandpur, Chittagong, Cox’s Bazar, Feni, Gopalganj, Jessore, Jhalkathi, Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirojpur, Satkhira and Shariatpur (MoWR 2005:2).

Figure 5.1: Map of the coastal zone of Bangladesh

Source: Adopted from GeoBangla website¹⁶

Based on geo-morphological features, topographical settings and hydrological regimes, the coast of Bangladesh can be divided into three distinct regions: eastern, central, and western (Ahmed and Wilde 2011, Islam, Huq and Ali 1999, Rashid 2014, UNESCAP 1987). The eastern coast, which covers from Big Feni River to Badar Mokam (World Bank 2000), is regular and unbroken and is termed as the ‘Pacific type’ coast (Ahmed and Wilde 2011). The central region, stretching from Big Feni River in the east to Tetulia River in the west, is the most dynamic of the costal zones, with series of accretion and erosion occurring here. The western zone, in which the fields of the present research lie, covers an area from the Tetulia River in the east to the international border with India in the west. This region is relatively stable and termed as ‘Atlantic type’ coast (Ahmed and Wilde 2011). The western coast, which consists of nine exposed and four interior districts, is the largest coastal zone in the country comprising 65% of exposed coastal land and 79% of interior coastal area (Karim and Mimura 2008:491). Since this zone is a part of the low-lying Gangetic delta, it is extremely vulnerable

¹⁶ Retrieved February 27, 2016 <https://geobangla.wordpress.com/2015/01/30/overall-geology-and-hydrogeology-of-the-southwestern-coastal-belt-of-bangladesh/>

to anthropogenic sea-level rise and sea tide reaches up to 150 km inland through river channels in this region (Rashid 2014:59).

The most notable natural resource of the coastal Bangladesh is several mangrove¹⁷ ecosystems, including the mighty Sundarbans. Globally, mangrove forests cover an area of 14,650,000 ha of coastline (Alongi 2008:2) in 121 countries (Wilkie and Fortuna 2003) with an economic value of about 200,000 – 900,000 USD/km² (UNEP-WCMC 2006:5). The specific area of the Sundarbans covers 4,141 km² (Wodon 2015:39) of transitional zone between marine and fresh water in the south-western part of the Bengal delta. Divided approximately in a 2:1 ratio between Bangladesh and India (see Figure 5.2), this area is home to 4.3 million people (Wodon 2015:39), most of whom live in poverty with limited access to public services.

Figure 5.2: Map of the Sundarbans

Source: Wikimedia¹⁸

As an ideal mangrove ecosystem, the Sundarbans play a key role in human sustainability and livelihoods by providing benefits under all the four categories of

¹⁷ In ecology and ecosystems study, the term ‘mangrove’ refers to individual plant species, while ‘mangal’ refers to a plant community and habitat where mangrove vegetation thrives (Chapman 1976, Grindrod 1988, Islam and Tooley 1999, Rashid 2014).

¹⁸ Retrieved February 27, 2016

https://en.wikipedia.org/wiki/Sundarbans#/media/File:%E0%A6%B8%E0%A7%81%E0%A6%A8%E0%A7%8D%E0%A6%A6%E0%A6%B0%E0%A6%AC%E0%A6%A8%E0%A7%87%E0%A6%B0_%E0%A6%AE%E0%A6%BE%E0%A6%A8%E0%A6%9A%E0%A6%BF%E0%A6%A4%E0%A7%8D%E0%A6%B0.svg

ecosystem services¹⁹ – regulating, provisioning, cultural, and supporting – as defined by the 2005 Millennium Ecosystem Assessment (UNEP-WCMC 2006). Traditionally, local people use this ecosystem profoundly for extracting food, timber, fuel, and medicine (Rainey 1891, Jalil 2014). In addition to 334 species of trees and herbs, the Sundarbans is the home of a large number of mammals (49 species), birds (315 species), fish and shellfish (204 species), reptiles (53 species), and amphibians (8 species) (World Bank 2000:20). On an average, 1 ha of healthy mangrove ecosystem can directly produce an annual yield of 25 kg shrimp, 100 kg fish, 15 kg crabmeat, 200 kg mollusc, and 40 kg sea cucumber and an indirect support for 400 kg of fish and 75 kg of shrimp maturing in off-shore areas (Khan 2011, Salik et al 2015). The Sundarbans is an essential breeding site and nursery ground for 24 species of shrimp including brackish water shrimp (*bagda*) and freshwater prawn (*golda*). About 1,500 million *bagda* fries are collected every year from the Sundarbans. Here people are employed in woodcutting, honey and wax collection, shrimp fry catching, shell collection, timber trading and so on. Wood and other resources collected from this forest serve as raw materials in numerous industries and factories throughout the surrounding areas. This forest ecosystem provides livelihood opportunities for at least 0.6 million people in Bangladesh (World Bank 2000:20).

The Sundarbans, a UNESCO World Heritage Site, is threatened by the new climate regime. According to a reasonable projection, 10-15% of mangrove forests may be lost globally due to climate shifts by 2100 (Alongi 2008:10). For

¹⁹*Regulating* services include Coastline protection from natural hazards, soil and beach erosion regulation, land stabilization, climate regulation e.g. carbon sequestration, and water quality maintenance; *provisioning* services are subsistence and commercial fisheries aquaculture, medicinal products, building materials, fuel wood, and ornaments e.g. jewellery, decoration; *cultural* services include tourism, recreation, spiritual i.e. sacred and heritage sites, and aesthetic appreciation; and *supporting* services include nutrient recycling, nursery habitats, and biodiversity (Crooks et al 2011, UNEP-WCMC 2006).

the Sundarbans, the scenario is bleaker – 96% decline in tiger habitat in the Sundarbans is predicted with a 28 cm SLR (Loucks et al 2010), and if the sea level rises by 1 metre by the end of the century, the whole forest may disappear. Environmental and climate change factors that may affect the Sundarbans, as other mangrove ecosystems, include deltaic subsidence (the delta is slowly sinking), salinity ingress, ocean circulation patterns, sea-level rise, intensity of cyclones as well as human responses to climate change (Gilman et al 2008, Wodon 2015).

5.3 Climate change in Bangladesh

The climate system of Bangladesh is characterized by wide seasonal variations in rainfall, moderately warm temperatures and high humidity, manifesting the nature of tropical (World Bank 2000) or sub-tropical (Rashid 1991) climate. Its weather is influenced by monsoon²⁰, pre-monsoon and post-monsoon circulations (Huq and Asaduzzaman 1999). The south-west monsoon, originating over the Indian Ocean, brings moist, warm and unstable air which causes significant amount of rainfall in the country. The monsoon generally reaches the country in early June and withdraws from the country in early October. From a meteorological point of view, four distinct seasons can be identified in Bangladesh. Table 5.1 summarizes the climate variations among the seasons.

Mean annual temperature is about 25⁰C with a range between 18⁰C in winter and 30⁰C in the pre-monsoon (Brammer 2002, Islam and Neelim 2010:2). Mean maximum temperature ranges between 30.4⁰C in the southeastern Chittagong coast and 36⁰C in northwestern Rajshahi. Mean annual rainfall is

²⁰ Monsoon is a seasonal shift in the prevailing wind direction which causes a change in the weather.

about 2,300 mm (Ahmed 2006:10) varying temporally and spatially – lowest (1250 – 1500 mm) in the extreme west and highest (> 5000 mm) in east and northeast (Ahmed 2006, Islam and Neelim 2010). About 80% of the total annual rainfall occurs in the months from June to September. January, on the other hand, is the driest month of the year.

Table 5.1: Seasons in Bangladesh

Season	Months	Weather characteristics
Pre-monsoon	March – May	High temperature, high evaporation rates, mean temperature inclination is oriented in south-west to northeast direction with the warmer zone in the south-west.
Monsoon	June – September	Hot and humid, intense torrential rainfall (four-fifths of the mean annual rainfall occurs), temperature gradient orients from west to east direction with the warmer part in the west.
Post-monsoon	October – November	Hot and humid with gradual decrease in nighttime minimum temperature and rainfall.
Dry/winter	December – February	Coolest, driest, sunniest. A south to north thermal gradient with the warmer zone in the south.

Source: Ahmed (2006), Islam and Neelim (2010)

However, the above-mentioned general weather and climate trends are notably impacted by the recent global climate shifts. Bangladesh has almost zero contribution to the global warming with a per capita GHG emission of 0.37 metric tonnes (mt)/year (ranking 174 out of 214 countries), comparing to that of USA 17.5 mt/person/year and 26-53 mt/person/year in oil-rich Middle East countries (Rashid and Paul 2014:7). In 2008, for instance, Bangladesh contributed only 0.14% of global CO₂ emission (Ahsan et al. 2011:122, Rashid and Paul 2014:7). Although Bangladesh plays a very little role in global GHG emissions, it is one of the few countries of the world that have already started experiencing the brunt of climate-induced disasters. The fact that Bangladesh was afflicted by at least 174

natural disasters between 1974 and 2003 (Reid 2014:126) corroborates the above claim.

The vulnerability context of Bangladesh and its people, like in other countries, emanates from multiple components including exposure factors, sensitivity factors, biophysical factors, and socio-economic factors. The vulnerability of a person or group can be viewed as their characteristics or situations, which manipulate their capacity to anticipate, cope with, resist and recover from infrequent disturbances like sudden shocks as well as chronic disturbance events like climate change. Because of the country's unique geographic location and hydro-geological characteristics, the future of Bangladesh is now unfortunately "trapped between the melting Himalayas in the north and the encroaching Bay of Bengal to the south" (Rahman, Noor and Ahmed 2009:13). Bangladesh is surrounded by mountains and hills on three sides – Rajmahal hills in the west, the Himalayas and the Meghalaya Plateau in the north and Tripura-Chittagong hills in the east – a fact that makes the country a discharging route for the huge amount of rainfall-runoff and snowmelt water from the Himalayas (Rahman and Salehin 2013). Bangladesh lies in the lower part of the GBM (Ganges-Brahmaputra-Meghna) basin. The total drainage area of the GBM basin is about 1.55 million km², only 9% of which is within Bangladesh (Rashid and Paul 2014:13). Riverine floods in Bangladesh are primarily caused by excessive rainfall in the upper catchment areas of the GBM basin in India, Nepal, Bhutan and the Tibetan region of China. The GBM rivers have a combined peak discharge of 180,000 m³/sec during the flood season, second in the world after the Amazon (Rawlani and Sovacool 2011:848). 91% of the total annual water flow of Bangladesh enters from upper riparian countries through 57 international rivers.

The above factors make the country susceptible to annual flooding on a regular basis. The topography of the country is low and flat with 80% of its landmass covered by floodplains (Rahman and Salehin 2013:69). About 10% of the country is within a 1 metre height range from mean sea level (MSL), one-third is under tidal excursions, and two-thirds of its critical infrastructure is less than 5 m above MSL (Climate Change Cell 2007, Rawlani and Sovacool 2011), making the country vulnerable to inundation by riverine floods, storm surges, and sea-level rise (SLR). The country faces two major hydrological hazards, floods in the wet season and droughts in the dry season, because of highly skewed temporal variation of precipitation. About 80% of the annual rainfall occurs during the monsoon season, while in the winter, the country becomes rainless for months. Moreover, the coastal make-up of Bangladesh, with an inverted-funnel shaped GBM estuary, amplifies cyclone storm surges when they approach the coast (Rashid and Paul 2014).

In addition to above geo-morphological and physical features, the climate sensitivity of Bangladesh is also determined by a number of socio-economic factors that affect the resilience of the people of Bangladesh to climate hazards. Bangladesh is an extremely populated country with a total population of over 168 million (July 2015 estimate) – ranking 9th in the world (CIA 2015) and with a density of 1,132 people/km². Bangladesh is also a poor country with a significant portion of its population living under poverty line. The Bangladesh Bureau of Statistics (BBS) defines poverty in terms of daily calorie intake – a person is defined as poor if (s)he takes food of less than 2122 calorie a day, while an ultra-poor is someone who can take less than 1805 calorie a day. In 2014, 25.6% and 12.4% of the population of Bangladesh were poor and ultra-poor respectively

(Prothom Alo 2014). Many of the extremely poor have no employment or income and suffer from continuous food insecurity, malnutrition and social vulnerability, being deprived from access to civic amenities like health and sanitation services, safe drinking water and education for their children. With a per capita income of only USD 1,314 (bdnews24.com 2015) and with 49.4% of the total population in multidimensional poverty²¹ (UNDP 2015:61), a substantial section of people, especially among the coastal and slum-dwellers, are forced to live in fragile ecosystems in hazard-prone areas, which makes them even more vulnerable and less resilient to climate change and other disasters. At community level, social vulnerability depends on several factors including location and pattern of settlement, land management systems, means of livelihood (e.g. dependence on weather-sensitive sectors like agriculture and fisheries), and pattern and sufficiency of infrastructure, among others. Low economic strength, insufficient infrastructure, low level of social development, lack of institutional capability, and higher dependency on the natural resources make the people of Bangladesh increasingly vulnerable to geo-hazards, particular forms of human-nature interaction leading to mankind's settlement in endangered regions despite potential threat (Islam, Shaw and Mallick 2013, Neverla, Luthje and Mahmud 2012).

Global climate changes and impacts can be understood in terms of basic contributor and primary and secondary impacts. Global warming, increase in global average surface temperature²² due to greenhouse gas emissions, is the *basic*

²¹*Multidimensional poverty* is a broader concept of poverty, comparing to the classical concept of poverty line. It is calculated as a weighted average of 10 socio-economic indicators. A person is considered to be in multidimensional poverty if she or he is deprived in at least a third of these indicators, with each indicator having a defined deprivation level (UNDP 2015).

²²In climatology, the term '*surface temperature*' refers to the temperature of the air 2 m (=6.6 feet) above the ground (Hay 2013:298)

contributor to subsequent climate change. *Primary impacts* are the increases in precipitation and sea level because global warming directly influences these two. Similarly, *secondary impacts* include changes in frequency and intensity of cyclones, hurricanes, floods, storm surges, coastal erosions (a geological process) and other hydro-meteorological adversities. The secondary impacts are not the direct effects of the basic contributor (global warming), but are the derivatives of global warming induced atmospheric and hydrologic cycles and disturbances (Rashid and Paul 2014). In Bangladesh, where ‘absolute certainty’ (Billet 2010, Neverla et al 2012) is the dominant frame for conceptualizing climate change through the process of domestication of global threats, there is a consensus among the ‘triple interface’ (Boykoff 2010) of science, policy makers and the public that the country has already started experiencing the negative consequences of climate change through primary and secondary impacts. The following paragraphs outline the ‘emerging signatures of climate change’ (Serreze and Barry 2010) in Bangladesh.

5.3.1 Temperature

All other climate parameters are more or less determined by atmospheric temperature. Thus, any change in the historical trends of air temperature can trigger climate change as a whole. Meteorological data indicate an increasing trend in the annual and monthly average maximum and minimum temperature for the entire Bangladesh in general. Climate data from 1971 to 2002 show an annual increase in average monsoon maximum and minimum temperature by 0.05°C and 0.03°C respectively (Planning Commission and UNDP 2009:26), data from 1967-2007 period shows an increasing trend in mean seasonal temperature with a

temporal variation within a range of 0.4⁰C - 0.65⁰C (IUCN Bangladesh 2011:18), and similarly, data from 1976-2005 period show that among 34 meteorological stations, 27 recorded an increasing trend in annual average temperature (Basak et al 2009:93). The above pattern of increase in annual atmospheric temperature matches with global and Asian trends. The IPCC declares that it is *very likely* that 1983-2002 was the warmest 30-year period globally in the last 800 years (IPCC 2015:40). IPCC also found that in Asia warm days and nights have increased, while cold days and nights have decreased since 1950 (IPCC 2014). Similarly, 1976-2005 meteorological data indicate an increase in 'hot days' (daily temperature > 29.3⁰C) and decrease in 'cold days' (daily temperature < 20.1⁰C) (Basak et al 2009).

Based on the results of various studies, including General Circulation Models (GCMs) and Providing Regional Climates for Impact Studies (PRECIS), the National Adaptation Programme of Action (NAPA) projected a 1.0, 1.4, and 2.4⁰C temperature rise for Bangladesh in 2030, 2050 and 2100 respectively (Karim and Mimura 2008, MoEF 2009b).

5.3.2 Rainfall

With about 80% of the population of Bangladesh directly or indirectly dependent on agriculture (Banglapedia 2003), rainfall is the single weather parameter that affects livelihoods of Bangladeshi people most. Precipitation data from 32 weather stations across Bangladesh during 1960-2001 period reveals that the mean annual rainfall in the country in this period was 2,447 mm, with the minimum of 1,450 mm in the mid-west (Rajshahi) region and the maximum of 4,050 mm in the north-east region (Sylhet) (World Bank Group 2010:7). The south-western coastal

region enjoys an average annual rainfall of 3,380 mm (Planning Commission and UNDP 2009:26). Due to orographic (mountain) effect, the precipitation gradient generally orients from east to west, the eastern zone having the most rainfall. Being situated directly in the path of moisture-laden south-westerly monsoon from the Bay of Bengal, Bangladesh is one of the wettest countries in the world in terms of monsoon rainfall. About 75-80% of annual rainfall occurs in the monsoon season (Islam and Neelim 2010), so any change in the monsoon system may lead to regional climate change. Excessive monsoon rainfall is responsible for much of the flood problems in Bangladesh (Rashid and Paul 2014). Shahid (2010) reported that the trend analysis of rainfall data of fifty years during 1958-2007 indicates an increase of average yearly rainfall at a rate of 5.52 mm/year. Increased sea surface temperature in the Bay of Bengal might have led to increased average rainfall in the west and south-western part of Bangladesh over the same period. The historical data also shows that precipitation is increasing in monsoon and pre-monsoon seasons, but decreasing in the winter, which is a marker of climate change extremes leading to occurrence of flood in one part of the year and drought in the other. One significant shift in precipitation pattern in Bangladesh is the increase in the number of short spells of intense rainfall and lacking equal distribution throughout the season. This erratic nature of rainfall mostly affects weather-sensitive livelihood systems including agriculture and fisheries.

The IPCC predicts that, in a warmer world in all RCPs²³, it is likely that total area covered by monsoons will increase as well as mean and extreme monsoon rainfall will intensify (IPCC 2014). The Bangladesh case, as it is in the

²³ Representative Concentration Pathways (RCPs) are a new comprehensive climate projection tool devised by the IPCC for the AR5 research. RCPs replace the previous method of SRES (Special Report on Emissions Scenarios).

Indian summer monsoon belt, is already showing consistency with the IPCC report. There is a direct correlation between global warming and increase in precipitation, because every 1⁰C increase in air temperature may lead up to 7% increase in the water-holding capacity of air (Ahmed and Diana 2015a, Trenberth 2008). According to a GCM projection, monsoon rainfall in Bangladesh would increase by 12% and 27% in the years 2030 and 2075, respectively (Nishat et al 2009:2). Precipitation in the winter, on the other hand will gradually decrease.

5.3.3 Flood

Being a disaster-prone country, Bangladesh suffered from 93 sudden climate-induced extreme events between 1991 and 2000, including floods, cyclones, tornados and droughts, resulting in about 200,000 death tolls and causing USD 5.9 billion in damages mostly in agriculture and infrastructure (Planning Commission and UNDP 2009). Since almost 80% of the total landmass of Bangladesh is floodplains (BBS 2010), flood is an inveterate natural disaster in Bangladesh. With only about 7-9% of the GBM catchment area, Bangladesh receives 90-93% water discharged through these river systems (Rashid and Paul 2014, Siddiqui and Billah 2014, World Bank 2000), which causes regular flood events in the country.

Every year seasonal flooding during the monsoon occurs in 20-33% of the total area (Rahman and Salehin 2013), which is viewed as *normal* by floodplain residents. Even in drought years, 10% of the country is flooded (Ahmed and Diana 2015a). Rashid and Paul distinguished between normal and abnormal flood regimes in terms of their impact on two critical elements: the elevation of dwelling structures and the depth of flood water in rice fields (2014). *Normal flood*, generally called *barsha* in Bangla, refers to relatively shallow floods that do

not inundate the common yard of a homestead, and that do not hamper the life cycle of dominant rice varieties, namely *aman* and *aus*. Farmers and farmed crops are well adapted to variations in the depth and duration of these beneficial annual phenomena. But any deviation from the annual normal flood scenario is viewed as *abnormal flood*, often called *bonna* in Bangla, which affects both of the above critical elements. Floods in Bangladesh can be classified into five major categories: flash flood, monsoon flood, river flood, tidal flood, and storm-surge flood (see Table 5.2).

Table 5.2: Major types of flood in Bangladesh

Type	Cause	Time	Tentative affected area
Flash flood	Run-off during heavy rainfall in neighbouring upland areas	Pre-monsoon	The foot of northern and north-eastern hills
Monsoon flood	Heavy rainfall occurring in the floodplains	April-August	South, south-western and central parts
River flood	Snowmelt in high Himalayas. Heavy monsoon rainfalls over the Himalayas, the Assam Hills, the Tripura Hills and the upper GBM floodplains	April-September	Catchment areas of the GBM Basin
Tidal flood	Astronomical tides from the Bay of Bengal	Throughout the year	The Ganges-Brahmaputra-Meghna estuary
Storm-surge flood	Storm surge water with occasional cyclones	April-June, September-November	Coastal area

Source: Ahmed (2006), BBS (2010), Dewan (2013), Hofer and Messerli (2006), Mirza (2002), Planning Commission and UNDP (2009), Rahman and Salehin (2013), Rawlani and Sovacool (2011)

Bangladesh was struck by 48 small, medium and big floods between 1954 and 2007, seven were severe among those, each covering more than 30% of the total area of the country (Planning Commission and UNDP 2009). Historical trend of the occurrence of floods in Bangladesh reveals that the frequency and intensity

of flood events are on the rise. The official chronological account of ‘big floods’ in Bangladesh since 1781 shows that out of 27 major floods in the 19th and 20th centuries, 12 occurred in the 19th and the remaining 15 in the 20th (Rashid and Paul 2014), which implies a 25% increase over a period of 100 years. While in general prediction a flood with covering 37% of land has a 10-year return period, the empirical data show that floods of this magnitude occurred 5 and 3 times in the last 30 and 15 years, respectively. Thus, it is quite evident that the frequency and severity of floods in Bangladesh increased significantly in the last decades. Table 5.3 summarizes impact of recent major floods in Bangladesh.

Table 5.3: Impact of major floods in Bangladesh 1984-2007

Year	Area inundated (km²)	Damage (million USD)	Affected population (million)	Deaths of people (number)
1984	28,314	378	20	553
1987	57,491	1,000	30	1,657
1988	89,970	1,200	47	2,379
1998	100,000	2,800	55	1,050
2004	60,000	6,600	36	750
2007	62,300	1,100		1,100
Total		13,078		7,489

Source: BBS (2010), Rawlani and Sovacool (2011)

Under climate change scenario with increased rainfall and drainage congestion, 18% of current lowly flooded areas will be vulnerable to higher level of flooding by the middle of the century. Moreover, 12-16% of new land will be susceptible to inundation due to floods (Ahmed 2006, BBS 2010).

5.3.4 Cyclone

Tropical cyclones, known to be the deadliest of all natural calamities, are intense vortices associated with lower surface pressure, strong winds exceeding 16 m/s,

torrential rains, and storm surge (Rao and Srinivas 2010). The coastal districts in Bangladesh are badly exposed to violent cyclones and storm surges that are originated in the Indian Ocean and track through the Bay of Bengal (BoB). The Indian Ocean and the Bay of Bengal is a basin, which serves as the breeding ground of strong tropical cyclones. Each year Up to 16 tropical storms and cyclones are formed in the Bay of Bengal and the Andaman Sea in two periods: April-May (pre-monsoon) and October-November (post-monsoon), a few of them crossing the eastern Indian, western Myanmar and Bangladesh coast (Alam and Collins 2010, Alexander 1993, Chowdhury et al 2012, Rashid and Paul 2014). Some of them turn ‘super cyclones’, category 4 or 5 on the Saffir-Simpson Hurricane Wind Scale²⁴, and batter the entire region where they make landfall.

The earliest recorded cyclone in the region of Bangladesh dates back to the late sixteenth century. Few historical sources including famous Ain-i-Akbari state a severe cyclonic storm that hit the Backerganj coast resulting in death toll of 200,000 people (SMRC 1998). Though it is clear that population density was far below than that of today, the casualty was by far extremely devastating. After that partial records of 27 more cyclones can be found till the end of the 19th century, which suggest an aggregate death toll of 352,000 (SMRC 1998). Among those, the Great Backerganj cyclone²⁵ of 1876 alone caused 200,000 deaths, 100,000 from drowning and the remaining from consequent famine (Mallick and Rahman 2013, SMRC 1998).

Twenty-six major cyclones hit the coast of Bangladesh since 1970, which affected at least 19 million people (Siddiqui and Billah 2014: 122). In the recent

²⁴ The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 categorization based on the hurricane's intensity at a given time. In terms of sustained wind speed, the categories are as follows. Category 1: 119-153 km/h, category 2: 154-177 km/h, category 3: 178-208 km/h, category 4: 209-251 and category 5: 252 km/h or higher.

²⁵ This cyclone was associated with the highest reported surge height of 13.6 meter (SMRC 2000).

past, four major cyclones in 1970 (Bhola), 1991 (Gorky), 2007 (Sidr) and 2009 (Aila) caused enormous mayhem in the country (see Table 5.4). Since 1970, though the number of cyclones formed in the Bay of Bengal has declined the intensity of the cyclones hitting Bangladesh and India coasts are increasing. The reason behind the increased strength is that the sea-surface temperature (SST) of the Indian Ocean is rising, causing increased moisture in the atmosphere, which, in turn, raises the strength of storms (IPCC 2007b, Reid 2014). It is predicted that cyclone intensity may increase by 10% due to future global warming (Ali 1999, Asaduzzaman et al 2011).

Table 5.4: Selected major cyclones that hit the Bangladesh coast 1970-2009

Landfall date	Location of landfall	Max wind speed (km/h)	Max surge height (m)	Death toll
12 Nov 1970	Chittagong	222	10.6	300000
25 May 1985	Chittagong	154	4.3	11069
29 Nov 1988	Khulna	160	4.4	1498
29 Apr 1991	Chittagong	225	6.1	138882
02 May 1994	Cox's Bazar	215	3.3	188
19 May 1997	Chittagong, Feni	225	4.6	126
26 Sep 1997	Chittagong	150	3.0	155
16 May 1998	Chittagong, Cox's Bazar	165	2.5	12
15 Nov 2007	Barguna, Patuakhali	250	9.1	3500
25 May 2009	Satkhira, Khulna	120	6.5	339
Total death toll				455769

Source: Ali (1999), Karim and Mimura (2008), MoFDM (2008), Rashid and Paul (2014), SMRC (1998), UN (2010)

Among the three destructive elements accompanied by cyclones (namely, heavy and prolonged rain, storm surge, and strong winds), storm surges are the most devastating. In probabilistic terms, Bangladesh is vulnerable to one major cyclone every year (Haque 1997, Karim and Mimura 2008), in every three years a severe cyclone hits the country on average (MoEF 2009a), and in every seven years one storm surge of 7 m height strikes the coast (Ahmed and Diana 2015a,

Dasgupta et al 2011). Cyclones and associated storm surges cause devastating damage to houses, livestock and human health - every year, on average, 6,000 people die from floods and storm surges in the country (Schiermeier 2014). The highest value of the height of any storm surge in Bangladesh was recorded as high as 13 m (Karim and Mimura 2008, SMRC 1998). The western coastal zone is deeply prone to storm surge inundation due to its low-elevation and poor defences against surge waves.

Between 1891 and 2007 a total of 26 severe cyclonic storms crossed the Bangladesh coast, among which 19 occurred in the last 48 years starting in 1960, whereas only 7 occurred in the previous 59 years (Tyagi et al 2010a:328). This fact indicates that though the total number of storms formed in the Bay of Bengal might have decreased but the frequency of actual intense cyclones that hit Bangladesh coast has increased. There is a projection that SST in the Bay of Bengal will increase by 0.35 - 0.72⁰C during daytime and by 0.5 - 0.8⁰C at night by the year 2050 (Ahmed and Diana 2015a, Chowdhury et al 2012). The increased level of SST would be associated with increased moisture in air that could make cyclones more strong at that time. Thus, it is predicted that the intensity of tropical cyclones may increase by 5-10% that will lead to increased storm surges and coastal flooding (Ishtiaq Uddin Ahmed 2011). The very severe cyclonic storm 'Nargis' that hit mainly the southwest coast of Myanmar in 2008 maintained its intensity of very severe cyclonic storm for about 12 hour after the landfall (Tyagi et al 2010b:315), similarly, cyclone Aila maintained cyclonic intensity up to 15 hours after landfall (UN 2010). It is an indication that, in future, cyclones may penetrate further inland affecting more people. Currently 8.3 million people live in

high-risk areas, which may rise to 20 million in 2050 under climate change regime (Ishtiaq Uddin Ahmed 2011:75).

5.3.5 Sea level rise

Coastal Bangladesh is particularly vulnerable to climate change induced sea-level rise. Bangladesh is a flat alluvial delta sloping gently from the north to the south at about 12 inch/mile to the latitude of Dhaka, and from there to the Bay of Bengal at about 6 inch/mile (Bowles 1965:57). It is a low-lying country with 62% of its coastal area having an elevation of less than 3 metres above sea level and 86% an elevation of less than 5 metres (Nishat and Mukherjee 2013:46). The above figures are significant since one-third of the country's total landmass is in the coastal zone (Islam 2004, Rashid 2014). Besides coastal areas, the most of inland Bangladesh is also low-lying – having an elevation only up to 10 metres above sea level (Nishat and Mukherjee 2013:46). Though the area that is termed as low elevation coastal zone (LECZ), a region within 10 m above MSL, is only 2% of total landmass globally (Oliver-Smith 2009), about one-third (54,461 km²) of Bangladesh falls under this zone (Mondal and Rajan 2009). The 10 m contour goes as far inland as the capital, Dhaka, which is located 60 miles inland (Rashid and Paul 2014). The above geological factors make coastal Bangladesh extremely vulnerable to sea-level rise and cyclonic storm surges from the Bay of Bengal.

By convention, mean sea level (MSL) is defined as “the average height of the surface of the sea at a particular location for all stages of the tide over a 19 year period” (Hay 2013:771), which is determined from hourly height readings from a tide gauge. Any fluctuation from the MSL is the relative sea-level change of that particular place. Melting of ice on land due to global warming is one of the

causes of sea-level rise (SLR). If all the ice on Greenland and Antarctica were melted down, the global average SLR would be 90.7 metres from current global MSL (Hay 2013). Thus, the phenomenon of global warming due to anthropogenic GHG emissions is of utmost concern for humanity.

Tide gauge data from different stations indicate that the sea-level has been rising in the coastal region of Bangladesh since the mid-twentieth century. A Bangladesh Inland Water Transport Authority (BIWTA) study concludes that between 1998 and 2007, sea-level in three stations such as Hiron Point (west coast), Charchanga (central coast), and Cox's Bazar (east coast) increased at a rate of 4.32, 2.34 and 3.49 mm/year respectively (Rashid 2014:75). In Mongla station, one of the fields of this study, SLR was recorded 4.65 mm/year in the period 1944-1964 (Rashid 2014). It is noteworthy that any analysis of SLR data on the Bangladeshi coast should incorporate the dynamic morphological nature and formation process of the coast. This dynamic delta is still developing through sedimentation in the Meghna estuary. A host of literature caters to different set of rates of sediment accumulation along the GBM river systems, ranging from 0.5 billion to 2.4 billion tons every year (Ahmed 2006, BBS 2010, Holeman 1968, Islam, Huq and Ali 1999, Khan and Rahman 2011, Rashid and Paul 2014, UNESCAP 1987). Since sediment accumulation is 5-6 mm/year and gross SLR is 7 mm/year, the net relative SLR in the estuary is 1-2 mm/year (Planning Commission and UNDP 2009). Considering the future emissions scenario, IPCC projected 14, 32, and 88 cm SLR at the Bangladesh coast, on average, for 2030, 2050, and 2100 respectively (Rashid 2014). Any range of SLR above 30 cm could have extreme consequences on Bangladeshi land, people, and livelihoods.

5.3.6 Salinity ingress

Salinity intrusion in water and soil is a major concern for the coastal ecosystem of Bangladesh, especially in the south-western zone. There are several reasons behind salinity ingress in the coastal areas that include regular intrusion of tidal saline water during high tide in unprotected regions, withdrawal of fresh water from upstream especially in the Indian Territory for common rivers, irregular rainfall, faulty management of sluice gates of polders, and capillary rise of soluble salts. Currently about 1.05 million ha of land in the coastal districts are affected by soil salinity. A study reveals that during 1973-2009 about 0.223 million ha were newly affected by soil salinity (MoA and FAO 2013:40). During the 1960s, earthen embankments were made along the banks of major rivers under the Coastal Embankment Project in the then East Pakistan in order to protect the reclaimed land from saline tidal surges and to enhance agricultural production in the area (Haq and Burns 1967, Schmidt 1969). These reclaimed and engineered landmasses are called polders. The Bangladesh Water Development Board constructed 139 polders in southern Bangladesh (MoA and FAO 2013:29). Now, after few decades, those polders are gripped with ‘second generation problems’ among which is that a number of polders become permanently waterlogged with saline water. If a large amount of saline water enters the polders overtopping the embankments, occasionally during cyclones and storm surges, the polders become waterlogged since the drainage system of most of the polders does not work now due to various reasons. This is one of the hot environmental issues in the polder ecosystems.

Climate change may enhance salinity ingress in various ways: “(a) directly pushing the saline/fresh waterfront in the rivers through higher sea levels; (b)

lower river flows from upstream, increasing the pushing effect from the sea; (c) upward pressure on the saline/fresh water interface in the groundwater aquifers (every cm of sea level rise will result in a thirty-fold rise of the interface because of the hydrostatic pressure balance); (d) percolation from the increased saline surface waters into the ground water systems; (e) increasing evaporation rate in winter, leading to enhanced capillary action and subsequent salinization of coastal soils; and (f) increasing storm surges which carry sea water” (World Bank 2000:22-23). Saline water from the Bay of Bengal is already entering 100 km upstream through estuaries and rivers (Allison et al 2003). In a warmer world under new climate regime, SLR induced salinity intrusion may affect 2 million ha of land in the coastal Bangladesh by 2050 (Ahmed and Diana 2015a). An SLR of 32 cm may intrude 10-20 ppt salinity level more in the Sundarbans (Nishat and Mukherjee 2013), which can adversely affect the entire mangrove ecosystem.

5.3.7 Drought

Drought is a recurrent phenomenon in north-west Bangladesh. Many factors are responsible for this agricultural adverse condition. They include higher temperature, seasonal shortage of rainfall, and reduced flow of river water because of diversion of water upstream. On average, drought occurs in Bangladesh once in 2.5 years (Habiba, Shaw and Abedin 2013), and major drought once in 5 years (Planning Commission and UNDP 2009). Due to drought condition, crop production was reduced by 25-30% in 2006 in northwestern region (Rahman et al 2007). At present, a severe drought can hamper crop production in 30% area of the country, causing a reduction of total national production by 10% (Planning Commission and UNDP 2009). In future climate change regime, due to rise in air

temperature and decrease in winter rainfall, it is predictable that moisture content of topsoil might fall significantly leading to acute moisture stress and droughts in the pre-monsoon season, especially in drought-prone areas.

5.4 Conclusion

Bangladesh is a country where almost every climate change variabilities and extremes are visible, a fact that has turned it as a ‘climate hotspot’ in the world. Similarly, coastal Bangladesh, where the empirical part of this study was conducted, is one of the most vulnerable regions within the country. Though coastal Bangladesh is rich with natural resources, it has become a fragile ecosystem on the verge of a new climate regime. Just like other sectors, aquaculture in the coastal region is profoundly affected by climate change related disturbances. In the next chapter, we will look into this issue in detail.

CHAPTER SIX

IMPACT OF CLIMATE CHANGE ON SHRIMP AQUACULTURE IN BANGLADESH

6.1 Introduction

The expansion of shrimp industry in developing countries like Bangladesh is hailed by many as ‘blue revolution’ (Islam 2014) or ‘pink revolution’ (Delap and Lugg 1999) because of its enormous potentiality to earn desperately needed foreign currency for the host countries. In Bangladesh, though horizontal expansion of shrimp cultivation and total amount of production has increased over the years, shrimp yield per unit of land has shown very little or no improvement. Table 6.1 demonstrates that comparing to other countries in the region, per unit shrimp production in Bangladesh is very low.

Table 6.1 Shrimp production comparison among selected countries

Country (1999)	Shrimp yield (kg/hectare/year)
Taiwan	4,000
Australia	4,000
Thailand	2,500
Malaysia	1,500
Bangladesh (2009)	633

Source: Aftabuzzaman (2010), Ronnback (2001)

The productivity level could be increased through improved technologies, better scientific management, and more investments. The productivity and sustainability of this vital coastal livelihood depend on technological and physical-environmental inputs and conditions as well as on the social organizations surrounding it. Though commercial shrimping in Bangladesh provides a wide range of economic benefits, its location at the critical juncture of human and

nature makes it vulnerable. The nature of the livelihood vulnerability in the coastal shrimp regime lies at the critical intersections between the physical arrangements of the *gher* structure, the biology of shrimp genesis, the prevailing agrarian social structure, and the community level endeavours.

As discussed in a previous chapter, vulnerability of a person, community, or system depends on three principal components: sensitivity, exposure, and capacity of response. In the case of the shrimp-farming community in Bangladesh, the above factors define the vulnerability context with regard to sudden climate hazards as well as gradual climate change. Commercial shrimp-based community in Bangladesh is not a monolithic entity or identity: at least ten different stakeholder groups are there in the local supply chain, starting from petty shrimp fry collectors to giant shrimp processing plant owners and exporters. Environmental hazards and stresses do not affect each of those groups equally. Climate fluctuations and disturbances affect primarily the bottom layer of the supply chain, i.e. at farming and production level, not at the subsequent phases of trading, processing, or exporting.

The stakeholders who live in the exposed coastal zones are more prone to climate disruptions. Shrimp fry collectors, shrimp farmers, fry traders, and local small-scale shrimp traders constitute the vulnerable cluster in terms of exposure to climate perturbations. On the other hand, shrimp exporters, processing plant owners, and rich shrimp merchants operate their businesses in Khulna, or Satkhira district headquarters – quite far away from the immediate exposed regions. In addition, they are equipped with economic power to tackle any problem and recover quickly. They do not fall under negatively sensitive group, i.e. they are not affected normally. These shrimp elites do not even bother about climate

disruptions. Among the groups who are at risk, local small-scale shrimp farmers are the most vulnerable segment. The reasons behind this are first, they live and operate their businesses in the highly exposed zone; and second, they are the major group having money invested in weather and climate-sensitive sector all the year round. If we compare this dimension of risk among the exposed stakeholders, we find that shrimp fry collectors, fry traders or shrimp traders can avoid big losses during a sudden disaster like cyclone, storm surge, or riverbank erosion. They just need to withhold their business for the time being and start operating after a few days – they have little risk of losing their capital. However, when a sudden disaster occurs, small-scale shrimp farmers generally lose their whole amount of money invested in *ghers*. Thus, shrimp farmers are susceptible to direct or primary impact of climate chaos, while the others face the indirect or secondary consequences. Besides, the rich shrimp *gher* owners from outside generally have, thanks to their wealth-base, higher level of capacity of response to a given shock. The rich shrimp *gher* owners, unlike the local small-scale farmers, are not physically exposed to natural calamities since they live in protected regions (towns). So these non-residential big farm owners are not affected doubly, as their counterparts in the shrimp farming zone do. Considering the above issues, the following analysis will focus mainly on the most vulnerable group of small-scale shrimp farmers.

Within this context, based on information from field-level investigation in shrimp communities in Bangladesh, this chapter focuses on a particular aspect of nature-human relationship – how emerging environmental and climate crises affect the shrimp-farming community, especially the local-level small-scale farmers.

6.2 The Challenges

Shrimp farmers and fry collectors expressed their concern about a number challenges and barriers that hinder the sustainability of the sector. They identified the following major problems.

6.2.1 Disease outbreaks in shrimp

Frequent incidences of an unknown viral infection in shrimp are a major concern for the farmers. Until today, there are no effective control measures against this infection. Other than the viral infections, because of the shallowness of the *ghers* and dependence on nature for shrimp feed, sometimes disease outbreaks occur. Moreover, during the start of the rainy season, when rainwater is added into the *ghers*, shrimps die en masse.

6.2.2 Scarcity of disease-free post-larvae (PL)

Shrimp farmers generally depend on hatchery PL for stocking. Though wild shrimp fry catch from open water is prohibited in Bangladesh and though Bangladesh produces shrimp fry more than the demand, producing over 10350 million of shrimp hatchlings in 2013 by 61 *bagda* and 70 *golda* hatcheries (BFFEA 2014), shrimp farmers still yearn to use wild fry in their *ghers* because of their better survival rate. But the farmers are compelled to buy the hatched PL because of several factors. First, nursery (hatched) PL is sufficiently available but wild PL is becoming scarce. Second, farmers get nursery PL at lower costs, 300-500 BDT/1000 PL, comparing to wild PL, 800-1200 BDT/1000 PL. Third, hatchery fry become matured for harvesting within 2-2.5 months, while wild fry

take longer time by a month (3-3.5 months). Because of the above-mentioned factors, shrimp farmers stock hatchery fry more. Nevertheless, the major concern about the hatchery fry is that its survival rate is poor and it is more prone to viral attack. There was no problem of virus or disease in shrimp before the mid-1990s when there was no shrimp hatchery in Bangladesh and shrimp was produced completely based on wild fry. Thus, the introduction of hatchery PL has brought the disease problems. Every year, shrimp in the vast majority of *ghers* (Figure 6.1 is the picture of a *gher*) in Bagerhat, Khulna and Satkhira suffers from viral problem, leading to huge loss to the cultivators. For this reason, scarcity of healthy shrimp PL is one of the major concerns for the farmers.

Figure 6.1: Partial view of a *bagda gher* in Koyra

Source: Field data

6.2.3 Lack of sufficient credit flow

A good portion of small-scale farmers suffers from credit insufficiency. The marginal farmers generally meet their own needs, but their demand of credit sharply increases because of unexpected distresses such as occurrence of disasters,

death of an earner in the family, production failure in shrimp for sudden calamities, social expenses like marriage or dowry payments etc. In rural Bangladesh, credit comes from formal and informal sources: formal sources include public and private banks and micro-finance institutions (MFIs), informal sources include non-institutional credit flows through *mohajans* and *dadandars* and borrowing from friends and relatives. According to Bangladesh Bank data, total disbursement of rural credit from institutional sources throughout Bangladesh was over BDT 279 billion in 2008-09 (MoA and FAO 2013:46). Public sector institutions disbursed 25% of the above amount, while the remaining 75% was delivered by MFIs including NGOs. The demand of credit in the country is much higher than that met by institutional set ups.

In the shrimping communities, PL collectors and marginal farmers take loans from *farias* (local-level fry and shrimp traders) and *dadandars* (local moneylenders). According to the local PL collectors, they take loan from *dadandars* at the start of fry catching season every year. Peak fry catching season in the Sundarbans is from April to June/July. The moneylenders generally are shrimp fry traders. Fry collectors take loans from them on the condition that they would sell their fry to those particular lenders at a lower rate (12-15%) from market price. Thus, fry catchers need to refund loan amounts within the season (about three months) – not by cash but in kind. Similarly, marginal *gher* farmers take loans from either fry traders or shrimp commission agents. When they take loan from fry *farias*, they have to buy shrimp PL from the *farias* at 20-30% higher rate than the market price. The farmers need to pay by cash (calculating the total price of borrowed PL) at the time of harvesting. Thus, farmers get loans in kind,

but refund that in cash. Credit suppliers unilaterally set terms and conditions of loans. This informal credit flow, therefore, is a peculiar system by nature.

The fry collectors and farmers view informal credit system as problematic because of its stringent conditionality. A borrower in this system is forced to sell his product to particular lender – making his labour ‘bonded labour’ for others at least for time being. Despite that, they resort to this system as because they do not get credit from other sources easily. For instance, if they want to take loan from bank, they have to produce various papers and to mortgage their land to the bank. In addition, generally banks take some days to sanction a loan. Moreover, sometimes the borrowers even need to pay bribe to bank officers to obtain loan. Those hassles are absent in the trad

itional *dadan* system. So in brief, both institutional and informal credit systems have drawbacks, which pose a challenge to the growth of shrimp cultivation in the region.

6.2.4 Lack of proper knowledge and training

Due to lack of adequate technical knowledge and training in advanced methods of emerging shrimp culture, framers cannot maintain the proper environment in shrimp *ghers* and consequently they do not get expected yield. Though shrimp cultivation is the mainstay livelihood in the coastal zone already for a few decades, the farmers are still quite ignorant of modern cultivation methods, pond preparation, nursery management, *gher* management at pre-, during and post-stocking stages, proper harvesting and marketing techniques and other aspects of shrimp farming. One shrimp farmer from Mongla commented, “*Shrimp has a life-cycle, we are not aware about that. From breeding to maturity, a shrimp goes*

through several stages. At every stage, it needs particular care, but we are ignorant about that. In this respect, we are still living in 'stone ages'. If there is excellent yield, we cannot explain why we got that much production; if the production is very low or if all shrimps die, we cannot explain why it happens. Our shrimp yield depends on luck – as if we are gambling.” Despite their lack of proper knowledge, the coastal inhabitants are forced to cultivate shrimp because they have no other livelihood alternatives in saline water area.

6.2.5 Illegal status of fry catching

Despite an official ban on shrimp fry collection from open waters since 2002, thousands of PL catchers still operate in the rivers and the Sundarbans. The ban was never implemented in full scale because of several reasons e.g. the demand of wild fry is high to the farmers because of its higher survival rate, a section of fry traders depend on wild fry, a section of public officials view the ban as an opportunity to collect rent, and there is no viable livelihood alternatives for the fry collectors (Frankenberger 2002). Moreover, the ban itself is irrational on the grounds that, as it is designed, it penalizes only the poorest segment in the fry supply chain, exempting the other groups of stakeholders at the phases of sale, trade, transport, storage, and stoking. Because of the ban, fry collection has never been stopped; only the suffering of the lowest strata in the shrimp supply chain has multiplied. If a shrimp fry collector from Koyra goes to the Bait Loa River in the Sundarbans (under Khulna Range), he has to cross four Forestry Department check posts. At every check post, a fry catcher has to pay approximately BDT 500-1000. In the three months of peak season, one fry catcher may be forced to pay bribe to officers from 20-25 times. One shrimp fry collector reported that in

2014 he had to pay a total of BDT 14000 as bribe to the officials. If they refuse to pay bribe, officers take away all the fishing equipments including nets, boat, drums etc. The officers make cash by selling those equipments. Before the ban in 2002, there were no such problems. Fry catchers would collect official licenses/permits to enter the jungle for collecting PL. Other than the Forestry Dept officials, police also take bribe. If forestry officials grab fishing nets from fry collectors, sometimes they handover those to the police. Fry catchers have to pay 1500 BDT/net to get those back. Moreover, police also takes regular bribe (generally 800 BDT/season/fry catcher). Another harsh reality for the fry collectors is that they cannot switch to new livelihood alternatives since there are no such alternatives in the region. Thus, the ban has only exacerbated fry catchers misery. This is why they dub the ban as the number one problem for their business.

6.2.6 Environmental and climate disruptions

Environmental and climate problems are a severe emerging threat to the shrimp farming industry in coastal Bangladesh. These problems include riverbank erosion, salinity ingress, SLR, cyclones and storm surges among others. These problems create other secondary problems for the shrimp species and the shrimp farming communities. These problems are discussed in detail in a section below.

6.3 Perception of Climate Change

Cultural and individual preconceptions shape perceptions of an issue. Human perceptions are social constructions since social learning shapes people's understanding. Local context and level of exposure play a considerable role in

defining a community's perception of climate and environmental hazards. In order to assess the resilience of a community, understanding of how different groups in that community comprehend climate change is vital. Public risk perceptions can necessarily induce or confine political, economic and social action to deal with particular risks. If a household or community apprehends shifts in weather parameters, it can take measures to adapt to new conditions, or it can search for supports from state and other stakeholders. The ambiguity of climate change risks is that they are sometimes referred to as 'dread risks' – in the sense that they are hard to control, have potential for disasters, and permeate the feelings of dread – or as 'unknown risks', since slow onset change in climate is hard to readily observe or quantify (Nurse-Bray et al 2012).

However, climate change is a well-established policy discourse in Bangladesh. Even mass people are more or less aware about it. Shrimp farming communities in Mongla, Koyra and Shyamnagar also understand environmental and climate change in their own ways. They perceived that changes in climate inconsistency had occurred within the last ten to fifteen years. One notable point is that their perceptions were influenced by the season and timing of the interviews and the immediate past season. For example, this study was conducted in the summer of 2014, so they replied questions on heat waves and temperature changes judging that year's experience; similarly, they answered questions on changes in winter weather mainly based on their experience of the immediate past winter season. Nevertheless, despite this 'incumbency effect' (see Ade, Freier and Odendahl 2014 for a discussion on incumbency effect in voting behaviour) of weather, shrimp farming people strived to compare weather patterns between the present and 10-15 years before. Overall, aquaculturists from all the three sites

have somewhat similar opinions on changes in weather/climate parameters and changes in the environment. This may be anticipated. While the impact of changes in climate and environmental conditions and shocks may be different in line with the level of well-being of the household, there are no differences between them in perceiving the changes, since all households of the three areas tend to witness the same climate phenomena. Table 6.2 summarizes shrimp farmers' perceptions of climate change and compares with scientific evidence.

Table 6.2: Shrimp farming community's perception of climate change

Parameter/phenomenon	Auaculturists' perception	Scientific data (trend)
Summer temperature	Increased heavily.	Increased slightly.
Winter temperature	Overall increased slightly with bitter cold waves for few days.	Increased slightly.
Monsoon rainfall	No change, delayed.	Increasing trend.
Winter rainfall	Decreased, virtually no rain.	Decreasing trend.
Frequency of cyclones or storms	No change.	Increased in the second half of the 20 th century.
Severity of cyclones or storms	Increased slightly.	Increasing trend.
Flood	Occasionally by storm surges, severe (Aila, Sidr).	Frequency and intensity increased throughout the country.
Salinity ingression	Heavily increased.	Increased significantly.
Sea-level increase	About 0.5 m within last 15 years in nearby rivers.	About 4-5 mm/year.
Drought	No or very few droughts in the locality.	Increasing trend in northern Bangladesh.

Source: Field data

In addition to changes in the above-mentioned primary indicators of weather and climate, people perceive other related changes in the environment. According to their opinions, the number of trees in the vicinity has reduced drastically. Especially after the devastating Sidr and Aila, most of the old trees died because of severe soil salinity. Storm surges engulfed the whole areas

overtopping the embankments by side of the rivers and saline water from the sea remained within the polders in whole areas of Koyra and Shyamnagar years after those catastrophes, due to drainage congestion in the polders. Local people opined that the total number of trees in the area has reduced to one-fourth comparing to that before Aila (see Figure 6.2). One shrimp farmer from Koyra sighed, '*Aila destroyed the history of the past 100 years*', referring to the loss of vegetation in the area. Aila wiped out most of the fruit trees in the affected areas including mango, banana, jackfruit, litchi etc. Farmers from Mongla reported that the fruit trees, which grew well in coastal areas previously like coconut and areca, are now struggling to survive. After Aila, local people attempted to plant trees, but those attempts mostly failed because of excessive salinity in water and soil. According to them, most of the tree species died just a couple of days after planting, especially for the first three years after Aila. For the last couple of years some newly planted trees are surviving. Until now, fruit trees' survival rates are low, only saline tolerant species like caraway grow well.

Another marker of environmental change is that the production of crops decreased significantly due to increase in water and ground salinity. Some people try hard to cultivate rice in their fields, who would cultivate rice before, but they get very low yields even after applying pesticides and fertilizers.

Figure 6.2:
Trees die after
salinity ingress
in Koyra

Source: Field
data

Raising livestock has become difficult. Grazing land has reduced. Though a portion of existing livestock died, or was wounded, during Sidr and Aila, the major setback came from the shortage of their food. Grassland reduced, vegetation hampered, and rice cultivation halted – all these lead to a significant decrease in livestock in the areas.

Aquaculture community also observed more insects and pests in crops, vegetables, and fruit trees. The people who grow fruits and vegetables on highlands and home yards for some time in a year reported frequent pest attacks. They associate this with shifting pattern in seasons.

In addition to the above environmental and ecosystems markers of climate change, people in the researched areas noticed frequent incidences of several health problems and diseases in humans associated with extreme and uneven patterns of heat, cold and rainfall including dysentery, headaches, asthma, fever, and cough.

People had previously experienced shattering natural disasters like cyclone Sidr and Aila and anticipate more disasters in the future due to a shift in the

climate regime. Their understanding of climate variability is essentially drawn from proxy or secondary indicators like crop failure, scarcity of fish in open water, livestock loss, increased sickness as well as the shared experiences of other members of the community. The community do not use any modern technologies to gauge weather changes; rather they attribute sickness, crop failures and other phenomena such as extreme heat or cold events or natural disasters. From Table 6.2 we find that farmers' perceptions of climate shifts significantly match with scientific findings. Though the interviewed rural people have little formal education and live on aquaculture and agriculture, they have clear perceptions of the changes in weather parameters that had taken place. Similarly, striking conclusions were drawn by Haque et al (2012) researching on climate change perceptions of local people in Khulna and Rajshahi. In a recent study in the shrimp aquaculture community in Mongla, one of the sites of this study, Shameem, Momtaz and Kiem (2015) found a high correlation between scientific evidence and local perceptions of climate change, at least for short-term variabilities.

Two issues are worth mentioning here. First, people living in the coastal areas of Bangladesh are going to be one of the first victims of climate change in the world. As we mentioned before, coastal Bangladesh is an ideal zone for gradual onset changes in climate due to global warming as well as for climate extremes. This is an exposed zone for SLR, salinity intrusion, severe cyclones, storm surges, SST and other climate chaos. People living in these areas are directly exposed to changing weather patterns and indirectly through changes in the quality of water, air and food in addition to changes in human settlements, ecosystems, agriculture, industry, and the economy (Haque et al 2012). They learn

about climate change practically by their own experiences. Therefore, they can very well map the regime change. Inhabitants of all the three areas live within 70-80 km up-estuary. They can regularly monitor the height of tide in the rivers, they can feel the changes in salinity level in water and soil, and they just watch catastrophic cyclones and storm surges. The coastal people in Bangladesh, as a vulnerable group, see climate change as something already occurring, rather than something coming in the future. Thus, their perceptions are based on the real changes in the exposed ecosystems – they do not just rely on theoretical discourses.

Second, people's perception of their vulnerability is also shaped by the way it is communicated in the media. Communication, both mass and interpersonal, has an important role in the course of creating public understanding of risks. At the beginning of this century, climate change and global warming became 'grand narratives' (Neverla et al 2012) for science, politics and the public. We can distinguish between two competing types of knowledge of anthropogenic climate change – the scientific construct and the cultural construct (Storch 2009). Media coverage of climate change is crucial in bridging the gap between scientific conclusions and public understandings. Limited public perception about global climate change in the global North and South, in general, is viewed as a communication problem. The case of Bangladesh is crucial. In scientific and policy discourses, the country is frequently termed as one of the worst victims of anthropogenic global warming. Furthermore, climate change is taken not only as an environmental problem but also as an economic concern and development threat in the policy and media discourses in Bangladesh, at least in the last two

decades. Thus, in Bangladesh media, global warming is portrayed as a scientific as well as risk phenomenon.

Among the alarmists, sceptics, radicals and pragmatic schools of climate change politics, vast majority of Bangladeshi stakeholders – including scientists, policy makers, governmental institutions, corporate business members, environmental activists, civil society organizations, and NGOs alike – take an alarmist approach in defining and identifying climate regimes in Bangladesh. Bangladeshi media and stakeholders depict man-made climate change as an ‘absolute certainty’ (Neverla et al 2012) for the country – as if it is an imminent catastrophe. Accordingly, policy discussions in Bangladesh imply that the country does not have any capacity for the luxury of ‘going slow’ or adopting a ‘wait-to-learn’ approach – it has to take immediate resilience actions.

Within this context, different stakeholders venture to transmit climate change messages to the public. Radio, TV, and newspapers frequently publish news reports, features, and articles on human-induced warming of atmosphere. Government and non-government agencies and organizations prioritize climate change agenda in their programmes and projects. Especially NGOs make people aware about likely changes in the climate and devise various coping strategies in their projects, particularly in disaster-prone areas like the southwestern coast. For the above reasons, local people become greatly aware of the changes in weather, environment, and climate.

6.4 Negative effects of climate change on the shrimp industry in Bangladesh

Climate change vulnerability is analysed in the previous literature by means of three sequential and essential conditions for recognizing such vulnerability

(Schroter, Polsky and Patt 2005, Wodon 2015). First, the people of a community may be more or less exposed to climate hazards in the sense that they do or do not experience such hazards or changing climate conditions more generally. Second, climate extremes and changes may affect the income sources, livelihoods, and assets of households more or less. Finally, households may show more or less resilience to weather shocks and changes when their income sources, livelihoods, assets and food security are affected (Wodon 2015). Since climate change is an emerging global issue, researchers tend to deal with broad aggregates, concentrating on global, regional, and national level impacts and vulnerabilities. Discerning impacts of climate change, especially slow onset changes, on small village communities is a recent trend.

Climate change variabilities and extremes that affect shrimp farming in coastal Bangladesh include atmospheric and water temperature increase, coastal tidal surges and flood, cyclone, saline water ingress, sea-level rise, etc. The overall impacts incorporate individuals as well as combined negative consequences of climate phenomena on the physiology (reproduction, metabolic activities etc) and growth of shrimp, which lead to reduction in net shrimp production, which in turn leads to low economic output from the sector adversely, affecting the farmers' livelihoods and food security, and the country's export earnings and its GDP. Increasing intensity and frequency of climate extremes may also damage shrimp-farming infrastructures. In the course of the field research for this project in southwestern Bangladesh where shrimp is cultivated, the following negative effects of climate change disasters and disruptions were found to be prominent.

6.4.1 Cyclones and storm surges

Cyclones and storm surges have devastating effects on the physiology of shrimps, *gher* structures, shrimp ecosystems, and surrounding infrastructures. After the cyclones *Sidr* and *Aila*, which hit coastal Bangladesh in 2007 and 2009 respectively, most of the shrimp farms in south-western Bangladesh were washed away. Cyclone *Sidr*, with a sustained wind speed up to 250 km/hr and storm surges up to 9.1 metre, affected 8.7 million people in 30 districts of the country, led to 3,400 deaths and injuries to over 55,000 people. One million households lost their dwellings (Siddiqui and Billah 2014). 567,000 people lost their main source of livelihood either permanently or temporarily (ILO 2008). Making landfall during high tide in late May in 2009, cyclone *Aila* was associated with tidal surges of up to 6.5 metres, affecting 3.9 million people in 11 coastal districts (UN 2010, Siddiqui and Billah 2014). This surge of water damaged partially or fully over 1,742 km of embankments, removing the only safeguard available to many households in the coastal areas. The instant impact of Cyclone *Aila* resulted in 399 deaths and approximately 7,100 injuries. About 100,000 livestock were killed, and almost 350,000 acres of cropland were damaged. *Aila* destroyed partially or fully about 5,000 institutions of various categories, and 157 bridges and culverts (UN 2010). In addition to these two, cyclones strike the southwestern coast of Bangladesh more or less frequently and cause huge damages.

Sidr destroyed 54,000 shrimp *ghers* (Siddiqui and Billah 2014), causing Bangladesh to incur a loss of USD 36 million (Ahmed and Diana 2015a). According to key informants of this research, about 90% of shrimp *ghers* in Shyamnagar and Koyra and about 80% in Mongla were damaged by *Aila*. Cyclones commonly cause human injury, death, damage to crops, livestock, and

shrimp *ghers*, and economic loss. According to the farmers, storm surges inundate shrimp *ghers* that causes shrimps to escape out from the ponds resulting in economic loss to the farmer. Especially, Aila caused huge losses to shrimp farmers. An assessment by the Department of Fisheries and the FAO indicates that production of shrimp in Aila-affected areas was reduced by 80% from a normal year's production (UN 2010). Since Aila destroyed the embankments along the rivers, shrimp farmers could not cultivate shrimp for one or two seasons, based on the location of *ghers*, because the entire farming areas were under water. That was enormous economic loss to them – they had to pass their days in hardship. Another negative impact of storm surges is that predators (shrimp-eating fish and aquatic animal species) intrude into the *ghers*, a phenomenon that affects overall shrimp production. Farmers reported that huge number of predators entered shrimp *ghers* at the time of Aila, causing reduced shrimp production.

Moreover, cyclones in the coastal areas cause contamination of pond water through debris and wastage intrusion that deteriorates the parameters of *gher* water that in turn causes disease, death or under-growth of cultured shrimp. If turbidity of water increases due to contamination, the gills of shrimp may choke because of accumulation of foreign substances dissolved in turbid water. The production of natural food for fish, i.e. phytoplankton, drops in turbid water (Roy et al 2011). Consequently, the shrimp encounters food shortage and difficulty in breathing, loses appetite, and in extreme condition, it may die. Decomposition of organisms in *ghers* due to storm surge inundation causes a sharp decline in dissolved oxygen (DO) in water (Ahmed and Diana 2015b). The ideal level of DO content in *gher* water is 5.0-8.0 mg/l for optimum growth of shrimp. Shrimp cannot continue its normal physiological activities if DO content level in water

goes below 2.0 mg/l (Roy et al 2011). Thus, through increasing turbidity and decreasing DO level in *gher* water, cyclones and storm surges pose existence threat for cultured shrimp. Moreover, flooded storm surge water frequently contributes to changes in the salinity of pond water that affects shrimp growth.

Cyclonic storms also destroy shrimp farming equipments. Farmers reported that they lost *patas*²⁶, *bajras*²⁷, *khachis*²⁸ and *charus* or *atols*²⁹ during severe storm surges of the Aila. Cyclones also damage shrimp farmers' houses – leaving them in distressed conditions. After cyclone Aila, 5,009 families in Koyra and Shyamnagar were forced to live in cyclone shelters or on embankments and roads for months (UN 2010). During that precarious time, they were stuck with their own existence question; they could not concentrate on taking care of their farms, which in turn caused production losses. Severe cyclonic storms cause damages to roads and communication infrastructure in the shrimp farming areas that hamper the transportation and marketing of harvested shrimp. Aila, for instance, destroyed partially or fully about 9,000 km of road in the affected areas. Aila damaged most of the roads in Koyra, Mongla and Shyamnagar. Instead of road transport, people had to use water vessels in order to move. Sometimes *katas*³⁰ went under water during high tide in the rivers. Thus, the business of shrimp commission agents and shrimp traders was also hampered severely. During the exact time when Aila crossed the research areas (11 AM – 4 PM, May 25, 2009), a number of shrimp carrying vans were in operation on the road.

²⁶*Pata* is a kind of protector made of bamboo sticks, used on the path of water passage during exchanging *gher* water so that shrimp or other fish does not go out of the *gher*.

²⁷*Bajra* is a basket made of bamboo sticks, used for collecting harvested shrimp.

²⁸*Khachi* is a type of net used for collecting harvested shrimp.

²⁹*Charu* or *Atol* is a piece of equipment (trap) made of bamboo sticks and used to catch shrimp from *gher* on regular basis, especially during springtides.

³⁰*Kata* is the market place where shrimp farmers and *farias* sell their shrimp to shrimp traders through shrimp commission agents.

Almost all of those vans were washed away by the cyclone causing significant loss to the traders. According to shrimp traders of Bongshipur in Shyamnagar, some of their fellow traders were forced to withdraw from business for few months because of Aila. Moreover, due to sharp decrease in shrimp production in the locality, shrimp business was dull up to 2 years after Aila.

Cyclones also affect shrimp fry collectors. Generally, cyclones reduce fishing days and catch rates for them. However, one important point to note here that during the landfall of cyclones, shrimp post larvae (PL) availability in rivers in the Sundarbans increases, but fry collectors are forced to restrain from their operation and to take shelter for couple of days in the canals. Thus, their total catch remains somewhat similar as before. Another impact on fry collectors is that they frequently lose their equipments due to devastating wind and storm surges.

6.4.2 Increase in atmospheric and water temperature

There is a direct correlation between air temperature and surface water temperature at lakes (Piccolroaz, Toffolon and Majone 2013, McCombie 1959). With rising air temperature, water temperature in shrimp *ghers* increases. Changes in water temperatures result in adverse impacts on ecosystems functioning in *ghers*, which in turn cause lower productivity and resultant losses to the farmers. Farmers reported that water becomes extremely hot during summer days. Two main causes are behind this, first, increased atmospheric temperature, and second, shallowness of the *ghers*. If *gher* water turns too hot, a deviation from optimum water parameter happens. The ideal temperature range for the growth of shrimp is 28 – 32⁰C. The growth and metabolic activities of shrimp double at every 10⁰C rise in water temperature. At a temperature lower than 25⁰C, shrimps may become

disease-infected because of stress. By contrast, if the *gher* water temperature reaches up to more than 35⁰C, shrimps become weaker and ultimately they die (Roy et al 2011). In southwestern coast of Bangladesh, water temperature in shallow *ghers* sometimes passes over the tolerable limit for shrimp PL as well as for matured shrimps. In addition, the increase of water temperature reduces the availability of wild fry in rivers.

Increase in air and water temperature at summer months causes pond water become extremely hot in which metabolic activities of shrimp are severely influenced. Increased temperature in the *gher* environment (i.e. soil and water parameters) increases the physiological activities of shrimp (Weiss 1970), requiring additional dissolved oxygen (DO) in pond water. However, the level of DO is inversely related to temperature and salinity, i.e., if temperature and salinity of water increase the DO level decreases (Farzana and Hossain 2015). This situation hampers growth and reproduction success of shrimp. Furthermore, increase in water temperature frequently causes stratification and less nutrient enrichment to surface waters (Harley et al 2016, Ahmed and Diana 2015b) which in turn leads to reduced growth in shrimp.

Moreover, water depth of shrimp ponds decreases with the increase in atmospheric and water temperature because of evapo-transpiration, which reduces the total volume of water in the *ghers*. Generally, DO concentration in *gher* water comes to its lowest level after midnight when all aquatic organisms respire and, as a result, shrimps face hypoxic condition (Farzana and Hossain 2015). Thus, the amount of O₂ in water falls below the essential level for the physiological activities of shrimp, and accordingly, shrimps growth rate and reproductive output

reduce and sometimes they die en masse. Shrimps also lack appetite in extreme hot water, which reduces their food intake and growth.

According to the shrimp farmers, brackish water heats up quickly comparing to freshwater. Shrimps are more affected by bacterial diseases when water becomes too hot. According to them, bacteria become active in increased temperature, leading to contamination of the entire *gher* environment. Farmers from the Mongla area classify their *ghers* into two types: *boddho gher* (closed farms, which are enclosed by dykes on four sides without any provision of regular flushing of tidal surge) and *shorboraho gher* (supply farms, which are attached to Pasur River and connecting canals and have provision of regular water exchange throughout the shrimp cultivation season). Water becomes hot quickly in those *ghers* which are not enough deep. If water temperature crosses the threshold level, shrimps have to suffer bad consequences. For this reason, shrimps die in very hot temperature, especially in the shallow *ghers*. Since there is no embankment in Mongla Upazila, water level in the *shorboraho gher*s are directly related to water availability in the Pasur River. During neap tide, water depth decreases and if the temperature is increased severely at that time, shrimps cannot survive in those *ghers*.

Shrimp fry are transported from Cox's Bazar to Khulna region: from Cox's Bazar to Jessore by air and from Jessore to shrimp farming areas on road. Shrimp PL is carried in cock-sheet boxes in which ice is put in order to keep water temperature at optimum level. However, cock-sheets become hot in hot weather, sometimes leading to the death of a portion of PL. Moreover, the PL cannot be stocked in the *ghers* quickly because of excessive temperature in *gher* water.

Since total volume of water decreases due to increased temperature, the density of shrimp population increases in the *ghers*. As a result, they have to struggle to get sufficient O₂ from water. Moreover, the volume of water decreases in hot climate but the total volume of salt in water remains same; thus, the salinity level in water increases. Though *bagda* is a saline-tolerant species, it also requires an optimum level of water salinity. If deviation occurs from that level, shrimps' growth hampers.

Shrimp traders reported that ice melts quickly in hot weather. If ice melts out quickly from shrimp carrying vans, quality of the shrimps deteriorates. Therefore, in order to retain the optimum physical quality of shrimp, including colour and temper, in hot weather, traders have to apply larger amount of ice for preserving, processing, and transporting shrimps. As a result, their icing costs rise with increased air temperature.

There is a spill-over effect. According to shrimp commission agents in *katas*, the demand of ice increases with an increase in atmospheric temperature. When the demand of ice increases, the local ice factories cannot supply sufficient amount of ice – as a result, a crisis in ice availability occurs. Shrimp traders need to buy ice from Khulna or Satkhira towns, which causes extra costs for the traders. The traders, in turn, adjust those extra costs with the price of shrimp. Thus, shrimp price falls ultimately. Farmers and farias become losers. Similarly, since total transaction in monetary value decreases, shrimp commission agents get lower amount of commission (profit).

6.4.3 Drought

In addition to increased temperature in air and water, prolonged rainless time occurs in some years leading to drought condition in the areas. Impact of drought on shrimp cultivation depends on the issue of unavailability of required amount of water. Drought is not a very common problem for shrimp farming in the research areas because most of the *ghers* use river water for cultivation; however, prolonged droughts sometimes result in short culture periods for shrimp, especially in the highland and in the areas far from rivers. Seasonal pre-monsoon drought increases water temperature and salinity that have an adverse effect on shrimp production. Aquaculturists in Koyra, Shyamnagar and Mongla experienced few droughts. During droughts water levels in *ghers* drops sharply. The farmers who can exchange water from rivers do not face this problem. However, those whose *ghers* are further inland cannot take effective measures. Therefore, they suffer. One such farmer commented, “*Our gher water is becoming poisonous, ppt (i.e. salinity) is rising, shrimp production is decreasing, and virus is coming.*” According to a news report, shrimp farmers in southwest Bangladesh struggled with a drought situation in April 2014 that caused a loss of USD 225 million worth of shrimp and fish fry (Ahmed and Diana 2015, Financial Express 2014).

Droughts have chain effects on the shrimp farmers’ food security and food consumption. According to the farmers, fruits and vegetable producers face production shortages during drought situations, which in turn create food scarcity and price hike in the area.

6.4.4 Heavy rainfall

Increased rainfall also hampers shrimp ecosystems. Excessive amount of rainfall causes turbidity in water. Water transparency level of 25 cm in *ghers* indicates sufficient amount of natural food in the water (Roy et al 2011). If this level falls due to intrusion of debris and organisms in water, sufficient sunlight penetration is hampered and the production of phytoplankton is seriously affected at the deeper level by reduced photosynthesis – phytoplankton is then produced only at the upper layer of the *gher* water. As a result, shrimps suffer from food shortage, which in turn retards their growth. Moreover, as mentioned above, turbid water causes breathing difficulties and loss of appetite in shrimps that also result into lower growth rate. Torrential rainfall also reduces the pH level in *gher* water. For shrimp culture, the optimum pH range in water is 7.5 – 8.5. If pH reaches to below 4 or above 11, shrimp may not survive (Roy et al 2011). Furthermore, extreme rainfall causes the DO level in *gher* water to fall (Farzana and Hossain 2015). Appetite of shrimps increases when DO level increases and drops with a decrease in DO level in water. Through all of these mechanisms, heavy rainfall challenges shrimp physiology and ecosystems.

Farmers from the fields reported that *gher* dykes submerge if excessive rainfall occurs for a long period (few hours). As a result, shrimps escape from the *ghers*. Farmers incur loss for this reason. In addition, shrimps frequently die in heavy rains, especially if it occurs at the start of the monsoon. Three things are worth mentioning here. First, the first rain of the monsoon, with thundershowers, is acidic with low pH ($\text{pH} < 7$). Rainwater during this time is associated with various elements from atmosphere including few gaseous components and dust and debris. However, after few days, from the middle of the monsoon, rainwater

becomes neutral. Therefore, when acidic rainwater mixes with the *gher* water, the *gher* environment becomes upset, changing in existing water and soil parameters. Second, *gher* water remains hot because of excessive water temperature at the start of monsoon, but rainwater is comparatively cold. Mixing of hot and cold water upsets the water parameter in *ghers*. Finally, *gher* water is brackish, while rainwater is fresh. Therefore, mixing of saline and freshwaters create an ecological imbalance in the *gher*, which leads to adjustment problem for the shrimps in *gher*. Existing literature indicates that low level of water salinity with water temperature fluctuations of 3-4⁰C results in the outbreak of white spot syndrome virus (WSSV) in shrimp (Ahmed and Diana 2015, Tendencia and Verreth 2011).

Since few *gher* dykes submerge during exceptionally heavy rainfall, shrimps escape from *ghers* at that time. However, according to the aquaculture communities, shrimps from *ghers* try to go out during heavy rains even if the dykes are not submerged. They crawl over dykes, and the farmers try to prevent them. They also informed that marketing of shrimp and shrimp fry becomes problematic in intense rains because of poor roads and transports at least in some areas. This is particularly true for Mongla Proper – Haldibunia, Shyamnagar Proper – Nowabnki, and Koyra – Khulna roads. The conditions of these roads are severely bad with hundreds of damages and deep patches on them. Aquaculturists also reported that they become more engaged in other works during rainy days including repair works on their houses. Thus, working hours and days on *ghers* are reduced at that time. According to shrimp fry collectors, sometimes heavy rainfall causes a decrease in the availability of shrimp fry in the rivers since salinity of water becomes low at the upper level.

6.4.5 Salinity ingress

In general, *bagda* is a brackish-water euryhaline species that can survive in water with a salinity range of 5-40 ppt (Ahmed and Diana 2015a), the optimum salinity range for shrimp culture is 10-25 ppt (Roy et al 2011). Salinity beyond this limit hampers the growth of shrimp. Therefore, increased salinity itself may be problematic for shrimp metabolism. Salinity in coastal Bangladesh has been increasing in recent time. Farzana and Hossain (2015) found surface water salinity range of 7-46 ppt in shrimp *ghers* in Shyamnagar neither the lower nor the upper value of which is suitable for *bagda* cultivation. If water salinity in the farm crosses the threshold limit, growth and survival rate of hatched PL decreases.

Increased water salinity can have a number of secondary impacts on shrimp physiology and ecosystems. Since there is an inverse correlation between salinity and DO level in water, if salinity level increases, the DO level decreases. The growth and existence of shrimp may be threatened in a lower DO regime, which we have already discussed in a previous section. Kautsky et al concluded that fluctuations in water temperature and salinity are accompanied by occurrences of diseases in shrimp (2000).

Aquaculture communities in southwest Bangladesh recognize salinity intrusion as the number one problem for the sustainability of the commercial shrimp industry in Bangladesh. They opined that at the root of every environmental problem, shrimp related or non-shrimp, is ground and water salinity. Even the livelihood on *bagda* farming is threatened by saline water and soil. Shrimp PL, especially hatchery PL struggles for survival in the *gher* water. Farmers observed that nearly 80% of hatchery shrimp PL die after they are

stocked in the farms. Overall production of shrimp is decreasing because of increasing salinity. With increased temperature, salinity level in water increases. Disease spreads in shrimp farms with an increase in water salinity. All these cause havoc in the area. On average, a farmer experiences disease outbreak in his *gher* once in a year. But this saline disaster is not so much highlighted in the media. One shrimp farmer from Mongla commented, “*The whole world knows about the disasters of Aila and Sidr; world people watched through satellite (i.e. TV); all came to support us. But no one knows about the ‘disaster under water’ (i.e. salinity); no satellites telecast this silent disaster.*”

Aquaculture communities, especially shrimp farmers from the Mongal area, pointed to climate change phenomena – such as cyclones, storm surges, temperature rise, SLR – as well as withdrawal of river water upstream as the causes of gradual increase in water salinity in the area. The Pasur River is a tributary of the Padma (Ganges). They opined that upward flow of saline water from the Bay of Bengal increases when India draws water from the Ganges at the Farakka Barge during dry season. In the monsoon, on the other hand, when more rainfall occurs in the area and India releases water from the Ganges, salinity level decreases. They also informed that though two or three crops are cultivated in other regions of the country, even the cultivation of just one agricultural crop in the salinity zone is very hard. Here people get only three months of time during monsoon to grow *aman* paddy. They remembered that there was no crop in the fields when Aila occurred (pre-monsoon), so no damage happened to rice crops. However, that was a peak time for shrimp – they were preparing to harvest the season’s first output, ‘ready to export’ shrimp. However, the Aila washed away all the *ghers* causing tremendous loss to them. Since Aila hit the area in the pre-

monsoon season, salinity level in the nearby rivers was at the highest point. When storm surges engulfed the whole area and water remained for long time, soil salinity increased significantly in the area due to natural absorption water into ground. Up to now, soil salinity is very high. Thus, Aila turned the region barren.

6.4.6 Sea-level rise (SLR)

Several studies show that the western part of the coastline is very highly vulnerable to sea-level rise (SLR) due to thermal expansion of ocean water and increased melting of glaciers and ice caps because of global warming (Sarwar 2013, Rashid 2014). The central coastal regions are highly or moderately vulnerable and the east coast is the least vulnerable to SLR. The IPCC projection of a one metre SLR by 2100 might submerge at least one-fifth of the country's total landmass (Rashid and Paul 2014:2), and a possible 45 cm SLR by 2050 could inundate 75% of the *Sundarbans* (Nishat and Mukherjee 2013:43), the largest mangrove ecosystem in the world that cater to the shrimp cultivation in the south-western Bangladesh.

Though SLR has not yet started affecting the shrimp *ghers* in the region directly, various stakeholders in the shrimp supply chain feel some indirect consequences. If the sea level rises sharply, the low-lying shrimp farms may be submerged causing production losses. This can happen especially in the areas outside the BWDB embankments. In Mongla, for example, there is no embankment; owners of *ghers* close to the Pasur River remain worried about inundation any time – especially during springtides when river water peaks. Moreover, in Shyamnagar and Koyra, people are always in tension about riverbank erosion due to the rise of water level in the rivers.

Changes in the mangrove ecosystem of the *Sundarbans* due to SLR can alter the breeding season and the breeding success rate in shrimp (Ahmed and Diana 2015a). Shrimp fry catchers who operate in the *Sundarbans* reported that their fry catch has dropped significantly compared to that ten years ago. So, there may be some connections between shrimp breeding and SLR in the *Sundarbans*. Fry collectors reported that their catch has dropped because they face problems in setting their nets in strong currents due to SLR.

6.4.7 Riverbank erosion

Riverbank erosion is a common natural hazard in the shrimp farming areas, especially in the Koyra sub-district of Khulna. Coastal areas are cyclone-prone areas. Storms of low intensity hit this area almost every year. These storms act as threats to the embankments. Almost each year embankments breach at one place or another. Thus, people become tensed constantly. SLR also threatens the embankments. Especially the risk increases during springtides in monsoon season when rivers are filled to the brim. Local people informed that in the last ten years hundreds of acres of land went under water of the Kobadak River in Gazipara and Gabbunia villages in Koyra. The Upazila Fisheries Officer at Koyra commented, “*SLR is visible in Koyra. People are worried about river erosion. The Union Council chairmen and members are always in tension – when the bad news of riverbank erosion comes. They cannot sleep at night during the new moon and the full moon.*”

Erosions damage/wash away dikes of shrimp farms (or, entire farms), which causes shrimps to escape from ponds causing heavy financial losses to the farmers. In some cases, shrimp farmers were forced to leave their occupations

since they lost their farms because of riverbank erosions. In addition, when the embankments are breached or washed away, water contamination happens with the intrusion of wastage into the unaffected shrimp *ghers*. Similarly, predator species enter the ponds and cause losses to shrimp production.

6.4.8 Overall socioeconomic impact on household and community

The above discussion portrays how shrimp production is directly or indirectly affected by climate shocks and shifts. In this section, we will look into how shrimp producers' household economy is affected by the production loss in shrimp due to weather shocks and changes. Two issues are worth mentioning here. First, there are two main reasons behind the shrimp farming livelihood in the localities in coastal Bangladesh. (1) Shrimp is a profitable livelihood option. Despite natural disasters, viral attacks and other setbacks that this sector faces, shrimp producers manage to make some profit out of it at the end of the day. Every year shrimp season starts in December through farm preparation and stocking of shrimp and ends in August-September by harvesting the last episode of the season. Generally, farmers start harvesting the first lot of shrimp in March. They stock shrimp seeds once in every two weeks from the start of the season up to three months before the end of the season; similarly, they harvest shrimps once in every two weeks from three months after the start of the season up to the end of the season. Therefore, if a farmer suffers any calamity at any time of the season, he stops stocking, takes measures to solve the problem, and starts restocking when the disaster is over. In this way, he generally recovers from losses. If a farmer, for example, makes losses at the beginning of the season, he may have time to recover by the end of the season; similarly, if he makes profit at the start of the season, he

can make up any loss by the end of the season. As mentioned above, a farmer, on average, is struck by calamities once a year. Thus, the petty aquaculture people can endure regular annual losses and meet their needs. Only the lowest strata, who are very few in number, suffer drastic repercussions that spread to the household or community level. However, if some drastic calamities happen suddenly like massive scale riverbank erosions or cyclones and storm surges, other than small-scale yearly phenomena, the whole community is shattered, except the wealthy few.

(2) Shrimp farming is the only viable livelihood option in the salinity-prone southwestern Bangladesh. Up to now, the local communities tried few other livelihood options including rice cultivation, but those attempts turned to failure. Especially after Aila, the total Aila-affected landmass became so saline that people have to resort only to *bagda* livelihood. Thus, adoption of a shrimp aquaculture livelihood in these areas is not ‘by choice’ but ‘by compulsion’.

Second, socioeconomic impacts which are the secondary consequences and spill-over effects of weather shocks and changes to shrimp, the primary being the negative impact on the growth and production of shrimp, are adaptation measures taken by the aquaculture communities as well. We will discuss all of these impacts in detail, connecting with adaptation and resilience actions, in the next chapter.

- A. Households use own savings during crisis, which makes them to be trapped in a vicious cycle where they cannot have upward mobility.
- B. Reduced education expenses for their children.
- C. They have to borrow from friends or relatives.
- D. They have to take loan from banks or NGOs.

- E. Some families emigrated from the locality.
- F. Some households send one or more members away to earn for the family.
- G. Unemployment rate is increasing in the region.
- H. The affected households curtail family expenses during crisis.
- I. Sell or pawn their livestock, jewelry, or land.

6.5 Conclusion

The shrimp aquaculture communities in south-western Bangladesh live with nature. Their livelihoods are tied to the tide of the surrounding rivers. Any fluctuations in the environment influence their lives a great deal. As coastal peoples, shrimp farming communities are not only exposed but also extremely sensitive to climate-driven threats. Their vulnerability context lies at the critical intersections between physical arrangements of the *gher* structure, the biology of shrimp genesis, the prevailing agrarian social structure, and the community level endeavours. Living in a capricious environment, they learn about the extent of weather shocks and climate change through their lived experiences. The mainstay of their livelihoods, commercial shrimp aquaculture, is climate sensitive in great deal. They gauge the repercussions, which rapid climate extremes and slow onset climate change have on their ecosystems. Every climate change phenomenon, including SLR, cyclones, storm surges, salinity, drought, temperature and precipitation regimes, has specific direct or indirect negative impacts on the shrimp farming livelihood in coastal Bangladesh. After looking into their vulnerability context, we will be discussing in the next chapter in which degree they become a climate smart and climate resilient community.

CHAPTER SEVEN

RESILIENCE TO CLIMATE CHANGE IN SHRIMP AQUACULTURE IN BANGLADESH

7.1 Introduction

The ability of household and community to cope with and to be resilient to weather shocks and climate change is often limited. In this penultimate chapter, we will discuss the strategies adopted by the community and households when confronted with climate shocks. First, the cultivation of shrimp species itself is an adaptive measure when facing the climate change problems in the coastal areas (Ahmed 2013, Pouliotte, Smit and Westerhoff 2009). Because of salt-water intrusion in coastal areas as a result of global climate change, and since rice cannot be cultured in saline water, coastal communities could adapt to the condition only by cultivating shrimp and other brackish-water fish species.

However, as discussed in the previous chapter, the saline-tolerant shrimp industry is not out of danger from the climate-induced adversaries. Developing adaptability and resilience to counteract negative impacts of climate disruptions is the main challenge for the community now. Meeting this challenge needs investment in building and safeguarding of protective infrastructures, development of climate proof production technologies and strengthening coping capacity of households and institutions. The process of adaptation and resilience to climate change is not just a perfunctory adjustment to natural perturbation, but a more intense socio-cultural encounter with core causes of vulnerability. Resilience strategies should incorporate local actions taken by the affected people and communities themselves in response to shifting environmental and climate

regimes supported by larger-scale, planned interventions by government or other institutions, which offer supports that are beyond the capacity of the local communities.

The shrimp industry in Bangladesh devises its own adaptation techniques to avert any detriment. We can look into the resilience efforts taken by the shrimp-farming community in Bangladesh by focusing on specified and general resilience. The shrimp-farming communities in Bangladesh generally develop specified resilience, with less emphasis on general resilience relating to climate perturbations. When a community develops coping mechanisms with regard to a specific threat, as noted in a previous chapter, its adaptive capability is termed as *specified resilience* (Folke et al. 2010). For example, if a climate-challenged human community develops resilience in addressing the problem of salinity ingress – but does not become resilient to drought, flood, cyclones and other climate threats – its resilience can be termed as specified resilience. *General resilience*, on the other hand, is the resilience that a community grows in order to address all sorts of shocks simultaneously. This type of resilience programmes addresses all the potential threats that affect the system as a whole or part of it. Thus, general resilience is holistic. In coastal shrimp farming areas, people are myopic in the sense that they just focus on immediate problems. When a natural calamity strikes them, they try to fight it. However, after recovery from that disaster, they forget about it and become relaxed. This tendency leads them to incur huge losses from disasters repeatedly. This is true for the climate hazards that affect the shrimp industry.

Shrimp farming communities' adaptation and resilience efforts are interlinked with the broader general coping mechanisms in the coastal areas. Ali

(1999) and Ahmed (2013) pointed out a few possible adaptation strategies to climate change vulnerabilities for the coastal population in Bangladesh. The strategies include: (i) the generation of alternative livelihood opportunities, (ii) community awareness for disaster management to fight sea-level rise, (iii) construction of coastal embankments for cyclone protection, (iv) afforestation of greenbelt in coastal areas, (v) construction of cyclone shelters, (vi) mixed culture of prawn-shrimp to fight salinity intrusion, (vii) building higher dikes around aquaculture farms to deal with floods, (viii) development of water irrigation facilities for coastal aquaculture to tackle drought situations etc.

7.2 Adaptation to primary impacts on farming

The shrimp farming communities apply specific strategies to tackle immediate effects on shrimps and *ghers*. At the shrimp fry collection level, the availability of shrimp PL in the rivers of the Sundarbans is affected by climate change phenomena like SLRs, water salinity increases, and cyclones and storm surges. PL collectors (Figure 7.1 is a photo of a female fry collector) could not devise any effective adaptation strategies for facing these changes till now. According to the PL collectors in the Sundarbans area, it is hard to catch shrimp fry when water height increases in the river due to SLRs. The rivers' current become strong and the fry collectors cannot apply their nets properly, which in turn affects the total amount of catch. On the other hand, shrimp fry become more available during cyclone days. Different species of fish and PL come with storm surges, which remain abundant in the rivers for about 5-6 days. After that period, fish and PL availability becomes normal again. Though shrimp fry becomes plentiful, the fry

catchers cannot operate in the stormy days. If they are on the PL catching trip in the jungle, they cannot come back to their homes in their villages.

Figure 7.1: A shrimp fry collector from *Munda* ethnic group with her equipments returning home after operation in nearby *Shakbaria* River

Source: Field data

Since the peak time for PL collection in the Sundarbans is the pre-monsoon months of April-June and since this is one of the two peak periods for cyclones hitting the Bangladesh coast, fry collectors often encounter, and have become accustomed (or, resilient) to this problem. As an adaptive response, they move out from the big rivers where they catch fry, and take refuge in the canals in the jungle during cyclones.

As remarked in Chapter Six, shrimpers perceive that there is an increasing trend in the number of hot summer days with intense heat in the region. At the shrimp farming level, one of the reasons behind the death of shrimps in hot summer months is the shallowness of shrimp farms. *Bagda* farms are rectangular enclosures, ranging from a fraction to several hundred acres, built in small depressions, called *beel* in Bangla. Unlike in the case of *golda* (freshwater prawn) farms, *bagda* farmers generally do not make trenches in their farms. The earthen walls, which they raise at each side to make the enclosures, are merely one meter high. Therefore, in the summer, due to evapo-transpiration, water depth in these farms becomes too low and water too hot. Though the optimum level of water

depth in *gher* for *bagda* is 1.5 m (Roy et al 2011), water depth in most of the *ghers* is as low as 0.75 m. As a result, shrimps die frequently because of heat stress. Recognizing the connections between the exposure to heat stress and retarded growth and mortality of farmed shrimps, in order to tackle this problem, a few farmers are now increasing the depth of their farms (locally called *ghers*) by making trenches at least at some corners of the *gher* so that shrimps can take shelter at that corner to avert heat stress during hot days. In addition, since shrimps may die because of O₂ shortage in *gher* water, which is caused by increased shrimp density within a lower amount of water due to climate change-induced extreme heat, some farmers have now become conscious enough to keep the stocking density of shrimp at moderate level in order to avoid the above problem. This is an adaptive measure to the climate change perturbations in the shrimp economy.

During storm surge floods and excessively heavy rainfall, dykes of *ghers* submerge and shrimps escape. The farmers address this problem, especially submergence problem due to heavy rainfall, by investing in farm infrastructure. A section of the farmers has already increased the height of the *gher* dykes to avert escaping of shrimp. As a protective measure, a few farmers also put net around their *ghers* to prevent shrimp from escaping.

One of the other measures taken by coastal shrimp farmers is that currently they transform their large farms into small ones. This helps them in two ways: first, the *ghers* are easily manageable now; and second, this reorganization lessens the risk of greater loss. If death outbreak in shrimp occurs in one *gher*, for example, in order to minimize the loss, the farmer can quickly take protective means for other farms, or he can harvest shrimp from them. In order to make the

PL hatched in high salinity³¹ hatcheries in south-eastern Cox's Bazar adapting to a lower salinity farm area in the south-western Khulna region, a few number of nauplii centres, locally called nurseries (see Figure 7.2), have developed in the region. These nurseries bring shrimp seed at nauplii stage and grow them in controlled tanks, exchanging water regularly and making the PL adjusted with *gher* water, for few days before the PL are sold to the farmers, who then culture them in grow-out ponds (*ghers*).

Figure 7.2: A *bagda* PL nursery in Koyra

Source: Field data

Also, as mentioned above, selling out pre-mature shrimp before any devastating disaster like cyclones and storm surges is viewed as an option by a section of farmers. Because, according to them, it is better to cash partially than to lose everything. They base on the fact that cyclones *Sidr* and *Aila* completely washed away thousands of shrimp farms in the coastal areas, causing almost 100% losses to the shrimp farmers.

Field observations suggest that though majority of shrimp farmers take one or more farm-level strategies to address climate change disturbances, some of them do not take any measure. The reason behind this is that though these people are aware about the climate change impacts on their farming, they cannot take any

³¹ Ideal level of water salinity in *bagda* hatchery is 29-34 ppt (FAO 2007).

anticipatory, autonomous, or planned adaptation strategy because of their financial inability.

7.3 Resilience at household level

If a shrimp farm suffers from disasters or virus attacks, the farmer incurs loss and consequently his household has to bear the brunt. As mentioned in the previous chapter, even if a small-scale shrimp farmer loses his entire production once in a year, he can recover that loss within the season. Generally, a farmer experiences production failure once in a season. So, household level impacts become obvious only if a farmer loses at least twice in a year or if he is marginally poor. In addition to that, the household of any small-scale shrimp farmer can be severely affected if there is a sudden large-scale calamity like cyclones and storm surges. In addition to shrimp farmers, households of shrimp fry collectors and other local-level stakeholders are affected directly or indirectly, in varying degrees, because of weather shocks and climate changes. When affected by income loss from shrimp due to weather shocks or climate change hazards, households in shrimp communities tend to rely on multiple coping mechanisms and resilience schemes.

Ownership, control, and distribution of resources are an important facet of vulnerability and resilience as well as architecture of entitlements discussed in an above section. Since poverty generally leads to lack of access to tangible and intangible community capitals that are crucial in the face of risks from environmental hazards and the resultant stress on livelihoods, poverty is a significant indicator of individual vulnerability (Adger and Kelly 1999). Nguyen and Wodon (2015) in their study in the *Sundarbans* found local people adopting mainly three broad coping strategies when responding to cyclone hazards:

consumption smoothing, income smoothing, and reducing investments in human capital. Though not mentioning the three categories, Ahamed (2013) also found similar adaptive strategies taken by the cyclone and storm surge affected population in Cox's Bazar, Noakhali, Bhola and Barguna coasts of Bangladesh. Poor and marginal households in shrimp farming communities who suffer from climate disturbances in the areas of the present study also take various adaptive mechanisms that we can categorize as the above as well.

7.3.1 Consumption smoothing strategies: As part of consumption smoothing when confronted with a negative income shock such as production failure in shrimp due to weather and environmental hazards, households accumulate reserves in good times, which they can use in crisis periods. This is the *most common* consumption smoothing strategy in the study areas. Farmers from the study areas informed that hazard-affected households spend their savings in bad times. The farmers who make profit earlier can spend from their savings during disasters. Since they apprehend disasters, they tend to make savings to use during calamities. If a shrimp-farming household makes profit by the end of a given culture season, it saves that for using in the next season; similarly, if a family profits at the start of a harvesting season, it saves for investing in the latter half, if needed. Though this is reasonably the most common household response to production loss due to climate change, in reality, the aquaculture community cannot make significant amount of profit from shrimp every year. Moreover, households that are forced to spend their own savings every year to face crises become trapped in a vicious cycle in which they cannot have upward economic mobility in society.

The households who do not have enough savings to meet the loss and restart shrimp stocking in *ghers*, generally borrow money from neighbours, friends or relatives as a *third* choice coping mechanism. However, here also arise few concerns. Since their friends, neighbours and relatives are also from same economic strata, generally they cannot support much. Moreover, few of those friends or relatives become worried about getting their money returned in due course, so they often are reluctant to lend. This is why the farmers frequently take loans from money-lending persons or organizations as the *fifth* consumption smoothing strategy. In order to recover from the loss and to start shrimp stocking anew, the farmers take loans from local moneylenders, NGOs and banks. They can repay the loan amount after harvesting. Thus, they make up the damage caused to them.

If they are not able borrow from their friends or relatives, the distressed households usually sell poultry, reserved food grains, livestock or other minor assets as the *fourth* choice adaptation strategy. This is also a common measure taken by the shrimp-farming communities. The households also sell or pawn other valuable assets such as land and jewellery as the *sixth* consumption smoothing strategy when confronted with negative income shocks. The lower middle class families, including shrimp fry collectors, generally adopt this option as a means to cope with the adverse situation. Nevertheless, selling productive assets like land may have long-term negative effects on the households' income.

On top of most of the above mechanisms, afflicted households curtail family consumption expenses as the *second* choice consumption smoothing strategy. They change eating patterns and reduce food intake and they spend less on food and clothes. This compromise in food intake can have long-term

detrimental effects especially when the nutrition of young children in the households is hampered. This is a very common practice during income shocks among fry collectors and small-scale farmers despite the fact that about half of the population in these areas are already below the poverty line, consuming only 2,122 kcal/ person/ day or less (UN 2010).

7.3.2 Income smoothing mechanisms: The second category of household responses entails income smoothing through diversifying a household's sources of income and making those sources less exposed to climate chaos (Wodon 2015). Ellis (2000) contends that rural households in developing nations diversify or transform their livelihoods because of inadequate income from single livelihood activity. Since paddy or other agricultural crops do not grow well in more than one million hectares of land in the saline region in Bangladesh (Roy 2014, Islam, Rahman and Salam 2008), and even the newly invented saline-tolerant rice varieties cannot endure the salinity level in water and soil in the areas (Roy 2014), the aquaculture communities' most common income smoothing strategy is to diversify aquaculture practice. If *bagda* production drastically falls due to viral attack or other shocks, the aquaculturists depend on other aquatic species that survive despite the shocks. Some carp and other species of fish (which they call as *shada machh*, meaning extra fish) are cultured with *bagda* including grass carps, mono-sex tilapia etc. In addition to cultured species, some other species (locally called as *bajey machh*, meaning by-products) including *tengra* and *fassey* enter into *ghers* when water is exchanged, especially in *shorboraho gher*s in Mongla area. Farmers get some earnings from those cultured and non-cultured fish

species. Therefore, in order to save their capital invested in the *ghers*, they diversify aquaculture practices as a resilience strategy.

In the current salinity regime, there is very little scope for diversifying livelihoods outside of aquaculture. Some households cultivate *aman* rice in the lean season of shrimp. However, due to water and soil salinity, rice production is not satisfactory. In addition, the price of fertilizers, pesticides and other inputs are high. Combining the above factors, shrimp farmers are generally reluctant to cultivate rice on their lands. Nevertheless, some of them cultivate this variety as an income smoothing technique. Some households tend to grow vegetables in highlands and courtyards for limited time with little success. Similarly, few households seek off-farm employment in the locality as a response to economic shock due to adverse climate and environmental conditions. Thus, livelihood adaptation as an income smoothing strategy in the face of climate disruptions in the study areas is both an incremental adjustment to regular livelihood activities or transformation of livelihood systems at least temporarily.

In the milieu of coastal Bangladesh, seasonal displacement or temporary, circular migration is a common phenomenon among the lower strata of society. Migration is a socially embedded process, which is generally perceived as an indicator of low adaptive capacity of individuals or communities to stressful changes in the environment (Adger 1999, Brooks, Adger and Kelly 2005, Salik et al 2015). However, considering the broader perspective of migration in the context of adverse impacts of climate change, instead of treating migration as a threat, it can be viewed as a form of coping strategy for the affected households (Barnett and Webber 2009, Scheffran, Marmer and Sow 2012). As an income smoothing strategy and as a soft adaptation measure (World Bank Group 2010) of

temporary livelihood diversification in the lean period or after a shock, some farmers search for employment outside the locality as day labours or agricultural labourers. These temporary migrants generally go to nearby agricultural (rice cultivating) areas such as Jessore, Mollahat, Gopalganj or to towns such as Dhaka or Khulna. They leave their families in their houses. Thus, these households frequently face insecurity, especially when the only adult male migrates out seasonally. Another coping option for the affected households is to migrate out permanently. Households migrate from the area in extreme adverse conditions. After Aila, for example, according to a UN report, as many as 40,000 people migrated from Koyra *upazila* alone (UN 2010). Similarly, Nguyen and Wodon (2015) found that 10% of households migrated from the Sundarbans permanently, and 16% sent a household member away for work.

In this study, the elder brother of one of the interviewees from Gazipara in Koyra migrated from the area to Jessore district after Aila. He lost his shrimp production entirely and found no employment in the area, so he moved to Jessore initially as a temporary agricultural labour in a household there. Afterwards, he took his family with him. Now he has become permanent in Jessore for the last seven years. Similarly, the elder brother of another interviewee from *Gabbunia* village in Koyra permanently migrated to West Bengal, India after he had lost his entire *gher* and homestead in erosion of the *Shakbaria* River few years back. The follow up information is that that particular interviewee (he was interviewed in mid-2014) also, apprehending further riverbank erosion, migrated to West Bengal in late 2015.

7.3.3 Reducing investment in human capital: In addition to the above-mentioned income and consumption smoothing strategies, the coping option of last resort entails reducing investments in human capital. Fry collectors and petty farmers from all the three areas reported that they do not seek medical advice from specialized doctors because of higher expenses. They mostly depend on village level quasi-medical persons for treating any physical ailment. This could have serious detrimental effects on the health of children of these households.

Another household level adaptation strategy as a form of reducing investments in human capital is to stop children's education after a certain stage when education cost rises. The needy families stop their children's education halfway, especially after Higher Secondary Certificate (HSC) exam. This is a common scenario in all the three areas. Only the top few (about 10-15%) households can bear the cost of higher education for their children. Education cost rises significantly after HSC because to get admission in universities they have to receive coaching; and if they get admission, they have to live in Khulna or Dhaka. This is an expensive thing for the small-scale shrimp farmers who suffer losses in shrimp production due to disease outbreak or climate shocks. In this situation, they marry their girls off after HSC and engage their boys in farm activities or let them search for jobs outside. Again, they cannot marry their daughters off to wealthy families because they cannot arrange large ceremonies or pay a hefty amount of dowry.

Because of drop outs at midway, the youth of the localities become 'unemployed' in the sense that usually they do not work full time in *ghers* and they do not get any job easily because of lack of educational qualifications. Only few of them do tutoring to school children in the community, get jobs in the

garments sector in Dhaka, or get paltry jobs in local NGOs. Social structural issues come forth here. Children from lower middle class families with some education neither can do lower class jobs like day labourers nor can get higher status jobs. They are stuck in a dilemma. These jobless youths sometimes create social problems in the community. Therefore, there are significant drawbacks of reducing investments in human capital as a coping strategy. However, the farmers could have no other choice in their precarious conditions.

7.4 Resilience at community level

Long-lasting general resilience, which is a manifestation of communities' latent adaptive capacities (Nelson et al 2007, Pelling and High 2005), can be built on strong community capitals. Community capitals are resources of a community that are invested for the collective wellbeing of the entire community. Social scientists frequently mention human capital (i.e. an individual's innate and acquired personal attributes such as work skill, education, knowledge, and health which contribute to ability to earn a living and strengthening the community), cultural capital (i.e. community's worldview, values and norms), financial or economic capital (i.e. material property, wealth and other financial sources available to be invested for business development, civic and social enterprises), physical or built capital (i.e. physical infrastructure of a community including machinery, homes, factories, water, roads, transport, shelter and energy), political capital (i.e. community members' access to resources, power and power brokers), environmental or natural capital (i.e. availability and sustainable use of natural resources for human consumption), and social capital (i.e. the extent of social networks) (Magis 2010, McCrea et al. 2014, Murphy 2007, Norris et al. 2008,

Poortinga 2012, Sherrieb, Norris and Galea 2010, Ungar 2011, Wilson 2012, 2013). In order to gauge the overall community resilience, this study mainly focused on the built, natural, social and financial capitals of the shrimp-farming communities.

The present study focused primarily on the role four major community capitals – natural, physical, economic, and social – in building and activating resilience attributes in community members as well as in the community as a whole. In the shrimp-farming communities in Bangladesh, there are somewhat developed physical infrastructures by means of roads and buildings, etc. comparing to those a few decades before; but the economic condition of the average people are not so much strong. Similarly, though these communities have rich natural or environmental capital by means of forest and water resources, they lack strong social capital to collectively fight against any disaster. They have strong bonding capital (i.e. close ‘inward looking’ horizontal ties of social network that build cohesion within a community), but weak bridging capital (i.e. loose horizontal ties of ‘outward looking’ social networks across various social and ethnic groups) and very weak linking capital (i.e. vertical relationships across power or authority gradients). This fact leads to cooperation among close relatives and neighbours during a calamity, but fails to erect a strong broader community based on cooperation and leading to self-reliance of the entire community. Moreover, there are only limited external institutional supports through governmental and non-governmental organizations. The following paragraphs explain this.

7.4.1 Natural capital: Though it is clear that none of us would survive without the help of key ecosystems services and food production from natural resources, the shrimp communities particularly, as coastal communities, rely significantly on coastal resources for their livelihood. The shrimp communities reiterated the significance of natural capitals in building climate proofed livelihoods in the region. Natural capitals, including the Sundarbans, rivers, water resources etc, have direct use value, indirect use value and non-use value (DFID 1999) on them. They recognize the Sundarbans as their main natural capital. The majority of the Bangladesh part of this mangrove ecosystem lies in Mongla, Koyra and Shyamnagar areas. As mentioned earlier, 0.6 million people from surrounding areas are directly dependent on this mighty forest for earning their livelihoods. Every day thousands of people from the research areas enter the jungles to extract assets of various categories. The Sundarbans, as the world's largest single block of tidal halophytic mangrove forest, performs valued functions to the local people. In addition to serving as breeding grounds for numerous fish, mammals, reptiles and other species of animals that we discussed in a previous chapter, this forest offers protection from waves, tsunami, tidal bores, shoreline erosion, cyclones, storm surges and other havocs that originate in the Indian Ocean or the Bay of Bengal (Barua, Chowdhury and Sarker 2010). Mangrove forests absorb 70-90% of the energy of wind generated waves (UNEP-WCMC 2006), reducing the intensity of cyclones. Moreover, mangrove ecosystems have high potential for sequestration of carbon – ranging 40-450 mt/km²/yr, and CO₂ – 184-987 mt/km²/yr (Crooks et al 2011). Considering the total area covered by the Sundarbans, it can be said that this forest sequesters enormous amount of carbon and carbon di-oxide every year. Thus, the Sundarbans acts as a shield against climate chaos for the poverty-

stricken people of the coast of Bangladesh. One shrimp farmer from Shyamnagar commented on the protective role of the Sundarbans, “*Despite our torture, the Sundarbans always protect us from disasters from the sea. The jungle is like our mother – it nourishes us, protects us, brings up us.*”

The brackish-water ecosystems in the Sundarbans are the breeding field for the *bagda*, *golda*, *horina* and other species of shrimp. All wild shrimp fry, whether inside the jungles or from the rivers, come from the Sundarbans. A substantial number of fry catchers from the research areas regularly collect shrimp PL from rivers in the jungles. From mid-April to mid-July is the peak season for collecting *bagda* fry from the Sundarbans.

In addition to the Sundarbans, the local people view surrounding rivers as important natural capitals that provide livelihood support to them. At least ten big or small rivers including *Kobadak*, *Pasur*, *Koyra*, *Kholpetua*, *Jamuna*, *Chuna*, *Malancha*, and *Shakbaria*, run through the three *upazilas*. Shrimp cultivation is directly related to these rivers. Aquaculturists use water from the rivers in their *ghers* for stocking shrimp. They regularly exchange *gher* water from the rivers. Water parameters of their *ghers* largely depend on that in the rivers. Moreover, as mentioned above, wild fry is caught from the rivers. Farmers generally prefer wild fry to hatchery fry because of their higher survival rate.

Changes occurred to the total volume of natural resources in the past ten years. Though the total area of the Sundarbans might not have reduced, according to the aquaculture community, the thickness (i.e. vegetation density) of the forest has shrunk significantly. The main reasons behind this are over extraction of wood and *golpata* (*Nipa fruticus*), severe cyclones, and corruption of the forestry department officials. The miscreants break laws and indiscriminately extract wild

resources from the forest. They randomly kill tigers, deer, crocodiles and other wild animals. The forestry officials, who are in charge of safeguarding these national resources, allow the miscreants to destroy the forest resources in exchange of rent (bribe). They help them break law.

Figure 7.3: The Sundarbans and the *Shakbaria* River

Source: Field data

The forestry officials, on the other hand, are extraordinarily enthusiastic in implementing the law (for show) which bans shrimp fry collection from wild sources including the rivers and the *Sundarbans* (Figure 7.3 is a picture of the jungle and the river). In this case also, they are motivated by their self-interest – to extract rent (bribe) from the petty fry catchers. In fact, this ill motive of the forestry dept officials is one of the reasons behind the inaction of the law (Frankenberger 2002). As mentioned in a previous chapter, a shrimp fry collector has to pay as much as 14000 BDT in bribe to the forestry officials in a season of three months.

One important point to note here is that corruption has become almost institutionalized in Bangladesh, making it a kleptocratic country. All public

sectors have corruption³² in their practices. If we take a deep look into how corruption has become so pervasive in Bangladesh, we can find that officials in the civil services have to go through a corrupt and kleptocratic system starting from their very recruitment as officials. A significant portion of them has to pay large sums of bribe in order to get their jobs. Then after recruitment, they again have to bribe the higher officials in order to get timely promotions or desired postings. Thus, these officials are the products of a system based on bribery. Again, the salary structure is not so lucrative and public officials get meagre amounts as their monthly remuneration from the government. Thus, in order to get back the amount they had already spent illegally and to gather hefty sums for their livelihoods, a majority of the public officials remain engaged in corrupt practices. This issue is more clarified in the following paragraph citing examples from corruption studies in Bangladesh.

Corruption can be defined as ‘the abuse of public office for private gain’ (Bardhan 1997) or ‘the abuse of entrusted power for private gain’ (Transparency International 2009, Mahmud and Prowse 2012). We can distinguish between eight categories of corruption: bribery; wage/asset stripping; extortion; fraud; favouritism, nepotism and patronage; refusal or negligence to provide services; influence peddling; and procurement irregularities (Karklins 2002, Transparency International 2009, Mahmud and Prowse 2012). Between June 2009 and May 2010, in order to obtain services from various sectors, 72% of households in Bangladesh were forced to pay bribes of an average amount of BDT 4834/household, equating to a national total of USD 1.36 billion (TIB 2010). Corruption in six sectors in Bangladesh (education, health, land administration,

³²For a critical discussion on how corruption penetrated especially in judiciary and bureaucracy in Bangladesh in recent times, see Islam 2011.

law enforcement, the judiciary, and tax authorities) sucked up 3.84% of annual household income in 2007 with disproportionate shares by different strata: low-income households lost 4.1%, middle-income households 3.6%, and high-income households 2.4% of annual income (Iftekhharuzzaman 2009, Mahmud and Prowse 2012). Moreover, according to a 2005 report by TIB, forest and environment is one of the most corrupt sectors in Bangladesh, with nearly 90% of people engaged in corruption in this sector are public officials (Mahmud and Prowse 2012). All the above findings are reflected in bribery cases of the forestry department officials in the Sundarbans. The fry catchers are in the lowest socioeconomic strata in the country and they have to pay proportionately the most share. They are just victims of the system.

Shrimp fry catchers also reported that in addition to the corrupt forestry officials, another major problem in the jungle is frequent attacks by robbers. There are numerous robber bands in the Sundarbans – each year the number is increasing because the social evils who have charges and court cases of murder and other severe crimes against them take refuge in the Sundarbans coming from different parts of the country. According to local people, these miscreants are the ‘kings of the jungle’. In the jungles, they have no tension of being caught by the police. They earn their livelihoods just by robbing without any fear. One of the fry collectors commented with anguish, *“The Sundarbans is not a reserve forest for tigers; it is a sanctuary for dacoits.”*

Every year at least two groups attack a fry catcher. Generally, the robbers take the fry collectors in their custody, by force and by terrorizing with firearms, as hostages. The fry catchers’ family or friends rescue them after paying the sum of amount claimed by the miscreants. In 2014, the rate of their demand was 8000

BDT/boat. Thus, a fry catcher, in addition to paying 22000 BDT/season as rents and bribes to police and forestry officials, has to pay at least 14000 BDT to the dacoits every season. After paying so much money and being bonded to the *dadandars*, the petty shrimp fry collectors, in reality, cannot make any profit from their profession at all. For this, a shrimp fry collector from Koyra lamented in agony, *“People bring up their own children. After biting hard work, we bring up the forestry officials, the police, and the dacoits. Our children have nothing to get from us.”*

Natural capital from rivers also declined in the last ten years. The availability of fish and other aquatic resources in the rivers has gone down sharply. The major reasons behind it are water pollution, oil spillage³³ from ships, killing fish by applying poison at the mouth of the Pasur River by miscreants, and wild shrimp fry collection. Aquaculture people in Mongla reported that one of their main environmental concerns is that water in Pasur River is becoming poisonous day by day. The reason behind it is the fact that some miscreant groups catch fish by applying poisonous liquid in the canals at the mouth of the river deep into the Sundarbans. This poison spreads all over the areas through water. As we mentioned earlier, though shrimp fry catching from wild sources is prohibited by law now, the fry collectors cannot stop catching because of some practical reasons. One of them is that they have no alternative jobs to do. Therefore, stopping the decade old profession is an existence threat for them. The wild fry collection part is the only component in the commercial shrimping that is deteriorating for natural environment. In addition to the decline in forest and river

³³ A recent incidence of oil spillage occurred on the Shela River in the Sundarbans on December 9, 2014 when an oil tanker, carrying about 350,000 litres of crude oil, collided with another vessel and partly sank in the water. The oil spill spread over a 60 km long area along the Shela and the Pasur rivers, which was branded as an ‘ecological catastrophe’ in the Sundarbans, threatening trees, planktons, and vast populations of fish and dolphins (The Guardian 2014).

resources, total landmass of the areas also declined in the last decade. Due to riverbank erosion, especially in Koyra, the community lost hundreds of acres of land. Contrarily, only few small *chars* (island) emerged in the rivers, but those *charlands* are not inhabited yet.

Though overall natural capital declined, it continues to be very vital for building resilience to climate change for the local communities. Local people's perception, which matches with scientific findings, is that the Sundarbans is a natural protector for them against cyclone and other disasters. As mentioned above, this mangrove forest reduces the strength of cyclones significantly. Moreover, the forest and the rivers are the last resort for many during disasters in the shrimp communities. After Aila, for example, people had no employment in the locality since all *ghers* were washed away and could not be cultivated again for up to two seasons. Many small-scale shrimp farmers have no other choice but to go to the jungle and river and try for earning their livelihoods there. One of the interviewees in Koyra, after losing his *ghers* in Aila, started collecting honey from the jungle. He worked in a group of four. Every day, from dawn to dusk, they would collect about 40 kg of honey that they would split among themselves. In this way, he earned livelihood for his family plus education costs of three young brothers. From this case study, it is obvious that in addition to protection and regulating services, the forest offers provisioning services to the shrimp-farming community in times of crises, allowing them to be resilient to shocks.

7.4.2 Built capital: In terms of the development of physical or built capital, the aquaculture communities are in moderate to lower position. Affordable transport, secure shelter and buildings, adequate water supply and sanitation, clean and cost-

effective energy, and access to information are the major components of built capital that are crucial for sustainable and resilient livelihoods (DFID 1999). Most of the dwelling houses in these areas are *kacha* houses built with tin roof, earthen floor and wooden walls. During Aila, most of the thatched or mud houses were completely damaged. After that, almost all households improved their housing conditions but still *paka* (full brick-built) house is rare in the vicinity. The vast majority (above 95%) of the dwelling houses are *semi-paka* (floors are brick-built) or *kacha* which are not cyclone resilient. Climate change projections predict a 10-year return period of average severe cyclones in Bangladesh and as seven years have already passed since Aila, people are vulnerable to be affected by another cyclone with most of the people living in current housing structures. In the vast majority of villages, there is no electricity connection from the Rural Electrification Board (REB). However, they have solar panels for lighting their homes. They purchase solar panels by themselves or by taking financial help from NGOs. A few NGOs – such as Islamic Relief, Bangladesh – also provided solar panels for the needy households free of cost after Aila. In addition to privately owned dwelling houses, there are government and non-government establishments such as buildings of various offices and organizations, educational and religious institutions, and cyclone shelters, which are part of the areas' physical infrastructure. Table 7.1 shows some of the selected categories of institutions or establishments the buildings of which are accessible to common people especially during disasters.

Table 7.1: Number of selected types of establishment in the research areas

Institute or establishment	Mongla	Koyra	Shyamnagar	Total
College	4	3	6	13
High/Junior high school	26	48	41	115
Government primary school	32	54	81	167
Registered non-govt primary school	29	58	73	160
Community primary school	3	14	22	39
Madrasah	16	28	38	82
Mosque	110	157	499	766
Temple	29	136	94	259
Church	11	1	0	12
Cyclone shelter	16	47	16	79
Total	276	546	870	1692

Source: Respective *Upazila Nirbahi* Offices

Other than the above-mentioned infrastructures, there is a total of 227 km paka (carpeting) road in the three *upazilas*, and 275 km of brick-soling road out of more than 1737 km of road. The total length BWDB embankment in Koyra and Shyamnagar is 339 km with 46 sluice gates. The main transports used for harvesting, carrying or marketing of shrimp or shrimp PL are truck, lorry, trawler, *korimon-nosimon*, pick-ups, motorcycle, rickshaw-van, bicycle etc. In general, condition of roads is not good in the aquaculture communities. Instead of being an asset for resilient livelihoods, roads and transport infrastructure can become a constraint. If the roads are not in good condition, shrimp farmers and traders are deprived of expected amount of profit due to the damage of shrimp and extra carriage cost. A shrimp trader at Bongshipur Mokam sarcastically commented on the condition of a local road, “*If you go to Nowabenki from Shyamnagar Proper by motorcycle,³⁴ your kidneys will fail, let alone your shrimps!*”

Despite the fact that overall built capital of the communities is not developed enough so that it might be viewed as an effective community resilience enhancer, some advances happened during the last decade. As mentioned above,

³⁴ Rented motorcycle is one of the main passenger-carrying vehicles on that road.

after Aila local people made their houses stronger. The length of carpeted roads also increased slightly. The government and NGOs built a few cyclone shelters where people, who have no disaster-resilient house, can take refuge during cyclones. Nevertheless, a majority of cyclone-affected people do not, cannot, or are unwilling to go there because of a number of safety, security, hygiene, environmental, awareness, proximity, gender or religious factors (Mahmud and Prowse 2012, Schmuck 2000).

Built capital can provide essential services in the wake of disruptive climate events. It is used in various capabilities in order to enhance adaptability of the community. During Sidr, 15% of the affected people took refuge in cyclone shelters. Currently there are 2591 cyclone shelters in which 2.8 million people (7.3% of coastal Population) can take refuge during disasters (World Bank Group 2010). Generally, people also take shelter in neighbours' houses if those are strong enough. Schools and college buildings are also used as temporary cyclone shelters for a few days. Though mosques and temples are not usually used as cyclone shelters, disaster warnings are circulated through announcements from mosques. While newly constructed cyclone shelters have provisions for keeping cattle at the open space of ground floors, during cyclones and storm surges, cyclone shelters could not be used for any shrimp related purpose. Only the affected people can take shelter there. If, for example, a cyclone hits the community at a time when a farmer had already harvested shrimp from his *gher*, he cannot use the shelters for preserving harvested shrimps. He can have only two options either to leave it at home unattended or to sell it to *farias* within the quickest possible time, generally for a cheap price. There arise some people during the disasters who exploit the situation.

As mentioned earlier, though BWDB embankments have some drawbacks, they are crucial for adopting a resilient livelihood in the locality. The embankment protects shrimp *ghers* in Koyra and Shyamnagar from regular tidal surges and low-elevation storm surges. Other built structures that enhance adaptability of aquaculture livelihoods are roads and transports. Despite the fact that the road transportation is not well developed yet, most of the main roads are at a satisfactory level, according to the farming community. The Shyamnagar – Satkhira and Mongla – Khulna roads are good enough to transport shrimp and shrimp fry without any major casualties.

7.4.3 Economic capital: In general, economic strength of a community depends on total economic growth and the stability and distribution of income among community members. Economic or financial capital is vital because it can be readily converted into other types of capital in times of necessity and can be used for achieving desired livelihood outcomes (DFID 1999). In general, the state of finance capital and its role in building resilience is poor in the shrimp communities, if we consider it from a community perspective. According to the key informants, average size of about 80% of *ghers* in these areas is 5-8 bigha. From one *gher* of this size, a farmer can sell shrimp and fish up to BDT 250,000 – 300,000 every year in normal situation. He can make a neat profit of up to BDT 150,000. If the *gher* is attacked by virus or suffered from production loss due to climate disasters once in a season, the farmer can still recuperate the loss and make little amount of profit. However, if a *gher* is attacked twice or more times in a season, the farmer cannot make profit – he has to incur losses. As discussed above, he tries to recover from this type of situation by taking different income

smoothing or consumption smoothing measures or by reducing investments in human capital.

Generally, people in shrimp communities cannot save much. Whatever amount they can save at the end of a season, they reinvest it in aquaculture or buy land. A few shrimp farmers deposit their savings in banks or NGO accounts. Some NGOs, including JJS, Prodipan, and Brac, have deposit schemes in the area. In addition to banks and NGOs, some local cooperative associations and clubs have deposit schemes for their members. Members of those cooperatives or clubs regularly deposit various amount of money ranging from BDT 20/week to BDT 10/day.

In addition to registered cooperative associations and clubs, there are unregistered and informal collective arrangements for accumulating capital in the coastal region, which arose from particular production relations. Southern Bangladesh is a region of polders. Shrimp *ghers* in Koyra and Satkhira are inside the polder areas. Aquaculture people bring saline water from rivers in various ways. In 13-14/2 polder in Koyra, for example, shrimp farmers generally adopt four different pathways to bring water from the Kobadak and the Koyra rivers. First, the small-scale farmers whose *ghers* are near sluice gates of the embankment use those gates; second, the rich farmers with *ghers* of hundreds of acres make sluice gates by themselves cutting the embankments; third, small-scale farmers whose *ghers* are not near the sluice gates put pipes beneath the embankments by boring those; and fourth, small-scale farmers whose *ghers* are not by the side of sluice gates bring river water through siphoning method, locally called *ninety system*, putting 6-12 inch diameter pipes on top of the embankments and using tube-well to run water through the pipes. Generally, 20-25 small-scale

farmers use a single underground or overtop pipe to supply water in their *ghers*. Now, the farmers who share the same arrangement for using river water create informal cooperatives among them. They form a committee comprising a president and a cashier, and generally deposit BDT 50-100/month/farmer. If any of them face any crisis, he can borrow from the common fund without paying any interest. Thus, aquaculture people have some minor channels to possess liquid asset that can be readily cashed and spent in crisis times.

Major livelihoods and employment opportunities in the areas are aquaculture, agriculture, petty transport driver and worker, shrimp trading, shrimp fry collection, other shrimp related jobs, small-scale business, jobs in government offices and NGOs, wood and honey collection from forest, and teaching in local educational institutions. According to the aquaculture workers, no significant new jobs were created in the localities during the last 10 years. The only new employment opportunity that has been created is in few mobile top-up outlets. Therefore, in the lean seasons (September-November), when shrimp is not cultivated, farmers do not have any serious work to perform. After harvesting shrimps, there remain some other fishes (*shada machh* and *bajey machh*) in *ghers*. They remain somewhat engaged with *ghers* taking care of those fish and preparing the *ghers* for next season. Only a few of them cultivate rice during this three-month period. In this lean period, usually they have no income from *ghers*; they spend from their savings that they made in the peak season. Shrimp fry collectors remain engaged in their lean periods in fishing in rivers and collecting honey and golpata from the Sundarbans. Also, some of them seasonally migrate from the area to find work as agricultural labourer in nearby districts.

Disaster resilience support amongst immediate family members is very vital. Beggs, Haines and Hurlbert (1996) found that family members provide essential recovery assistance during disaster periods. One or more members from less than 10% of families live in different cities and towns in Bangladesh for job or business purposes. They send money to their families, some of them on a regular basis and others occasionally. The amount of remittance depends on their income and savings. The households use that money for various purposes including land purchase, regular family expenditure, festivals and family occasions, shrimp cultivation etc. They also use the remittance for enhancing coping capacity of the households to weather shocks.

Other than the above-mentioned household-level and small-scale group initiatives, there is no common community fund in any of the three aquaculture communities, a fact which makes collective engagements in resilience-enhancing or other community activities difficult. Therefore, any financial liability for recovering from weather shocks or disease outbreak in *ghers* goes to the affected *gher* owners; the community as a whole do not take any measure.

According to the farmers, overall economic condition of the community has deteriorated slightly in the last ten years. Before this period, salinity problem was not so severe and disease outbreaks in shrimp were not so frequent. Most of the aquaculture farmers would make profit on a regular basis. However, Aila changed the whole scenario – salinity ingress has been accompanied by viral attacks in *ghers*. In addition, frequent heat waves are affecting the shrimp yield in the locality in recent years. Furthermore, according to the key informants, the loss that the community people suffered from Aila has not yet been recovered fully.

7.4.4 Social capital: Social capital is the most intangible, hard to measure and complex part of community capital. Social capital of a community depends on its members' networks and connectedness, membership of more formalized groups, and relationships of trust, reciprocity and exchanges that enhance cooperation, reduce transaction costs and provide informal safety nets for the vulnerable groups (DFID 1999). Resilience is affected by multilevel attachments, both distal and proximal, including family, peers, neighbourhood, community, and society (Greene, Galambos and Lee 2003). Broadly, social capital in a community develops through objective formal and informal group ties and networks, norms, and social trust (Coleman 1988, Putnam 1995, Smith, Anderson and Moore 2012).

If we look into the bonding, bridging and linking social capital in the shrimp communities we find that bonding capital is strong among neighbouring households and among households who are friends or relatives of each other. They meet frequently on various occasions and tend to help each other in times of need. In this way, they receive psychological-emotional, informational, and tangible supports from the close groups. These close groups are the primary source of social support in the shrimp communities. Social support in the shrimp-farming community, as in elsewhere, can be viewed as social interactions that offer tangible assistance to the farmers as well as a loving and compassionate social relationship among community members. Generally, shrimp farmers enquire about the situation of neighbours' farms when they visit their homes or when they talk over mobile phone. The farmers visit their neighbours, relatives, or friends' house 4-5 times a week, spending less than an hour per visit. Though they generally do not have meals during these irregular courtesy visits, they share their thoughts on different issues. Moreover, in addition to emotional and informational

support, they get financial help in times of need. As discussed before, borrowing money from close friends or relatives is the third choice consumption smoothing strategy adopted by a farmer in crisis. Islam and Walkerden (2014) found that Sidr-affected households in Barguna received tangible and intangible supports from the households of in-laws in great deals. But the findings from this study suggest that shrimp farming households in south-western Bangladesh tend to receive more frequent supports from the neighbouring households, at least if they need immediate intangible and small-scale financial support, whether they are relatives or not. Thus, proximity matters. Neighbouring farmers are cooperative with one another in farm related activities also. If one goes to Satkhira, Chuknagar or Rampal to buy shrimp PL, for example, usually he also purchases for his neighbour, if requested. In addition, if a *gher* owner faces any disturbances in the *gher* he consults with the owner of the neighbouring *gher*. The neighbour advises him as per his knowledge.

Beggs et al (1996) view community bonds as ‘informal insurance’ that allows victims to receive tangible (financial, physical, logistic) and intangible (emotional, spiritual, informational) supports. Bonding social capital among the community members in shrimp areas, in general, except close neighbours and friends, is not so high. There are a number of organizations and cooperatives in the communities that act as formal platforms, which provide aquaculture members to be connected with a wide range of people from his/her profession and locality and beyond. A farmer can get additional tangible and intangible resources through the added connections that might be used in pursuing specific goals and solving collective crises. In Mongla, Koyra and Shyamnagar there are a total number of 703 cooperative associations and 121 clubs of various categories. These

organizations take decisions on matters after discussing among the members in general or among members of the executive committees in particular. Thus, community members have a fair share in the decision-making processes of these small-scale groups.

As mentioned above, these clubs or associations raise funds through deposits by members. It is found from field-level observation that since the majority of the organizations are clustered in *Upazila* central areas, most of the shrimp farmers from peripheral villages do not get involved in any of these associations or clubs. Therefore, they do not get any support from them. In general, a club or association office serves as a meeting place for the members, they can share their individual or common problems with one another, and they can get advice from others. In addition, some of these groups offer loan facilities, though often a very insignificant amount, for the members. The farmers get loan at the start of the season when they stock shrimp PL in *ghers*. They need to pay the loans by weekly or monthly instalments. Interest rates on these micro-loans range between 10% and 12%. The association leaders also give advice on shrimp cultivation. Since the leaders do not have any experience of receiving training on shrimp farming, the cooperatives do not provide any training facility for the members. They cannot offer any specific training on how to adapt to rising temperature, salinity intrusion, cyclonic storms, or viral attacks in *ghers*. The leaders only offer advice based on their experience. Though these organizations do not focus solely on climate change issues, they arrange some awareness sessions for local youths before disasters like cyclone or storm surges. The youths then start helping the old, children and the disabled. Thus, a section of shrimp farmers might have some informational, advising and financial support from these

secondary and formal groups, especially in times of financial shock triggered by weather shocks. As we have discussed in the financial capital section, in addition to formal and registered cooperatives and clubs, there are special informal groups based on water sharing.

Besides the above-mentioned cooperative and club activities, bonding social capital enhances through informal get together sessions at various places on daily basis. Aquaculture people frequently meet at the local tea-stalls, for example. They also spend time playing cards, chess or carrom. At these sessions, the farmers share their views and ideas on various issues. The most popular topic is the current political issues in Bangladesh and beyond. One of the farmers from Koyra commented on this, *“Since unemployment rate is high in the locality, most of the people have a lot of time to gossip. They debate fiercely at the tea-stalls on the latest political agenda of the world. (It seems that) they all are master politicians.”* At these tea sessions, they also share shrimp-related current issues and problems. For example, they share information on the price of shrimp, any incidence of viral attack in *gher* etc. In addition, they share any information on latest weather developments, if they know it. At these sessions, problems are shared only; no particular solution comes out of them.

In general, people in shrimp farming communities are peace loving and live in harmony. Nevertheless, a few disputes grow at times mainly over land ownership and lease issues and other social matters. The disputes are settled largely at community level. Two age-old informal traditional institutions play roles in this context: *samaj* (meaning community, a platform based on kinship, neighbourhood or caste) and *salish* (meaning arbitration, a forum of mediation involving the clergy and prominent community leaders). When a dispute is

brought before the *samaj*, community leaders arrange a *salish*, in which the dispute is settled and all involved parties agree with the decisions of the *salish*. In shrimp communities, very few conflicts are brought before formal courts, the disputes that cannot be settled through the *salish* at local level, generally involving civil and criminal problems.

In shrimp farming villages, traditionally the elderly and respected people are treated as community leaders. As von Rueden and colleagues reported that group members are wary of maltreatment by leaders in small-scale egalitarian societies, credibility, generosity and justice are central to leader emergence and effectiveness in these communities (von Rueden et al 2014). Similarly, in agrarian village communities in Bangladesh, pro-sociality is vital for leadership; therefore, the traditional leaders strive to do good for the community as a whole, and they remain unbiased to all in the community. These community leaders include the elderly, the educated class such as schoolteachers, traditionally landed class like (the previously) *zaminders*, and religious leaders like the imams of local mosques. On an average, community members respect and have trust in them and consequently they have an authority over the community people.

However, during the last couple of decades, a change in the community leadership in rural areas has been in operation. Now, local political elites and newly emerged moneyed class have turned to be the leaders of the community. This newly emerged leadership is not well accepted by community members. Researching in shrimp aquaculture villages in Paikgacha, Khulna, Mohammad Bashir Ahmed (2011) associated this shift in the leadership in rural communities with the emergence of shrimp regime in the localities. Nevertheless, this is a general trend in village communities throughout the country. Mozumdar et al

(2008) and Lewis and Hossain (2008), for instance, found the same pattern in changing leadership in rural Bangladesh, studying in agricultural villages in Mymensingh and Faridpur respectively. A number of factors are responsible for this shift including changes in political structures; changes in local level administration; influx of liquid money in rural areas; NGO interventions; the impact of media, modernity, and globalization; and so on. Rural Bangladesh has been passing through a transitional phase in which critical shifts are taking place in social structure and organizations. Generally, the elderly in a community cannot keep pace with rapid institutional transitions, and thus they lose their authority (von Rueden and Vugt 2015).

In Max Weber's authority development scheme, legal-rational authority replaces traditional authority in modern capitalist rational society (Weber 1968, Ritzer 1996). In other words, the rise of rational economic and political structures is a prerequisite for the development of legal-rational authority. If a society lacks in developing rational economic structures, it lacks in developing rational authority. We find in the case of Bangladesh that the country is going through a critical transitional phase in which economic structures are based neither fully on feudal production relations nor on modern capitalist production relations. Thus, in this midway of social development, a chaotic condition is prevalent in economic and political structures. Traditional leadership is losing authority, but rational structures of authority have not yet taken a complete shape. A new type of kleptocratic authority is on the rise. Thus, when asked about who the leaders are, members of shrimp-farming community were divergent in their reply – in some respect they opine for traditional community leaders, in other respects for local

political leaders, still in other respects for elected local government representatives like Union Council chairmen and members.

This newly emerging leadership is not so much trustworthy to the community members. Trust is an important component of social capital. Without trust among the members of a community, bonding relationships cannot be strong. Similarly, bridging and linking capitals also depend on trustworthiness of the involved individuals and groups. Trust can be defined as “socially learned and socially confirmed expectations that people have of each other, of the organizations and institutions in which they live, and the natural and moral social orders that set the fundamental understandings for their lives” (Barber 1983:165, cited in Smith et al 2012:384). The importance of trust lies in the fact that it enables people to undertake actions that otherwise would not have been possible without its presence. A shrimp farmer’s resilience to climate change, his motivation to learn and plan, and his concern in changing behaviour – may all be influenced by the degree to which he trusts others in his community and beyond.

Literature on trust suggests four types of trust: dispositional (depends on a trustor’s inclination to trust or distrust in a given situation), rational (depends on trustors’ assessment about what they believe to be the expected outcomes of potential trustees’ expected actions), affinitive (depends on the amount of meaningful personal relationships between trustors and trustees), and systems-based (depends on a set of procedures and rules or systems) (Stern and Baird 2015). In addition to these types, there may be ‘lack of trust’ or ‘distrust’. Lack of trust indicates a situation where a trustor cannot make a judgement about a likely trustee’s action because the trustor does not have ample information. Distrust, on

the other hand, implies an individual's explicit negative expectation about the prospective trustee.

Shrimp farmers in coastal Bangladesh have very high level of trust in family members. They trust their fellow community members to a great extent. These people include their friends, neighbours, relatives, and people of their own village, regardless of religion. They have less confidence in people from other communities and villages. Except the traders themselves, other stakeholders (farmers and fry collectors) have very low level of confidence in businesspersons and traders. The shrimp-farming community, in general, has very low trust, lack of trust, or distrust on politicians, government officials, local government representatives, the police, and the courts.

A few points need to be added to the above-mentioned trust gradient. Very high level of trust in immediate family members reflects affinitive trust. Since they know their neighbours well through continuous interactions and since they have mutual dependence on one another, they put higher trust in community members irrespective of religion or ethnicity. They do not base their confidence on ascribed identities like ethnicity or religion, but on rational understanding through experiences. Thus, according to them, there are culprits among followers of every religion whom none can trust, and so reliance and trust vary from individual to individual, regardless of religious affiliations. This is the common view among the Hindus, Muslims, *Mundas*³⁵, and *Bagdis*³⁶ of the research areas. Thus, despite media portrayal of Bangladesh as a fertile ground for rising Islamic terrorism (Choudhury 2014, Roul 2015), field data suggest a unique communal harmony in rural Bangladesh. Since people from other villages and communities

³⁵ An ethnic minority group in south-western Bangladesh

³⁶ A traditional fishing community, lower caste Hindu by religion

are generally not in regular contacts, trust in them is at lower range. As mentioned earlier, a kleptocratic public administration in Bangladesh caused the people to have low confidence in government officials. For political leaders, the shrimp-farming community has divergent views. They have no confidence in the leaders in general, but a few national level leaders are trustworthy to them. The Member of Parliament (MP) from one of the research areas, for example, is very popular in the region and he is sincere and serious about local problems. The majority of the people in the shrimp producing community have the least trust on the police. They equate the police with corruption and bribery. The image of public officials and the police is a reflection of systems-based trust (or distrust). Generally, people have lack of trust or distrust in these two institutions – it does not matter much to them who holds the post.

Bridging social capital forms through formal and informal horizontal connections between two or more parallel communities. The shrimp farming villages keep contact with one another for various purposes. Generally, shrimp households maintain regular contacts with neighbouring villages for business, agriculture, aquaculture, education, and religious purposes. Moreover, they visit those villages for meeting friends and relatives. Bonds among different communities increase through occasional arrangement of joint programs like sports, festivals etc. Since people are busy with own jobs, they cannot manage time for frequent physical visits to neighbouring areas, but they keep contact with friends and acquaintances through mobile communications. They take suggestions from friends and relatives in other shrimp farming communities on the various stages of shrimp cultivation such as *gher* preparation, shrimp stocking, in-culture *gher* management, shrimp harvesting, shrimp marketing etc. Sometimes they also

borrow from or lend money amongst one another. Generally, people from one community are not involved in climate change adaptation programs in another community. Nevertheless, the farmers share ideas and information about any weather and climate related problems over mobile phone, when they contact each other. Thus, there is a weak form of bridging social capital in the shrimp communities through informational networks, if we assess it from the perspective of climate change resilience.

In the shrimp farming communities, vertical linking social capital is also very weak. The community leaders are somewhat connected to *upazila* level administrative and political authorities, but only few of them have connections with district or national level authorities. If shrimp farmers inform the community leaders about any aquaculture-related problem, they generally approach to the Union or the *upazila* administration. However, the farmers do not get effective solutions at these levels, especially if their *ghers* under threat from climate change or environmental perturbations. Some of the leaders, especially one UP member from Koyra and the MP of Mongla, frequently try to contact national-level policy makers in order to make them aware about the local perspectives of the shrimp farming communities. The MP speaks in the National Parliament about local problems including riverbank erosion and SLR. Thus, there is an effort to use the upward linkages in favour of addressing climate change adaptation policies. However, these efforts have not brought any significant positive result for shrimp aquaculture in Bangladesh.

In addition to the above bonding, bridging and linking aspects, there are disaster management committees (DMCs) at *Upazila* (headed by *Upazila* chairman), Union (headed by UP chairman), and (now) Ward levels (headed by

Ward member) for addressing specific weather extremes like cyclones. If there is any warning for cyclone, the DMCs meet and decide on likely measures to adopt. The DMCs then make the community aware through circulating the warnings. Thus, event-specific measures are taken only for extreme disasters. These actions too do not address the problems that shrimp farmers might face.

Some changes have occurred in the different aspects of social capital in the last ten years. Now shrimp farmers visit the homes of relatives, neighbours or friends less than before. Similarly, people would send cooked food items to their neighbours' homes more frequently than they do now. The reasons behind these changes are, among others: people can contact others more easily over mobile phones now which was not as common before, most of them have become self-centred, many of them remain engaged with their own businesses, and the price of daily necessities has risen sharply. Due to advancement in the communication and transport sectors, the peripheral rural people are now more connected with national centres, a fact which broadens their linkages. According to the shrimp farmers, participation in social and religious gatherings decreased slightly because most of the local youth remain busy in mobile and online connections, through which they receive news and information of the whole world even on socio-religious issues. They sometimes do not feel these programs necessary for them. Moreover, because of widespread mobile connection, face-to-face contact among friends and relatives from different areas declined in some degree. As mentioned before, a shift in community leadership is also taking place. All the above-mentioned factors are playing roles in influencing the overall amount of social capital in the communities.

From the above discussion, we can draw the following conclusions on the role of community in building resilience in the commercial shrimp sector in Bangladesh.

1. If a shrimp farm is affected by weather shock or environmental and climate change, the responsibility of adaptation and recovery rests solely on the *gher* owner or cultivating farmer in charge.
2. The community as a whole does not take any measure to build resilience to climate perturbations in the sector in general.
3. The community has disaster management committees (DMCs) which take event-specific measures only for extreme weather events. Their actions generally do not address the problems that shrimp farming might face during the disasters.
4. The capability of the community in addressing climate issues is very low.
5. The capability of the community has changed over time, since various categories of community capital have changed (increased or decreased).
6. Whatever tangible and intangible resources the community has are not utilized properly for the benefit of the whole community.
7. Bonding social capital within primary groups is still effective in resilience-enhancing initiatives in the community. Although the sole responsibility of adaptation to and recovery from climate shocks and other calamities lies in individual farmers, the affected farmer often receives tangible and intangible supports from his close neighbours, relatives, or friends.

8. Thus, we can say that the community role in building resilience is moderate in some aspects and low in other aspects.

7.5 Outside interventions: governmental initiatives

Given the enormous convulsion and multiplicity of climate change hazards, and implications for lives and livelihoods of local communities, it is hard for the communities alone to face its manifold challenges. Though resilience approach emphasizes on self-organization of the communities, by promoting the idea that resilience comes within them, it risks underestimating the challenges of creating this type of internal shift (Martin et al 2015). Thus, outside interventions are essential to address the internal challenges and boost resilience of a community. In order to increase community resilience, it is important to enhance positive relationships within and among communities and, for the local government service providers, to capitalise on existing relational resources and encourage their further development (Murphy 2007). Synergy between the state and community social capital is significant in the sense that state-society linkages are important both for wider sustainable development and for the co-management of resources. State institutions like the government and formal laws play the pivotal role in determining access to resources and defining the architecture of entitlements, which is based on material and social aspects of resource use (Adger and Kelly 1999). State authorities can augment sustainable and resilient resource management and boost coping capacity of the communities (Adger 2003).

7.5.1 Case study 1: The Coastal Zone Policy 2005: With the aim of addressing the adverse impacts of climate change in Bangladesh, the consecutive

governments have adopted a series of policies, programs and action plans. Moreover, there are a number of policies³⁷ adopted by different ministries to address coastal or aquaculture issues. Although these policies directly or indirectly addresses at least one of the themes – coastal zone, aquaculture, and adaptation to climate change – here we can review two of them, which are the most relevant for the topic of this research. The Coastal Zone Policy 2005 (CZPo), builds on the different sector-oriented policies. It declares the Bangladesh government’s intention to build an integrated coastal zone management (ICZM) scheme in Bangladesh. It defines the goal of ICZM as “to create conditions, in which the reduction of poverty, development of sustainable livelihoods and the integration of the coastal zone into national processes can take place” (MoWR 2005:3). The prime goal of the coastal development process is to enhance economic growth and poverty reduction in the zone. To achieve this goal, the CZPo emphasises the use of available opportunities through effective management – it declares shrimp culture as a priority livelihood sector for the coastal zone, investing in it can enhance the living standard of the coastal communities. In order to increase the income of the coastal people, the CZPo also focuses on exploring economic provisions based on local resources. The provision of *bagda* culture in brackish water is treated as an opportunity in resource utilization.

³⁷ Some of the policies and acts that directly or indirectly incorporate aquaculture, coastal and climate change issues are National Environment Policy (1992) and Implementation Plan (1992), National Tourism Policy (1992), Livestock Development Policy (1992), National Forestry Policy (1994), National Children Policy (1994), National Environment Management Action Plan (NEMAP) (1995), National Energy Policy (1996), Environmental Conservation Act (1997), National Education Policy (1997), National Fish Policy (1998), National Policy for Safe Water Supply and Sanitation (1998), The National Policy for the Advancement of Women (1998), National Water Policy (1999), National Agricultural Policy (1999), Industrial Policy (1999), National Shipping Policy (2000), National Health Policy (2000), National Rural Development Policy (2001), National Land Use Policy (2001), Coastal Zone Policy (2005), National Adaptation Program of Action (NAPA) (2005), Coastal Development Strategy (2006), Bangladesh Climate Change Strategy and Action Plan (BCCSAP) (2008 & 2009), second Poverty Reduction Strategy Paper (PRSP-II) (2009), and National Shrimp Policy (2014).

As part of livelihood enhancement activities, the CZPo aims to promote collateral-free credit with simple terms and conditions. Thus, the CZPo recommends loan facilities for the coastal communities, including shrimp cultivation. In another clause the CZPo, in fact, discourages an arbitrary halt on shrimp fry catching or other employment opportunities in the zone without ensuring alternative employment. The CZPo also emphasizes on improving the condition of built structures in aquaculture areas especially by developing “an integrated network of communication including highways, major roads, rural roads, railways and waterways” (MoWR 2005:4). In order to address the vulnerability of the coastal poor, it recommends the introduction of an insurance plan for improving their social security. For addressing natural disasters and climate changes, the CZPo suggests specific measures. For protecting the coastal community against coastal and riverbank erosion and for rehabilitation of the affected people, the Policy reiterates the adoption of effective measures. Regular maintenance of sea-dykes and embankments is prioritized as a first line defence against cyclonic storm surges and tidal surges. The Policy also suggests combined safety measures against cyclones incorporating the construction and maintenance of cyclone shelters, road system, multi-purpose embankments, *killas*, and cyclone warning system. It encourages the planting of trees in the coastal region through social forestry schemes.

As part of effective management of natural resources, the CZPo encourages environmentally sustainable and socially responsive shrimp aquaculture in the zone. It recommends the optimum utilization of every opportunity and potentials of coastal aquaculture including shrimp, crab, pearl, and sea grass culture. It suggests that special measures should be taken for the

preservation and development of the natural ecosystems resources in the Sundarbans. The CZPo also recommends special adaptive measures for the coastal zone against climate change and implementation of the identified resilience schemes. It suggests an institutional framework for observing SLR and a contingency plan for adapting to the impact of SLR³⁸. From this review, we find that the Bangladesh government encourages and assists a sustainable, climate-proof shrimp aquaculture in the coastal belt of Bangladesh.

7.5.2: Case study 2: The National Shrimp Policy 2014: Since shrimp is a contested industry, there had been a demand for long from concerned parties for a comprehensive shrimp policy in Bangladesh. After four decades of commercial shrimp farming in Bangladesh, the Ministry of Fisheries and Livestock finally adopted ‘National Shrimp Policy 2014’ (SPo) on August 18, 2014 (MoFL 2014:17097). This is the only government document that deals exclusively with the shrimp industry in Bangladesh. The prime objectives of the SPo include enhancement of the production of shrimp in the country through culturing shrimp in a planned way that incorporates the application of appropriate technologies and the consideration of economic, social, environmental, and climate change issues in the farming zone; adoption of vertical or horizontal or both techniques in expanding the production of shrimp; fulfilment of the national demand of animal protein through sustainable development and management of available resources; emphasis on environment-friendly integrated shrimp farming, crop diversification and crop rotation management; appropriation of proper measures for alleviation of poverty and improvement of socio-economic conditions of small-scale and

³⁸ This review of the Coastal Zone Policy is primarily based on the Ministry of Water Resources document ‘Coastal Zone Policy 2005’ (MoWR 2005).

marginal farmers, fishers, and other people engaged in production, procurement, processing, and marketing of shrimp; adoption of necessary measures to effectively stop shrimp fry collection from natural sources by providing alternative livelihoods for the existing shrimp fry collectors; production of healthy and disease-free shrimp PL through specific pathogen-free (SPF) brood stock; development and application of suitable techniques for tackling climate change risks; and institution of protective system against diseases in shrimp through development and application of modern and sustainable management systems.

The SPo defines a few areas for its implementation that include shrimp production and sustainable management, creation of employment opportunity and poverty alleviation, improvement of socio-economic conditions of the people engaged in shrimp industry, and training and research on shrimp culture. The strategies for implementation of the SPo include gradual transformation of existing extensive and improved extensive culture method into semi-intensive farming, disbursement of financial grants for disaster affected shrimp farmers, arrangement of exchange of water in shrimp culture in-polder and out-polder areas through sluice gates approved by the BWDB; improvement of shrimp culture infrastructure maintaining the environmental symmetry; conservation of natural water bodies and ecosystems in the mangrove forests and the adjacent Bay of Bengal through environment-friendly shrimp culture in the vicinity; prohibition of the intrusion of saline water on any piece of land in the coastal districts without prior consent of the owner of the land; limiting the size of *bagda* farms up to 12.14 hectare (30 acres); encouraging the shrimp farmers to maintain the width of inter-farm dykes between 1.5 m and 2.5 m; encouraging the people of concerned areas for sustainable and environment-friendly culture, production management,

procurement, preservation, processing, and marketing of shrimp; encouraging shrimp farmers and others to adopt eco-friendly shrimp culture method through exhibition/demonstration of eco-friendly and economically profitable and successful shrimp technologies; taking of initiatives to encourage public and private banks and financial organizations to disburse loan to shrimp sector; and taking of initiatives to encourage public and private insurance companies to introduce ‘shrimp insurance’ in order to make the industry risk-free and more profitable³⁹.

From the brief review of the most important two government policies it is notable that the Bangladesh government takes a uni-linear top-down technical approach for improving the shrimp sector. It lacks, in general terms, specific strategies to encourage and augment people’s participation in the projects. It puts little emphasis on enhancing community capacity to build resilience from within to weather shocks and climate change in the shrimp culture zone. Moreover, though the SPo encourages public and private financial organizations to sanction loans to shrimp cultivating community, it says nothing on regular disbursement of loans through the DoF, the sole government authority in charge of governing the shrimp industry. Finally, as per field data, the SPo has not been implemented yet in the field level. This is comprehensible as the policy was adopted just few months ago, it will take more time to obtain the expected outcome.

7.5.3 Safety net programs: As part of government initiatives in addressing specific climate disasters in the coastal region the Bangladesh Government, as mentioned in previous sections, adopted hard or structural adaptation measures

³⁹ This review of the Shrimp Policy is primarily based on the Ministry of Fisheries and Livestock document ‘National Shrimp Policy 2014’ (MoFL 2014).

(World Bank Group 2010, BCAS 2013) and constructed cyclone shelters and embankments throughout the coastal districts. Moreover, an amount of BDT 30 billion has been allocated to the Bangladesh Climate Change Trust Fund since the 2009-10 fiscal year (MoEF 2016) for implementing the projects and programs taken by the Bangladesh government throughout the country under the Bangladesh Climate Change Strategy and Action Plan (BCCSAP).

Moreover, the Bangladesh government has several safety net programs for the poor and ultra-poor households throughout the country. These safety net schemes help the disaster-affected population to be resilient in some degree in facing climate changes. Though the safety net programs are not directed solely for the shrimp culture community and though this study is primarily designed for locating specific government programs that address resilience and adaptation of shrimp farming communities; in order to have a holistic picture how the government helps the poor in general, we can look at the summary findings of a previous study that had a focus on general broad government schemes. Researching on disaster affected population in the Sundarbans, Nguyen and Wodon (2015) found as many as 29 programs⁴⁰ running in the area as part of government safety net schemes, conducted by different ministries and departments. These programs reach some of the poorest and most vulnerable households in the area. However, since these schemes are not developed

⁴⁰ The schemes include Old Age Allowance; Allowance for the Widowed, Deserted and Destitute; Allowance for the Financially Insolvent Disabled; Maternity Allowance for the Poor Lactating; Honorarium for Insolvent Freedom Fighters; Honorarium for Injured Freedom Fighters; Gratuitous Relief; General Relief Activities; Allowances for Distressed Cultural Personalities/Activists; Stipend for Disabled Students; Cash for Work; Housing Support; Agriculture Rehabilitation; Subsidy for Open Market Sales; Vulnerable Group Development (VGD); Vulnerable Group Feeding (VGF); Test Relief Food; Food for Work; Employment Generation for Hardcore Poor for 100 days; Stipend for Primary Students; School Feeding Program; Stipend for Secondary and Higher Secondary Female Student; Rural Employment Opportunities for Protection of Public; and Rural Employment, Social Forestation and Rural Maintenance Program (Nguyen and Wodon 2015).

especially for the shrimp farming community or for the coastal people, their impact on building resilience of the shrimp-farming community to climate changes is almost zero. The following paragraphs are based on field investigation in Mongla, Koyra and Shyamnagar on the actual field-level contribution of the Bangladesh government in enhancing the adaptive capacity of the shrimp aquaculture community in south-western Bangladesh.

7.5.4 Local-level interventions by the Department of Fisheries: From the government level, the Department of Fisheries (DoF) in Bangladesh provides various supports to the shrimp-farming community in order to adapt or be resilient to climate disruptions. As part of farmers' capacity building, *Upazila* (sub-district) Fisheries Offices organize training for shrimp cultivators on a somewhat regular basis on various subjects including using and operating new technologies, shrimp farm preparation and management, postlarvae (PL) nursing, quality control, good aquaculture practice, sustainable farming, coping with climate hazards etc. These trainings are generally conducted before the start of a new farming season every year. Training on disaster management in shrimp is very rare and generally organized after a severe natural calamity affected the sector. For example, after the cyclones *Sidr* and *Aila*, the Upazilla Fisheries Offices (UFOs) organized awareness building and recovery training workshops in the affected regions. The DoF finances these training programmes that cover only selected shrimp farmers in a community. The DoF, through its field-level UFOs, also provide technical assistance to the farmers in the forms of soil and water quality test and diagnosis of diseases. In order to enhance the financial capital of the shrimp farming communities, the DoF helps the farmers to obtain bank loans.

The DoF has a micro-loan scheme for small-scale aquaculture. The scheme is established with the departmental revenue budget that runs as a revolving fund. However, actually this loan scheme is of no use to the aquaculture community. They do not even know about this facility. There are some hidden reasons behind this. Though there is no definitive instruction from the DoF, the UFOs normally disburse only up to BDT 50,000. Disbursing BDT 50,000 to a farmer is extremely rare; generally, the loan amount ranges between BDT 10,000 and BDT 20,000, which is also very rare. The DoF policy is to sanction this loan to people who are currently cultivating fish (including shrimp) or who are willing to start fish culture. However, since this loan has very low interest rate (only 5% as service charge) and it can be repaid in five annual instalments that are very easy terms and conditions; this loan is sanctioned under political influence. Local political leaders, especially from the party in central power, pressurize the UFOs to offer this loan to those leaders' followers.

Generally, the farmers who get loan through political channels are not willing to refund it. The UFOs also cannot pressure them since they have political influence in the area. In this way, those loans turn to be 'bad loans', which cannot be recovered easily. Sometimes, if the concerned UFO is adamant to recover the loan, this issue goes to courts, the UFOs file certificate cases at the UNO courts against the defaulters. Thus, this is a kind of harassment for the sanctioning officer. Another reason behind low recovery rate (30%-40%) of this loan is the lack of monitoring. The *Upazila* Fisheries Offices have very little work force, generally only 3-4 staffs. It is quite hard for them to manage time, after finishing all the official jobs in time, to go to a borrower's home frequently to monitor his situation. Moreover, because of this lower rate of recovery, the DoF introduced a

new system few years ago. Under this arrangement, the sanctioning official is personally responsible for recovering the loan. If the concerned officer cannot recover the loans he/she sanctioned, the entire aggregated amount is deducted from his/her pension. Thus, this loan has become a liability for the field-level officials. They are now very reluctant in disbursing this micro-loan to aquaculturists. Even, they do not like to disclose that there is such a loan facility in their office. In very rare cases, the UFOs sanction this loan to just 1-3 persons per year. Among these 1-3 lucky persons, shrimp farmers might not be more than one in a year. In addition, that farmer generally should have good political backing. In summary, this loan is out of the reach of the shrimp farming community and it does not help them in any way.

The DoF also sometimes provides inputs (lime, fertilizer, feed etc) support to selected farmers. For example, the Mongla, Koyra and Shyamnagar UFOs provided inputs support to a number of shrimp farmers in the 2008-09 fiscal year. In addition to formal training, assistance, and supports, the field-level DoF officials organize informal discussion sessions with the local farmers. In these sessions, the officers give advice and suggestions on sustainable aquaculture practice, among others. All these supports, both hard and soft, can enhance, with only limited capacity, the adaptability and resilience of the commercial shrimp sector.

7.6 Outside interventions: NGO initiatives

With a density of 3.5 foreign NGOs (branches) per square mile (Islam 2001), it would not be any exaggeration if we call Bangladesh a 'land of NGOs'. In Bangladesh, over 22,000 NGOs are in operation in 80% of villages contacting

about 35% of total population of the country (DFID 2000, Lewis and Hossain 2008), most of them are small, local organizations with only very few large-scale national NGOs on the scale of the internationally known agencies (Lewis 2010). NGOs, a couple of which are the world's NGOs, have become an indispensable development actor in Bangladesh. The most notable feature of NGOs in Bangladesh is that they pioneered micro-credit as a poverty alleviation tool in the country and in the world. NGOs in Bangladesh work on different issues including human rights, hazard management, empowerment of women, human rights, education, poverty reduction etc. Their recent priority area is adaptation to climate change.

7.6.1 Overview of the role of NGOs in addressing climate change: As civil society organizations, the NGOs try to play an important role in reducing climate change induced vulnerability of local communities. With the consideration that their involvements may offer backup support to community level resilience initiatives, they are devising series of adaptation programs especially in disaster-prone areas. Their interventions incorporate both hard and soft adaptation approaches including infrastructure (house and roads) building, livelihood diversification, disaster recovery and rehabilitation, reducing psychological shocks and trauma (Islam and Neelim 2010). In order to implement their programs and projects, NGOs invest a large amount of money every year, managing from international funding organizations. NGO funding in Bangladesh between July 2009 and June 2010, for example, amounted to about USD 484 million (Ahmed and Wilde 2011).

NGO role in the mediatisation of climate change is crucial in the context of a developing country like Bangladesh. NGOs in developing countries frequently work as issue entrepreneurs (Neverla et al 2012) and this was especially observable in Bangladesh during the Copenhagen Summit in 2009. During that time, a number of NGOs were active in generating campaigns, both in Bangladesh and at the conference venue, about the detrimental effects of climate change in Bangladesh. They were campaigning against the already visible issue of climate disruptions in Bangladesh. Their campaigns drew attention of world media.

Apart from campaigning against the adverse impact of climate change in global forums, NGOs in Bangladesh generally adopt a community based adaptation (CBA) approach in addressing the climate problems on the ground. The Bangladesh Centre for Advanced Studies (BCAS) and the International Institute for Environment and Development, UK (IIED) jointly organized six international conferences on CBA between 2007 and 2012 (BCAS 2012). These conferences identified few major areas where NGOs experiment with CBA strategies. The identified areas include local-level capacity enhancement, education and awareness, climate proof agriculture, use of indigenous knowledge in disaster risk reduction, vulnerability assessment exercises etc. Some of the components of CBA approach are participatory research, collection and use of indigenous knowledge and technologies, livelihood support for vulnerable groups, and advocacy campaign (Siddiqui and Billah 2014). In order to have a micro level focus of adaptation programs under CBA approach, the NGOs are developing local adaptation plan of action (LAPA) through which community-specific plans could be devised for implementation.

7.6.2 NGOs and climate change adaptation in shrimp farming: three case

studies: Having said all the above things about NGO initiatives in Bangladesh, we now turn to the actual field-level NGO interventions in the research areas. More than fifty NGOs are working in Mongla, Koyra and Shyamnagar. Most of them have projects in all the three areas. Since these are disaster-prone zones, majority of the NGOs address climate change adaptations in one way or another. But one striking fact is that none of the NGOs exclusively approach the shrimp farming community, though shrimp is the mainstay of coastal economy and as many as 95% of population depends on shrimp culture (Farzana and Hossain 2015) directly or indirectly for earning their livelihoods. In the absence of any exclusive project on climate change resilience of the shrimp farming community, we will review three selected NGO projects that deal with climate change adaptation in the locality as a whole (the projects usually keep shrimp farmers outside their scope). The case studies are based on information gathered from the respective project managers.

1. NGO: Brac

Project title: Disaster, Environment and Climate Change (DECC)

Project area: Mongla

Project duration: October 2012 – December 2015

Number of beneficiary: support – 100, Total beneficiary – 500 (in Mongla)

Main activities/outcomes:

- a. One time inputs support to the direct beneficiaries up to the value of BDT 14000/person, no cash support was provided.

- b. Training for the beneficiaries on the subject of their respective support type.
- c. Various supports were provided to the beneficiaries based on the suitability of the activity in the beneficiary's neighbourhood. The input supports included small grocery shops, rickshaw van, goat raising, crab farming, and tailoring (sewing machine for women).
- d. Rehabilitation of shrimp PL collectors (total 75) through input supports (mainly grocery shop).

Brac focused on livelihood support and diversification through the DECC project in Mongla, Koyra and Shyamnagar area. Since they supported only 100 persons from each *upazila* and support amount was very little (only about USD 180), this initiative has very weak (almost zero) impact on local people's adaptation to climate change. One important aspect of this project is that it included shrimp PL collectors and focused on their rehabilitation, though the effort is negligible if we consider from the beneficiary number and support amount. Nevertheless, Brac's role in enhancing climate change resilience of shrimp-farming community can be termed as 'very low'.

2. NGO: *Jagrata Juba Shangha* (JJS)

Project title: Increasing Resilience and Reducing Risk of Coastal Communities to Climate Change and Natural Hazards in the Bay of Bengal (Paribartan)

Project area: Koyra

Project duration: February 2011 – January 2016

Number of beneficiary: 1080 (in Koyra)

Main activities/outcomes:

- a. Campaign in schools: A total of 75 students from three schools were trained on how to adapt to climate change and reduce risks during disasters.
- b. Public awareness programs through observing environment day, disaster reduction day etc; arranging stage shows about climate change adaptation; and publishing articles in national and local dailies.
- c. Pilot programs implementation: A total of eight agricultural farmers were provided with support for cultivation of rice, fish (non-shrimp) and vegetables. Supports were provided to four women in building disaster resilient house, rainwater preservation and vegetable cultivation through management of saline water. Ten eco-friendly, lower fuel-consuming stoves were distributed. A total of five homesteads were raised in order to make them safe from storm surge water. A total of 1500 seedlings of various saline tolerant fruit species were distributed.
- d. Six sets of disaster warning equipments were supplied to three unions and three villages, one set each.

The JJS did not focus on shrimp farmers in its climate change projects. Almost all of the beneficiaries of the Paribartan project were non-shrimp households. Moreover, this project had very little impact even on the target groups. From point of view of enhancing resilience in shrimp culture, we can say that this project had nearly zero contribution.

3. NGO: Local Environment Development and Agricultural Research Society (LEDARS)

Project title: Strengthening Livelihood Security of Climate Change Vulnerable People

Project area: Shyamnagar

Project duration: October 2013 – September 2016

Number of beneficiary: 670 families (in Shyamnagar)

Main activities/outcomes:

- a. Formation of climate resilient groups: 31 climate resilient groups have been formed consisting of 140 vulnerable people. LEDARS conducts regular monthly meetings with the groups.
- b. In order to strengthening organization of tiger widows, a total of 4 tiger victim groups were formed comprising of 80 tiger widows⁴¹.
- c. Three Union climate resilient committees (UCRC) were formed to enhance the access of poor on *khas* water bodies and to re-excavate those for preservation and use of rainwater during dry season for second crop cultivation.
- d. Organizes three farmers' innovation fairs in order to disseminate and inspire adaptive innovations by local farmers.
- e. Supports UCRCs to observe national and international days at community level like World Water Day, Village Women Farmers Day, Climate Action Day, and Food Day.
- f. In order build awareness among the local youths, LEDARS organized one youth environmental camp.

⁴¹ A tiger widow is a woman whose husband was killed by an attack of a man-eater tiger.

- g. A number of information, education and communication materials including crop calendars, posters, and billboards were distributed or hung in different places.
- h. A two-day long training session was conducted on saline, flood, and drought resilient paddy and vegetable cultivation.
- i. Seeds of saline, drought, and flood tolerant crop varieties were distributed once to 400 most vulnerable farmers up to 1 acre of land each.
- j. Saline tolerant fruit seedlings were distributed among the beneficiaries.
- k. To develop carbon sensitive families, LEDARS distributed improved cooking stoves among the beneficiaries.
- l. Under the project, LEDARS excavated 27 small ponds in the beneficiaries' land to reserve freshwater for crop cultivation.
- m. The project constructed a small-scale production house where 10 women work.
- n. Introduced river ambulance to provide medical services to islands in the Sundarbans.

Through this project, LEDARS is working on livelihood diversification as a means of strengthening resilience of the local people to climate change in selected villages in Shyamnagar and Koyra. Their initiatives are also very little in scope. Moreover, during field investigation it was found that from an anti-shrimp point of view, LEDARS deliberately exclude shrimp farmers from their projects.

Examining the above-mentioned and other NGO projects on climate change vulnerability, adaptation and resilience, we can conclude that NGOs do not have any significant contribution in building resilience in shrimp farming

communities. A shrimp farmer from Mongla succinctly pointed to the inadequacy of support from public and private institutional structures, *“There is no research [on shrimp] in our region; the government does not highlight our needs; there is no activity of NGOs [on shrimp sustainability]. The NGOs are expert in extortion by lending money to poor people; but they don’t have any initiative for enhancing the production and marketing of shrimp.”*

7.7 Conclusion

It is obvious that since Bangladesh is at the receiving end of global climate disasters, not at the producing end, the only viable option for it is to devise adaptive measures in responding to those disasters. People living in coastal ecosystems have just three options for adaptive response to climate shocks and variability: protection, accommodation, and retreat (Klein et al 2001, Sterr 2008, Tol, Klein and Nicholls 2008, Saroar and Routray 2013). Since ‘protection’ through construction and maintenance of coastal infrastructure and ‘retreat’ through emigration from the whole area (at least 25 million people would need to evacuate from the exposed coastal areas in Bangladesh) are neither within the reach of nor feasible for the local communities, the coastal shrimp farmers in Bangladesh have the only option to accommodate by reducing sensitivity and enhancing own adaptive capacity in order to offset negative impacts of climate change on the shrimp sector. Through effective resilience efforts at local and community levels, Bangladesh can minimize the loss from the brunt of global climate change. Shrimp farming communities in south-western Bangladesh have their own adaptive and resilience mechanisms through which they fight against

and cope with environmental and climate hazards in order to have a sustainable shrimp industry.

If we analyse the comparative roles of different stakeholders in building resilience to climate changes in the shrimp-farming communities, we find that through both anticipatory (proactive) and autonomous (reactive) adaptive measures, the shrimp households tend to adopt resilience enhancing initiatives, with more or less success. Through *gher* management and household management, the household-level actions focus on 'high' or 'moderate' level resilience strategies.

As discussed above, shrimp communities are rich in community capitals in various degrees: they are quite rich in natural and bonding social capital, moderate in built and bridging social capital, and weak in financial and linking social capital. Community leadership does not take necessary resilience actions horizontally or vertically. In general, community people are not of much support for a given household (except close friends, neighbours, and relative) in building resilience to weather shocks and climate change, especially if we consider the amount of tangible supports provided. Thus, as mentioned earlier, community endeavour in building resilience to climate change may be dubbed as 'moderate' or 'low'.

Governmental and non-governmental institutions and organizations have little interventions, which are mainly devised to address specific events. The governmental institutions have policies on climate change, capacity building and awareness raising programmes, technical and inputs supports, and very limited-scale loan facility. However, the initiatives of the governmental institutions lack effective funding and support throughout the year. Even the fisheries officers from

both national and local levels revealed this fact. They commented during interview sessions that the fisheries department gets lower amount of funding from the ministry, so they cannot run projects throughout the year. Thus, if we consider the government's role in building resilience of the shrimp industry in Bangladesh, we can term its role as 'weak' or 'low'.

In terms of building resilience to climate change in shrimp farming communities, NGOs have divergent roles. In the shrimp farming regions, we can find three groups of NGOs in terms of the level of their support to shrimp culture: pro-shrimp, anti-shrimp, and nonaligned. An interesting fact is that the so-called pro-shrimp NGOs, who support shrimp cultivation in Bangladesh like ASA, and Brac, also do not have any project directly addressing shrimp aquaculture. As we found in the above case study of a Brac project, they provide support to shrimp-farming community in a very low degree. They just provide loan services⁴² under microfinance schemes, which is again a part of their profit-oriented business trade. The neutral NGOs, such as JJS and Rupantor, have no say to shrimp. They maintain distance from this sector, and remain busy with other activities – their role in building resilience in shrimp sector is zero.

The anti-shrimp NGOs, like Islamic Relief Bangladesh (IR) and LEDARS, blatantly oppose the growth of industrial shrimp farming in their projects or campaigns. The manager of an IR project during the interview session fiercely opposed shrimp cultivation in the locality, mainly on the ground of perceived (rightly or wrongly) negative effects of shrimp on the environment and livelihoods.

⁴² NGO loan amount ranges between BDT 50,000 and 300,000 – with a gradually decreasing interest rate of 27%. They offer this loan service to shrimp and non-shrimp people alike.

Figure 7.4: Anti-shrimp campaign by LEDARS.

(This poster portrays shrimp as a monster that swallows everything in the locality: agricultural livelihoods, livestock, vegetation, mangroves etc.)

Source: Field data

LEDARS also profoundly oppose the very existence of shrimp culture in the region. Under their project ‘Campaign for prevention of saline water to restore agriculture in coastal region of Bangladesh’, for example, they organized activist movements against shrimp farming at local and national levels. From an absolute anti-shrimp position, one of the objectives of the project is ‘to set up a model village in the coastal area to show how people can survive without a shrimp based economy’. In a poster, the LEDARS portrayed shrimp as a monster that swallows everything in the locality (see Figure 7.4). Thus, since they question the very existence of shrimp aquaculture and since they campaign to abolish it, their role in resilience building in the sector is certainly negative. Considering the above-mentioned diverse role of NGO interventions, we can dub them as ‘very low’, ‘zero’ or ‘negative’. Finally, we can present the comparative roles of shrimp

farming households, communities, government agencies, and NGOs in building resilience to climate change in a resilience gradient (see Figure 7.5 below).

Figure 7.5: Resilience gradient in shrimp aquaculture in Bangladesh
(Relative role of different stakeholders in building resilience to climate change)
Source: Drawn as per findings of this research

From the above discussion, it is evident that shrimp farming community in Bangladesh does not receive sufficient outside assistance in order to build community-level resilience. Right through the history, the people of Bangladesh have shown their guts and innovative intelligence in fighting against all odds and wrath of nature. Since the first human settlement in the Sundarbans region by Chand Sadagar around AD 200-300 (Martin et al 2015), the ever-fighting people are always coping with the harsh and dynamic natural environment. As part of their coping schemes, they introduced shrimp culture in the area. Now, since the sustainability and existence of shrimp is in question due to human-induced global warming, the local stakeholders are devising their specific strategies with more or less success on trial and error basis. It is likely that alternative development

interventions can secure people's adaptation strategies and promote a future generation able to cope with climate change extremes and variability.

CHAPTER EIGHT

CONCLUSION: SYTHESIS AND RECOMMENDATIONS

8.1 Introduction

Climate change is, and will remain, the biggest environmental threat in many parts of the world. Because of long residence time⁴³ of CO₂ and other greenhouse gases in the atmosphere and because of the thermal inertia of oceans, the current trend of climate changes will prevail in the coming centuries regardless of reductions in greenhouse gas emissions (Eriksen et al 2011, Matthews and Caldeira 2008). For this, in addition to mitigation, climate change adaptation has become a pressing issue for the last couple of decades. Climate change adaptation (or resilience) is chiefly a localized course of action that depends on individuals, social networks, economies, ecologies, political structures, and the capabilities of all those to work collectively to absorb, learn from and transform in the face of new realities (Martin et al 2015). Accordingly, resilience in aquaculture in Bangladesh, as in elsewhere, is primarily an outcome of joint endeavours of various stakeholders. The present study offers new evidence on the magnitude to which farmers, households, and communities in shrimp farming zone are affected by and adapt to climate hazards. This final chapter summarizes central results of the study and suggests a few potential policy implications.

Vulnerability and adaptation to weather shocks in the context of a changing climate has become an important issue in the development community. This is particularly significant in fishing and aquaculture in international context and in the saline ecosystems in the south-western coast of Bangladesh where millions of

⁴³ 'Residence time' refers to the span of time a substance lasts in a system or environment. More than half of the anthropogenic CO₂ has about 100 years (Mondal and Rajan 2009, Rashid and Paul 2014), while about 20% has a residence time of several thousand years (Archer 2005).

inhabitants frequently face climate threats. What is the extent of vulnerability of aquaculture to climate hazards? What are the adaptation mechanisms that households declare having used or to be used to cope with changing climate in shrimping zone in Bangladesh? In what extent do they utilize their community capitals in building resilience to climate change? What are the specific governmental and non-governmental institutional interventions that aid community resilience in the aquaculture sector?

This study provides answers to those questions based on primary and secondary data. Over the past few decades, the bulk of literature on climate disaster and adaptation has tended to place too much emphasis on the global, regional, and national processes. A major contribution of this study within the extensive literature is the fact that it relies on thick qualitative data from the sites of climate change; that it brings the local community-level dynamics of actions and transformations to the fore; and that it focuses on a specific livelihood sector – commercial shrimping in Bangladesh – for which the existing evidence regarding the impact of weather shocks on households and communities, their ability to cope, adapt and be resilient, and the extent to which the households’ perception and experience of environmental and climate stressors lead to specific community-level interventions remain scant. Drawing on an analytic framework of community resilience, this thesis explores not only how and in what extent aquaculturists are able to map their adaptation strategies by their own specific ways of regulating the environment, but also how and in what extent institutional policies and programs intervene in the sector. With a key focus on the dynamics in the bottom of the industrial shrimping in Bangladesh, the following two sections summarize the findings of this study and propose some policy interventions.

8.2 What have been found?

This research on the nature of community resilience in shrimp industry in Bangladesh suggests a number of important trajectories, with implications for other aquaculture industries in the global South. Five sets of simplified assertions of which documentation has been provided in previous chapters can broadly describe the result of this study.

1. My analysis suggests that there is *no feasible livelihood alternative to shrimping* in the brackish-water coastal region in the south-western Bangladesh. The mounting salinity ingress in surface and ground water as well as in soil has led the local socio-ecological system experience a change (Momtaz and Shameem 2016). In the changing salinity regime, *bagda* farming has been treated as a planned adaptation strategy by the salinity-affected households. Rice or other agricultural crops do not grow well in more than one million hectares of land in the saline region and even the newly invented saline-tolerant rice varieties cannot endure the salinity level in water and soil in the areas. Local farmers had already tried rice cultivation several times, but all those efforts were in vain. Most of the time water and soil salinity levels remain optimum only for salt-tolerant *bagda* shrimp; sometimes the salinity level even rises beyond the optimum level. In every specific ecosystem, there are viable livelihood options. It is not feasible to cultivate dates, for example, in icy polar regions because dates can only be produced in hot deserts. Similarly, the cultivation of rice or other crops in the Sundarbans-surrounding ecosystems is not a good

option up to now. Thus, as I mentioned before, adoption of a shrimping livelihood in these areas is not ‘by choice’ but ‘by compulsion’.

2. Local stakeholders’ perception of climate change is a crucial contributor to making adaptive changes (Momtaz and Shameem 2016). I found that the *shrimpers’ perception of climate change substantially matches to scientific data*. As mentioned earlier, there are several reasons behind this. Living in an exposed zone for SLR, salinity intrusion, severe cyclones, storm surges, SST and other climate chaos, people of these areas base their attribution of hydro-climatic phenomena on their repeated personal experiences, on associated impacts on their lives and livelihoods, and on mediatization of global warming as ‘grand narratives’ in the country. Thus, a convergence of scientific construct and cultural construct construes this level of consciousness of the common people.
3. Peculiar hydro-geo-morphological and environmental characteristics make south-western coast of Bangladesh *one of the most exposed regions to climate crisis* in the world, a fact that makes it a ‘climate hotspot’ (in Bangladesh context) within a ‘climate hotspot’ (Bangladesh as a hotspot in global context). The new climate regime has turned this region a fragile ecosystem despite the presence of its rich natural resources.
4. Small-scale shrimp-farming households in the exposed zone have *limited ability to adapt* to adverse impacts of immediate and gradual shocks and changes. They try their level best in facing the calamities with their inadequate capacity. Only few households seem to be involving in medium-term or long-term adaptation strategies. Social construction and distribution of entitlements effectively restrain thoughts and actions of

individual people – entitlement inequalities lead to unequal responses to external perturbations like climate extremes and other natural hazards (Adger and Kelly 1999). Because of this entitlement inequalities, the marginal shrimpers resort to income-smoothing and consumption-smoothing strategies that might not appear as welcome options for them.

5. Only *few actual resilience measures are provided* by communities in which shrimping households live. Due to the absence of effective use of community capitals and due to the disorganized leadership, community supports are limited. Similarly, the shrimpers receive only meager amount of support from the public and private institutions.

In delineating the levels of resilience different stakeholders embrace, we can discern two interrelated dimensions: distributive, and institutional. This study finds that distribution of community resources and capitals, and the patterns of resource access and use across a social landscape made up of shrimp farmers, traders, fry collectors and others are vital in coping and adaptation to climate disturbances in the shrimp-farming ecosystem. We found that even within the same commodity chain, different stakeholders have different levels of vulnerability to weather and climate shocks because of their varying degree of access to resources and exposure to hazards. If we think of a vulnerability continuum, we find that the local marginal shrimp farmers are the most vulnerable group in terms of susceptibility to natural disasters because they are most physically exposed to calamities. The non-residential shrimp lords such as processing plant owners, and big shrimp merchants and exporters, on the other hand, are placed at the other pole of the continuum being the least (nearly ‘non’) vulnerable group. Other stakeholders lie in between these two groups.

Figure 8.1: Vulnerability continuum in shrimp-farming sector in Bangladesh

Source: Field observation

Similarly, because of lack of access to economic, natural, social, physical and other community capitals, the small-scale farmers and fry collectors cannot build strong resilience in a fragile coastal environment. Though household-level initiatives are also the prime resilience initiatives in the area and the marginal group exerts all its capabilities in the face of natural calamities and changes, this segment remains the most vulnerable.

Analysis of institutional dimension incorporates examination of local power dynamics, forms of dependency and trust, community's capability of mobilizing resources from outside, and impact of public and private interventions, among others (Finan 2009). From the field study, we found that local power relations associated with regime shifts in national state power determine the access and control of common pool of resources in the coastal belt including leasing of *khas* land, which in turn creates and perpetuates a power asymmetry in local level that determines the capability of coping to natural hazards at household and community levels. Findings from this study suggest, as delineated in the previous chapter, that there is a clearly visible resilience gradient in the shrimp farming communities in terms of the stakeholders' comparative roles in adaptation initiatives. As delineated by Adger and Kelly (1999), access to resources (or

community capitals, in other words), range of income sources, and social status of individuals or households in a community define individual vulnerability (or resilience, by extension); the collective vulnerability (or resilience) is determined by institutional and market structures in a community, region, or nation. Field data suggest that the vulnerability of shrimp community to climate change is coupled with environmental hazards, underdevelopment of community capitals, lack of opportunity for livelihood diversification, and socio-economic inequalities. Shrimp farmers, particularly the lower strata of the shrimp value chain, are stuck in chronic poverty, which restricts their capacity to tackle climate risks sufficiently (Momtaz and Shameem 2016). Even then in the study area, through anticipatory as well as autonomous adaptive measures by *gher* and household management, the house-hold level resilience *actions*, which are markers of individual resilience, can be termed as ‘high’ or ‘moderate’. At the collective level of resilience endeavors, if we consider the amount of tangible supports provided by the community to a particular shrimp farmer, if we consider how much rich a community is in terms of social (bonding, bridging, and linking), economic, natural, and built capitals, and if we consider how well these capitals are utilized in times of crisis, community interventions in building resilience to environmental and climate shocks can be placed at a point in between ‘moderate’ and ‘low’ levels. Similarly, it is found in the field that governmental interventions have ‘low’ level of influence. Finally, the NGOs, having three different perspectives on the shrimp industry (either support or oppose or remain neutral), have ‘very low’, ‘zero’, or ‘negative’ role in enhancing resilience of shrimp-farming communities in coastal Bangladesh.

As elaborated in our conceptual model (see Figure 2.2 in Chapter Two), climate change dimensions such as long term changes in weather parameters i.e. temperature and rainfall, temporal shifts in seasonality and climate extremes, on the one hand, have negative impacts on community resources and capitals as well as on the architecture of entitlements in the study area. On the other hand, resilience dimensions such as strategic thinking, leading, linking and outside interventions act positively in the study area on the levels of community resources and architecture of entitlements. This second aspect (i.e. resilience dimension) is found not so strong in the shrimping communities in Bangladesh. As a combination of somewhat moderately rich community capitals and poor level of entitlements at the lower strata of shrimp-farming community, community resilience *per se*, if considered as the result of adaptation endeavors across scales from individual to institutional structures levels, is not adequate.

8.3 What need to be done?

This study is motivated by concern for understanding how the use of community capitals and institutional interventions shape the actions that create and enhance resilience of the shrimping community to climate variability, change, and extreme events. Resilience to climate change is an intricate subject that presents a number of challenges. This entails a process of viable adjustment in response to new and shifting environmental scenarios. So, resilience of shrimp industry cannot be treated as standalone issue and the future pathways should be directed by particular institutional and policy measures.

8.3.1 Introduction of shrimp insurance: The whole shrimp industry needs to be brought under public and private insurance schemes so that the farmers can have

financial compensations in case of damage or loss of production due to adverse climate conditions or hazards.

8.3.2 Increased technical assistance: The Department of Fisheries should provide shrimp farmers with technical assistance including salinity and pH tests of soil and water, and diagnosis of disease in shrimps. Increased technical assistance could enhance the production of shrimp.

8.3.3 Aiding capacity enhancement: The Upazila Fisheries Offices should aid shrimp farmers and local traders with trainings and workshop sessions for capacity enhancement. The workshops and trainings should be on a variety of sustainable shrimp cultivation related topics such as enhancement of shrimp production, use of new technology and scientific method, gher preparation, hatchery (or nursery) operation, disease control, gher management, harvesting and post-harvesting works, processing etc. Also, farmers and other local stakeholders should be trained on how to cope with and adapt to sudden weather shocks and gradual climate shifts. Currently, farmers do not receive any systematic teaching on climate hazards from public or non-governmental organizations. Various awareness building workshops should be arranged.

8.3.4 Increased financial and inputs support: In order to enhance economic capital of the farming people, public and private institutions should offer more financial and inputs support to the shrimp-farming communities. Financial supports could be in the forms of direct sanctioning of loans, helping the farmers in availing loans from banks, offering grants and awards. Financial supports need to be provided at the start of the season and immediately after a sudden disaster.

More inputs supports in the form of feed, seeds, equipment, and fertilizer need to be provided.

8.3.5 Implementation of the national shrimp policy: Though the National Shrimp Policy 2014 adopts a top-down technical approach that has substantial drawbacks and though it puts little emphasis on enhancing community capacity to build resilience from within to weather shocks and climate change in the shrimp culture zone, full-fledged implementation of the Policy could support shrimp farming in a number of ways.

8.3.6 Integrated coastal management: The adaptation approach in the coastal saline zone should be embedded in an integrated coastal management framework that seeks out win-win situations. In order to avoid land-use conflicts between different sectors including agriculture, aquaculture, and forestry and to enhance the ability of the coastal communities to respond to the impacts of environmental and climate stressors, the land zoning scheme proposed by the Ministry of Land in 2011 should be implemented.

8.3.7 Avoidance of maladaptation: In addressing large-scale coastal problems like salinity intrusion, cyclones and storm surges in order to support shrimp and non-shrimp livelihoods, planned interventions from the Bangladesh Government is required. However, policy makers, local-level implementing authorities, and members of society should be attentive about maladaptation, in which adaptation programs benefit one group or sector of the society at the expense of increasing the risk to another group or sector (Barnett and O'Neill 2010).

8.3.8 Public funding in research and monitoring: A significant increase in public funding in research and monitoring the changing trends in climate in the country and in the region is required.

8.3.9 Increased positive role of NGOs: Environmental NGOs should keep the local ecosystems context in mind and advocate for pro-shrimp campaigns in the brackish-water zone.

8.3.10 International collaboration in controlling global warming: In order to make Bangladesh less vulnerable to the Bangladesh Government should take more initiatives for effective collaboration with countries with similar interests for jointly dealing with the climate change impacts and implement adaptation strategies.

8.3.11 International negotiations for binding emissions targets: The Bangladesh Government should support strong, binding GHG emissions reduction targets for developed countries so that the Bangladeshi people face lesser extent of climate vulnerability.

8.3.12 Ensuring fair share for climate change adaptation for Bangladesh: Since the current regime of anthropogenic climate change is mostly caused by the developed nations, the Bangladesh Government should strongly claim fair share of climate change adaptation costs from the emitters. In international negotiations Bangladesh can advocate for a ‘polluters pay principle.’

8.4 Conclusion

Against the backdrop of the fact that June 2016 marked the fourteenth consecutive month of record-breaking heat (Slezak 2016), there is little doubt that global warming is apparent. Natural science perspectives on climate change cause, impact, mitigation and adaptation are largely techno-scientific that Finan (2009) termed “climate change without a human face” (p.35) in that they restrict the analytical focus primarily on, for example, the change in weather parameters, the amount of land lost, vegetation change, decrease in biodiversity etc. Adopting a social science perspective in contrast, this study places its emphasis on the dynamic interface of natural and human systems under change in a very unstable and precarious ecological setting. This study provides new insights on the extent to which aquaculture communities are affected by climate shocks and changes in a transitional socio-ecological coastal landscape, how far they are able to be resilient, and how they have benefitted from public and private institutional supports. Professionals and policy makers can use this report as a discussion document in order to building a consensus for mapping sector-specific adaptation schemes.

In specific terms, this study contributes to sociology of climate change and resilience by providing thick qualitative narratives on local community-level dynamics of actions and transformations from a site where climate change is a day-to-day reality. As mentioned earlier, previous studies on climate change adaptation in aquaculture greatly emphasized global, regional, and national processes. On the contrary, this study focused on household and community-level interventions that act positively or negatively on climate adaptations.

Additionally, this research contributes to sociology of aquaculture by providing some fascinating insights into a specific aquaculture-based livelihood sector, i.e. industrial shrimping in Bangladesh. This is a novel research in the context of industrial shrimping in Bangladesh. Commercial shrimp is the second largest export commodity in Bangladesh, which is threatened by changing climate regimes. However, we cannot find any comprehensive sociological study on the degree of resilience of this sector. This is the first research in its scale.

General sociological significance of this research lies in its contribution (i) to introducing a new conceptual framework for analysing resilience of a community and (ii) to providing a resilience gradient framework that can be employed in sociological studies of resilience in climate-threatened communities around the globe. This thesis not only provides thick empirical information on adaptation and resilience from the sites of climate change, but also develops a conceptual framework in order to make elaborate interpretation of field data. This framework, partially based on McCrea et al (2014), illustrates the structural relationship between climate change dimensions, resilience dimensions, capitals and resources, architecture of entitlements, and overall resilience of a community. Total resilience of a vulnerable community directly depends on how rich the community is in terms of various capitals and resources as well as on the architecture of entitlements of its members. Community capitals and architecture of entitlements are positively impacted by resilience dimensions and negatively affected by climate change dimensions (see Figure 2.2 at page 37). This conceptual framework takes a sociological face by focusing on social forces and processes – prioritizing social, cultural, political, and economic issues, among

others. This framework can be replicated in interpreting adaptability and resilience of the communities elsewhere in the world who face similar climate challenges.

Finally, the resilience gradient that illustrates relative roles of various stakeholders in building resilience is another contribution to knowledge. As like climate change has a 'human face', resilience to climate change also involves socio-cultural interventions. Resilience is not a mere techno-scientific approach. The resilience gradient, taking socio-cultural practices and processes into consideration, establishes a hierarchy of the roles played by households, community, and public and private institutional set-ups. This resilience gradient (see Figure 7.5 at page 225) can be used in future sociological studies of climate change adaptation across communities in similar conditions around the globe.

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APPENDIX: INTERVIEW SCHEDULE FOR SHRIMP FARMERS

Climate Change and Resilience in Industrial Aquaculture: A Study of Community Capitals in the Shrimp-farming Zone in Bangladesh

[This questionnaire is made as a data collection tool for the researcher's PhD study. It does not involve any type of harm for the participants. Your assistance in completing the questionnaire is particularly important for the study. If you consent to take part in the study, all the information you provide will be absolutely anonymous and confidential. Thank you very much for your help.]

PART A: PROFILE OF THE RESPONDENT

1. Respondent's relationship with shrimp farming
2. Number of large scale farmers in the village
 - 2.1 How did they acquire land? Any force?
 - 2.2 Where do they live?
3. Respondent's personal information:
 - 3.1 Name:
 - 3.2 Address:
 - 3.3 Contact number:
 - 3.4 Gender: ☐ Male ☐ Female
 - 3.5 Age: years
 - 3.6 Marital status:
 - 3.7 Education:
 - 3.8 Primary occupation:
 - 3.9 Non-shrimp activity/occupation:
 - 3.10 Annual income:
 - 3.11 Annual expenditure:
4. Respondent's family members' data

No	Name	Gender	Age	Education	Occupation	Annual income (in BDT)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
<i>Total family income</i>						

5. Respondent's ownership of land:
6. Respondent's household information:
 - 6.1 House type:
 - 6.2 Source of water:
 - 6.3 Power supply:
 - 6.4 Sanitation (Toilet):
 - 6.5 Total number of mobile phones:
 - 6.6 Other electronic goods:

PART B: INFORMATION ON SHRIMP AQUACULTURE

1. For how many years are you cultivating shrimp?years.
2. Did you start shrimp culture willingly? ☐ Yes ☐ No
 - 2.1 If 'No', who forced you? Why?
3. Why did you start shrimp farming? What were the responsible factors?

4. How did shrimp farming begin in this village?
5. Amount of shrimp aquaculture land: Self owned Bigha
 Land Leased in Bigha
 Other Bigha
 - 5.1 Which type of land have you taken as lease?
 - 5.2 Under which conditions have you taken lease?
6. Gher size:
7. Information on farm registration
 - Number of registered ghers ... Number of unregistered ghers ...
 - 7.1 Why have you not registered all of your shrimp farms?
8. Average yields of shrimp: Kg/bigha/year
9. Average shrimp price at the farm gate: BDT/kg
10. Have you expanded or reduced shrimp aquaculture area comparing to that of five years before?
 - 10.1 If 'Reduced', why?
 - 10.2 If you have leased out your land to others, why?
 - 10.3 If you have leased out your land to others, what are the leasing conditions?
11. Do you use separate nursery ponds and grow-out ponds for shrimp cultivation?
12. What actions do you take in preparing the shrimp ponds/ghers?
13. Information on in-culture fertilization
 - Type:
 - Frequency: times/week
 - Cost: BDT/bigha/week
14. Average water depth in the farms: Monsoon feet, Winter ... feet
15. Which type of aquaculture method do you practice?
16. Stocking density:
 - 16.1 At the start of the season PL/bigha
 - 16.2 Mid-season PL/bigha/month
17. What are the other species of fish that you cultivate with bagda shrimp?
18. Information on shrimp-prawn mixed culture
19. Do you cultivate rice with shrimp in the same piece of land?
20. Do you cultivate crops or fruits on dikes?
 - 20.1 If 'Yes', which vegetables and fruits do you cultivate on the dikes of ghers?
 - 20.2 If 'No', why?
21. Information on shrimp feeding
 - Quantity kg/bigha/week
 - Frequency times/week
 - Feeds:
 - Cost: BDT/bigha/week
 - 21.1 Among the above, which feed you think is the most suitable for shrimp?
 - 21.2 Names (brand) of fish meal used:
 - 21.3 Major ingredients of fish meal:
 - 21.4 Origin of fish meals:
 - 21.5 Have you found any negative impact of the imported fish meal on shrimp and/or pond?
 - 21.5.1 If 'Yes', what are the negative impacts?
22. Information on water exchange
 - 22.1 Frequency of water exchange: times/month
 - 22.2 Source of farm water supply:
 - 22.3 Method of farm water discharging:
 - 22.4 Destination of discharged water:
23. Information on labor force
 - 23.1 How many people are engaged in your farms?
 - 23.2 Who are they?

- 23.3 For which purposes do you hire labor from outside?
- 23.4 For which purposes do you employ female workers from your family and outside?
- 23.5 For which purposes do you employ child (under 18) workers from your family and outside?
- 23.6 Average working hours of laborers:
- 23.7 Average wage/salary of staff/worker:
- 23.8 On what conditions do your relatives and neighbors assist?
24. Information on annual expenditure on shrimp farms
25. Information on capital and credit
- 25.1 What are the sources of money that you invest in shrimp aquaculture?
- 25.2 On which conditions do you take loans?

<i>Loan from</i>	<i>Collateral requirement</i>	<i>Interest rate (W/M/Y)</i>	<i>Sanctioned for ... months</i>	<i>Repayment mode (one time or by installment)</i>
Bank				
NGO				
Cooperatives				
Mohajons				
Neighbors or/& relatives				
Others (specify)				

- 25.3 If you fail to repay the loan in time, what actions do the lenders take?
- 25.4 Are you currently on loan? ☐ Yes ☐ No ☐ No response (NR)
- 25.4.1 If 'Yes', what is the amount?
26. Information on shrimp post-larvae (PL)
- 26.1 Sources of post-larvae that you use as shrimp seeds.
- 26.2 Why do you use wild fry as shrimp seeds?
- 26.3 Price comparison between seeds from different sources.
- Wild PL BDT/1000 PL
- Hatchery PL BDT/1000 PL
- 26.4 Do you know that wild fry catching is prohibited by law?
27. Information on diseases of shrimp
- Have your farmed shrimps have ever suffered from any disease?
- ☐ Yes ☐ No ☐ Not sure
- 27.1 If 'Yes', what is the frequency? times during the last 5 years.
- 27.2 In your estimation, what was the total loss due to shrimp diseases in the last 5 years?
- 27.3 What are the major diseases?
- 27.4 When do shrimp diseases occur?
- Season: ☐ Summer ☐ Monsoon ☐ Winter ☐ Other (.....)
- Growth phase: ☐ After stocking ☐ Mid-crop ☐ End-crop
- 27.5 What are the major reasons for disease outbreak in the shrimp farms?
- 27.6 What are the protective and curative measures that you take in order to get healthy shrimps?
- 27.7 Do you have regular health checkups on the farmed shrimps?
- 27.7.1 If 'Yes' ---
- Frequency:
- Method of observation:
- 27.7.2 Which are the signs of a healthy shrimp that you observe?
28. Information on security issues
- 28.1 How many incidents of theft and robbery of shrimp have you encountered during the last 5 years? times

- 28.2 How frequently do these incidents occur on an average?
- 28.3 How much loss do you incur because of theft and robbery? ... BDT/year
- 28.4 In the time of distress, who come to assist you?
- 28.5 What measures do you take in preventing shrimp theft?
- 28.6 Have your farms been insured?
29. Where/to whom do you sell your harvested shrimp?
30. What are the positive impacts of shrimp aquaculture on your community?
31. What are the negative socio-economic and cultural impacts of shrimp aquaculture in your community?
32. How many households did migrate from the village in the last 10 years? Why? Where? What are they doing now?
33. Is your society divided along supporting the commercial shrimp? ☐ Yes ☐ No
☐ Once happened
- 33.1 Who support?
- 33.2 Who oppose? What are their major activities?
- 33.3 Any conflict in the last 10 years?
34. What are the negative environmental impacts of shrimp aquaculture in your community?
35. Who are the major beneficiaries of shrimp?
36. Who are the losers due to shrimp?
37. Do you think shrimp can ever be sustainable and free from socio-environmental negative implications? ☐ Yes ☐ No
☐ Ambivalent
- 37.1 Why do you think so?
- 37.2 How can shrimp aquaculture be made sustainable?

PART C: CLIMATE CHANGE: IMPACT AND ADAPTATION STRATEGIES

- What are the major challenges and constraints for shrimp culture?
- Have you heard about 'climate change'?
- Where have you heard about climate change?
- What is your observation about the changes in the following weather parameters and climatic phenomena in your locality?

<i>Parameter /phenomenon</i>	<i>Changes comparing to 10 years before</i>				
	<i>Decreased strongly</i>	<i>Decreased slightly</i>	<i>No change</i>	<i>Increased slightly</i>	<i>Increased strongly</i>
Intensity of heat during summer & drought					
Bitterness of cold during winter					
Increase in water temperature					
Frequency of cyclone & storms					
Severity of cyclone & storms					
Frequency of flood & heavy precipitation					
Intensity of erosion					
Salinity ingression					
Sea level rise					

- How have you and your family been affected by natural disasters in the last 10 years?

<i>Affected sector</i>	<i>Volume or frequency</i>	<i>Value of damaged items (BDT)</i>
Agricultural crop		
Aquaculture (including shrimp)		
Livestock		
Agricultural equipment		
Aquaculture equipment		

House		
Household items		
Others (specify)		
Total		

6. How had you been affected by cyclones Sidr (2007) and Aila (2009)?

<i>Particulars</i>	<i>Value</i>	
	<i>Sidr</i>	<i>Aila</i>
Fully damaged house (number)		
Partially damaged house (number)		
Fully damaged shrimp ghers (number)		
Partially damaged shrimp ghers (number)		
Monetary value of damaged livestock (BDT)		
Monetary value of damaged fisheries & aquaculture (BDT)		
Monetary value of damaged shrimps (BDT)		
Value of damaged poultry (BDT)		
Value of damaged agricultural crops (BDT)		
Other damages (.....)		
Total loss of properties (BDT)		

7. Impact of cyclone on family income
8. Average shrimp production before and after cyclone
9. What are the major climatic events and hazards that affect shrimp aquaculture in your area?
10. Please mention what specific effects climate inconsistency and extremes have on various stages and components of shrimp aquaculture.
 - 10.1 Impact on overall shrimp aquaculture
 - 10.2 Impact on the production (volume) of and income (profit or loss) from shrimp cultivation
 - 10.3 Impact on overall cultivation of other fish species (including prawn)
 - 10.4 Impact on overall rice cultivation in ghers
 - 10.5 Impact on overall cultivation of dike crops and fruits

PART D: RESILIENCE: COMMUNITY CAPITALS

[Some questions of this and the following sections are made in light of survey questions from (a) 'The Fifth DIPECHO Action Plan for South Asia' launched by the Humanitarian Aid Department of the European Commission (ECHO), and (b) 'Instruments of the Social Capital Assessment Tool' developed by the World Bank]

1. Information on natural/ environmental capital
 - 1.1 What are the major natural resources of this community?
 - 1.2 What is the nature of access rights over these resources?
 - 1.2.2 How secure are they? Can they be defended against encroachment?
 - 1.2.3 Is there any significant conflict over access rights?
 - 1.2.4 Who are in charge of safeguarding the natural resources?
 - 1.2.5 Do the govt. agencies discharge their duties sincerely?
 - 1.2.5.1 Why do you think so? Please mention any of your experiences.
 - 1.3 Did you observe any change in volume or amount of resources over the last 10 years?
 - 1.3.1 What were the reasons of change?

- 1.4 Did you observe any change in productivity of the resources in the last 10 years?
 - 1.4.1 What were the factors behind productivity change?
- 1.5 Do you think natural resources can be used in enhancing community resilience to climate change?
 - 1.5.1 If 'Yes', how?
 - 1.5.2 If 'No', why?

.....
2. Information on physical or built capital
 - 2.1 What construction material is used for the majority of the exterior **walls** of the houses in this locality?
 - 2.2 What construction material is used for the majority of the **roofs** of the houses in this area?
 - 2.3 What construction material is used for the majority of the **floors** of the houses in this area?
 - 2.4 What type of sanitary services do the most households in this area use?
 - 2.5 What is the primary source of water for most of the households in this area?
 - 2.6 What type of lighting do most of the households use?
 - 2.7 Do you think most of the houses in this community are cyclone tolerant?
 - 2.8 Do you think most of the houses in this area are comfortable to live in during hot summer?
 - 2.9 Do you think most of the houses are comfortable to live in during heavy rainfall?
 - 2.10 Do you think most of the houses are safe enough to stay in during flood or storm
 - 2.11 What measures should be taken in order to make the houses more adaptive to climate hazards?
 - 2.12 How many factories are there in your locality?
 - 2.13 Can you use factory buildings as cyclone or flood shelters?
 - 2.14 Total number of school, madrasah, and college in your village: ...
 - 2.15 How can you use the buildings of above mentioned institutes during climatic hazards?
 - 2.16 Total number of mosques and temples in your village:
 - 2.17 How are mosques and temples used in adaptation to calamities?
 - 2.18 What are the major types of road in your village?
 - 2.19 What are the major vehicle that you use in transporting shrimp and equipments?
 - 2.20 Do you think existing roads and transportation system is appropriate and sufficient for supporting the shrimp aquaculture?
 - 2.20.1 If 'No', what problems do you face with roads and transportation system with regard to shrimp aquaculture?
 - 2.21 How many cyclone and flood shelters are there in your village?

.....
 - 2.22 Who provide (made) these shelters?
 - 2.23 What purposes are the shelters used during non-disaster period for?
 - 2.24 What is the distance of the nearest cyclone/ flood shelter from your home? km
 - 2.25 Have you ever taken shelter in those shelters? ☐ Yes ☐ No
 - 2.26 Do you think the shelters are large enough to accommodate all affected people during a disaster?
 - 2.27 What is the condition of utility services in the shelters?
 - 2.28 In your experience, how many affected people go to shelters during a disaster?
 - 2.29 What reasons are people unwilling to go to cyclone/ flood shelters for?
 - 2.30 How are the shelters used in protecting shrimp during natural calamities?

- 2.31 Have you observed any change in total physical capital of this area in the last 10 years?
- 2.32 How do the changes in built structures (infrastructures) impact adaptation strategies for climate change in shrimp sector?
3. Information on financial capital
 - 3.1 What are the principal modes of savings in your community?
 - 3.1.1 What are the risks of the above options?
 - 3.2 Is there any community fund for emergency purposes?
 - 3.3 How is the community fund raised/ developed?
 - 3.4 Who controls/ manages the community fund?
 - 3.5 How the community fund is used for collective adaptation to climate change phenomena?
 - 3.6 How many cooperative associations are there in your village?
 - 3.7 How do the cooperatives raise their funds?
 - 3.8 How do the cooperatives use their fund for the adaptation of their members to climate change phenomena?
 - 3.9 How many members of your family live outside the village?
 - 3.9.1 Where do they live?
 - 3.9.2 Do they remit money?
 - 3.9.3 Do remittances vary by time?
 - 3.9.4 When do they remit most?
 - 3.9.5 What are the modes of transfer of remittance?
 - 3.9.6 How much money they send?
BDT/year ☐ NA
 - 3.9.7 What purposes are the remittances used for?
 - 3.10 Do you think your community is economically self-sufficient? Why and how?
 - 3.11 What are the major sources of employment in this village?
 - 3.12 What are the sectors in which new jobs have been created in this area in the last 10 years?
 - 3.13 What are the peak and lean seasons of shrimp farming?
 - Peak season: Lean season:
 - ☐ No peak or lean season
 - 3.14 Do shrimp farmers/labors get alternative employment during lean period?
 - 3.14.1 If 'Yes', in which sectors?
 - 3.15 If a shrimp farmer loses his farm or shrimps because of climatic extremes, does he get financial support from the community?
 - 3.15.1 If 'Yes', in what ways?
 - 3.16 If there is a sudden drastic calamity and all the shrimp farms of this area are destroyed, is there any viable alternative employment opportunities for the affected people?
 - 3.16.1 If 'Yes', what would be the alternatives?
 - 3.17 Do you think that your community's overall economic strength has changed in the last 10 years?
 - 3.18 Do you think that your community has sufficiently strong economic base to run resilience activities for the whole community? ☐ Yes ☐ No
☐ No idea
 - 3.19 Why do you think so?
- 4 Information on social capital
 - 4.1 In the last 12 months, have you been a member of any social/cultural/religious/educational/health/sports/environmental/occupational/financial/business group, organization or cooperative association in local or national level?
 - 4.1.1 To what extent do you participate in the groups' decision-making?
 - 4.1.2 How do the groups usually make decisions?

- 4.1.3 How effective are those organizations in enhancing group members' welfare?
- 4.1.4 How do these groups (if any) assist shrimp farmers in building resilience to climate change?
- 4.2 With whom do you spend time outside the household for recreational activities (e.g. have tea, talk, play games etc)?
- 4.2.1 On an average, how often do you spend time outside the household for recreational activities (e.g. have tea, talk, play games etc)? times/week or month or year
- 4.3 How frequently do you have meals with people outside the household?
- 4.4 How frequently do you visit neighbors' (other than close relatives) home? ...
- 4.5 How frequently do your fellow villagers who are not your close relatives visit your home?
- 4.6 In which type of collective activities do you participate
- 4.6.1 (For Muslims) How many times do you pray *salah* in the mosques?
- 4.6.2 Do you regularly join the two *Eid* festivals every year?
- 4.6.3 (For non-Muslims) How frequently do you join with other people in your religious rituals and gatherings? times/week or month or year
- 4.7 In the last 12 months, how many incidents of conflict and clash occurred in your community?
- 4.8 On which matters/issues those incidents occurred?
- 4.9 How does the community settle the conflicts and disputes?
- 4.10 How do you agree with the following statements?

Comments	Scale				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
In your community, it is generally expected that people will volunteer or help in community activities.					
Most people in this village/ neighborhood are basically honest and can be trusted.					
People are always interested only in their own welfare.					
Members of this village/neighborhood are more trustworthy than others.					
Most people in this village/neighborhood are willing to help if you need it.					
You feel accepted as a member of this village.					

- 4.11 How do you trust the following groups of people?
- People in your family
- People in your religion
- People from other religion
- People in your village
- People from other villages
- Same club or group as yours
- Traders and businessmen
- Politicians
- Govt. service providers
- Local govt. officials
- Courts/police
- 4.12 If there were a problem that affected the entire village/neighborhood, for instance shrimp disease, who do you think would work together to deal with the situation?

- 4.13 If some decision related to a development project needed to be made in this village, do you think the entire village would be called upon to decide or would the community leaders make the decision themselves?
- 4.14 In the past year, how often have members of this village got together and jointly petitioned government officials or political leaders with community development as their goal?
- 4.15 Were any of these actions successful?
- 4.16 In how many cases did you or your family joined to those activities?
- 4.17 Name of the surrounding villages with main occupation of inhabitants:

<i>Located to</i>	<i>Name of village</i>	<i>Distance (km)</i>	<i>Main occupation</i>
North			
South			
East			
West			

- 4.18 Types of roads that connect this village with surrounding villages:
- 4.19 For which purposes do people from your village (including you) go to surrounding communities?
- 4.20 For which purposes do people from surrounding villages come to your village?
- 4.21 How frequently do you visit nearby communities?times/month
- 4.22 How frequently do you talk to people from surrounding communities over cell phone?times/week
- 4.23 How frequently do you lend or borrow money to or from surrounding villages? times/year
- 4.24 How many of your relatives or friends do live in nearby communities?
- 4.25 Overall, what is the nature of relationship between your community and surrounding villages?
- 4.25.1 What are the main sectors of cooperation?
- 4.25.2 What are the main sectors of competition/conflict?
- 4.25.3 Was there any violent clash between the surrounding communities in the last 12 months? times
- 4.25.3.1 What were the reasons?
- 4.26 On an average, how much natural resources do your neighboring communities have comparing to your own?
- 4.27 On an average, how much built capital (infrastructures) do your neighboring communities have comparing to your own?
- 4.28 Comparing to your community, how frequently do other communities experience climatic hazards?
- Frequency:
- Intensity:
- 4.29 How frequently and on which aspects do you take suggestions from or discuss with farmers of neighboring villages about shrimp aquaculture?
- 4.30 Suppose there emerged a shrimp related crisis (e.g. new shrimp disease) in your neighboring villages, do they inform your community about the problem beforehand in order to make you aware?
- 4.30.1 What would you do for the above case?
- 4.31 In what ways do shrimp farmers from neighboring communities help you in building resilience to climate change?
- 4.32 Do you know about any community based adaptation (CBA) program/project that addresses your village as well as neighboring villages?
- 4.33 What are the major adaptation related things and issues that your community share with neighboring villages?

4.34 In which of the following communal works do all the nearby communities jointly participate?

4.35 What changes do you observe in the following matters in the present society comparing to those in 10 years ago?

<i>Parameters</i>	<i>Change</i>					
	++	+	NC	-	--	DK
Face to face interaction						
Mobile contact						
Participation in social and religious gatherings						
Overall social bondage and cohesion						
Tendency of mutual cooperation and help						
Interaction and cooperation among people of same profession from different localities						
Urban connection of rural people						
Rural people's linkage with national policy makers						

Note: ++ = Increased greatly, + = Increased slightly, - = Decreased slightly, -- = decreased greatly NC = no change, DK = do not know

4.36 Who are the leaders of this community?

4.37 How much are the leaders aware about the problems of the community?

4.38 Which problems of the community do the leaders prioritize?

4.39 What measures do community leaders take in order to address local problems?

4.40 How do the community leaders ensure greater participation of community members in collective works?

4.41 How much are the community leaders connected to upazila, district and national level administrative, political and legislative bodies and authorities?

4.42 How frequently the community leaders have meetings with upazila, district and national level administrative, political authorities with regard to community development? times/year

☐ Do not know

4.43 Do the leaders become successful in achieving the community demands?

4.44 Did you find the community leaders doing the following things in the last 12 months?

<i>Jobs done</i>	<i>Frequency</i>
Make the media interested in a local problem	
Take part in a protest march or demonstration for a community interest	
Contact a minister/MP	
Notify the court or police about a local problem	
Raise funds for helping disaster affected people	
Contact donor agencies	
Contact national level NGO authorities	
Contact migrated rich people from this area	
Others (.....)	

4.45 Do you think the leaders had any positive role in bringing the following development programs for the community?

<i>Programs</i>	<i>Role of community leaders</i>			
	<i>Positive</i>	<i>Negative</i>	<i>No role</i>	<i>D K</i>
Govt. projects for community development				
Govt./NGO projects or funds for shrimp dev.				

Projects for climate change adaptation				
Others (.....)				

Note: DK = Do not know

- 4.46 What level of acceptance and legitimacy does the leadership have in the community?
- 5 Do you feel that you have certain responsibilities towards your community?
 - 5.1 If 'Yes', what kind of responsibilities those would be?
- 6 Do you think that you have the ability to impact /work for well being of the community?
- 7 During the last 12 months, in how many collective works did you participate/volunteer?
- 8 Do you consider resilience to climatic hazards as a priority for your family?
 - 8.1 Why?
- 9 Do you think building resilience to climatic problems is a priority for your community?
- 10 What are the major activities of your community with respect to enhancing community resilience to climate change?
 - 10.1 Have you or your family ever participated in those activities?
- 11 Are there specific activities in your community that support and encourage the voluntary participation of people in group works on resilience to climate change?
 - 11.1 If 'Yes', what are those programs?
 - 11.2 Have you or your family ever participated in those activities?
 - 11.2.1 If 'No', why?
- 12 Did you ever work for any relief providing organization?
 - 12.1 If 'Yes', why did you support them?
 - 12.2 How did you support them?
- 13 If the community needs long-time (say, 1 year) & regular work from you for community interest, how much are you willing to volunteer? hours/week
- 14 When you have a complaint or a problem, who do you address to?
- 15 Are they receptive to your problems?
 - 15.1 How do they respond to your queries?
 - 15.2 Do you feel free to approach to them whenever you need any support?
- 16 What is the main strength of your community?
- 17 What are the main weaknesses of your community?

PART E: RESILIENCE: OUTSIDE ASSISTANCE

1. Have you ever received any assistance from external sources?
2. What are the external sources?
3. What are the major categories of support you received from outside?
4. How frequently do you get external support?
5. Does any govt. officer supervise or visit your farm? ☐ Yes ☐ No
 - 5.1 If 'Yes', how frequently do they visit?
 - 5.2 Why do they supervise your farm?
 - 5.3 How do they help?
6. Have you ever seek help from Upazilla Fisheries Office?
 - 6.1 If 'Yes', for which kind of problem do you seek help from them?
 - 6.2 How do they respond to your queries?
 - 6.3 Are their advices effective? ☐ Yes ☐ No ☐ Sometimes
 - 6.4 Do you know that the govt. officials are supposed to support you?
 - 6.5 If 'Yes', do you think you or other members of your community feel free to express their views or demand rights adequately?
7. Does any NGO support/assist you in shrimp aquaculture?
 - 7.1 If 'Yes', which NGOs support shrimp aquaculture in this area?
 - 7.2 What kind of assistance do they provide?

8. Are there any NGO who opposes shrimp cultivation in your community?
 - 8.1 If 'Yes', which NGO?
 - 8.2 On which grounds they oppose?
 - A. Environmental concerns
 - B. Socio-economic concerns
9. Information on financial grants
 - 9.1 What are the major types of financial support you received?
 - 9.2 When do you get financial grant generally?
 - 9.3 Who provide financial grants?
 - 9.4 How much grants have you received so far?
 - 9.5 For which purpose(s) have you spent the amount received through financial grants?
10. Information on technical assistance
 - 10.1 Number of times you have received technical assistance from outside: times
 - 10.2 Major types of technical support:
11. Information on capacity building
 - 11.1 How many times have you taken capacity enhancing training for shrimp aquaculture?times so far.
 - 11.2 Who conducted those trainings?
 - 11.3 What were the subjects?
 - 11.4 How frequently the trainings are conducted? times/year
 - 11.5 Do the participants need to pay for the trainings?
 - 11.6 How many of shrimp farmers have already taken training?
 - 11.7 What are the positives about training programs? ...
 - 11.8 What are the negatives about training programs?
 - 11.9 How many times have you participated in awareness building workshops?
 - 11.10 What were the subjects?
 - 11.11 Who conducted those workshops?
 - 11.12 Do you think shrimp farmers and local people have become more aware about negative impacts of shrimp cultivation?
 - 11.13 Do you think shrimp farmers and local people have become more aware about climate change phenomena and their impacts on the shrimp community?
12. Opinion about outside intervention.
 - 12.1 Do you think existing outside support is sufficient for the development of a responsible, climate resilient and sustainable shrimp aquaculture practice in your area?
 - 12.2 What actions should Bangladesh Govt. and NGOs take in order to effectively assist shrimp aquaculture in Bangladesh?