Differential livelihood adaptation to socio-ecological change in coastal Bangladesh

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The candidate confirms that the work submitted is her own, except where work which has formed part of jointly-authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

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These papers are based on the findings of this PhD research. As the first author, I designed the research, collected the data, analysed it and wrote the manuscript on my own. The co-authors are my PhD supervisors, who revised and provided feedback on earlier drafts of the papers.

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Abstract

Socio-ecological changes, brought about by the rapid growth of the aquaculture industry and the increased occurrence of climatic shocks and stresses, have significantly affected the livelihood dynamics of coastal communities in Asia. Empirical studies, to date, have largely provided a snapshot of the impacts and responses to a particular disturbance at a single spatial scale at a given time, often assessing the characteristics that make certain populations more vulnerable than others. To ensure equitable and environmentally sustainable livelihoods in the future, it is essential to unpack the complex social and ecological dynamics that drive long-term changes in a system's configurations and shape the adaptive capacities of actors within the system. This study, therefore, explores the drivers, differential livelihood adaptations and well-being outcomes of socio-ecological change in coastal Bangladesh, using poverty as central lens for differentiation. The study takes a socio-ecological systems approach, whereby insights from vulnerability, resilience, political ecology, livelihoods, adaptation, poverty and human well-being are integrated into an interdisciplinary conceptual framework. A mixed methods approach was used to collect empirical evidence from two communities, both of which underwent transformations in farming systems when maintenance of the *status quo* through incremental adaptation was no longer feasible.

Findings show that in the absence of good governance, social power resulting from high wealth status and associated political ties can steer the direction of socio-ecological change to one that is desirable for a small group of powerful stakeholders and completely undesirable for others. Differences in wealth status lead to differences in adaptive capacity; however, changes in vulnerability contexts brought about by power dynamics further exacerbate these inequalities. While resource constraints can restrict a household's livelihood adaptation options, its adaptation space can also become narrower through negative externalities arising from the activities of other households. This can push some households towards downward trajectories, locking them in a poverty trap. In contrast, good governance and wider participation in decision making, can shift the farming system to one that is desirable for the majority of stakeholders. The study emphasises that resilience building through transformational adaptation should account for the heterogeneous values, interests and needs of different households. This can translate into more equitable adaptive capacities and prevent the system from embarking on a maladaptive trajectory in the future.

Table of Contents

List of Tables

List of Figures

Abbreviations

BDT	Bangladeshi Taka
FGD	Focus group discussion
FSA	Fuzzy set analysis
IPCC	Intergovernmental panel on climate change
NGO	Non-governmental organisation
PCA	Principal component analysis
PWR	Participatory wealth ranking
SES	Socio-ecological system
SER	Socio-ecological resilience
SRL	Sustainable rural livelihoods
SLF	Sustainable livelihoods framework

Conversion Units

GBP 1 = BDT 120 (HM Revenue and Customs, 2014)

1 acre = 100 decimals

Chapter 1. Introduction

1.1 Research background

Socio-ecological changes brought about by the rapid growth of the aquaculture industry and increased occurrence of climatic shocks and stresses have significantly modified the vulnerability contexts in low lying coastal areas in many parts of Asia (Abdullah *et al.*, 2016, Orchard *et al.*, 2016, Pokrant, 2014). Export-oriented aquaculture was promoted by international development and financial institutions in indebted poor countries during the 1970s as a means of accelerating growth, increasing land productivity and fostering human well-being (Rivera-Ferre, 2009). Thus, soil and water salinity, which was once considered a bane for intensifying agricultural production, served as an enabling factor in the development of coastal areas, attracting millions of people and huge private investments (Joffre *et al.*, 2010). However, these coastal areas are also highly exposed to cyclones, tidal surges and salinity intrusion – the intensity and frequency of which are very likely to increase due to global climate change (Wong *et al.*, 2014, Nicholls *et al.*, 2007). On one hand, climatic shocks and stresses, such as increased temperature, higher salinity and coastal flooding, can have detrimental effects on shrimp productivity. On the other hand, weakening of coastal embankments, mangrove clearance, increased siltation of tidal rivers, elite capture of common pool resources and increased soil salinity brought about by shrimp farming can increase the climate vulnerability of coastal populations by increasing exposure to shocks and stresses and reducing adaptive capacities (Ahmed and Diana, 2015, Shameem *et al.*, 2015).

Socio-ecological changes shape livelihood dynamics, adaptive capacities and human well-being in distinct ways. Individuals and households differ in terms of their resource endowments, their capabilities to transform those resources into desirable livelihood activities, and their perceptions of what is desired (Leach *et al.*, 1999, Sen, 1993). In reality, individuals and households have different levels of autonomy to choose their livelihood pathways. Their adaptation space can be constrained by the broader socio-economic and political landscape, as well as by their previous decisions that can lock them in to particular pathways (Osbahr *et al.*, 2010). While an adaptive response may be effective for one social group, it may cause negative externalities that can undermine the adaptation options and outcomes of another group (Osbahr *et al.*, 2010). To ensure sustainable and equitable livelihoods in the future and prevent further environmental degradation, it is essential to

understand the long-term conditions and processes that drive socio-ecological change, the differential livelihood dynamics and adaptive responses to these changes, and the inequalities in well-being outcomes (Tanner *et al.*, 2015, Benessaiah and Sengupta, 2014).

Given the inherent complexity of socio-ecological systems, a holistic in-depth analysis of different elements within the system requires an integrative, interdisciplinary approach that bridges across several ecological and social knowledge domains (McGinnis and Ostrom, 2014, Binder *et al.*, 2013). Particularly, within the literature on aquaculture transitions, there is a clear demand for integrative approaches to analyse the drivers and consequences of social and environmental change in coastal regions of Asia (Bush and Marschke, 2014). Bottlenecks in cross-fertilisation of concepts with different epistemological origins have often resulted in isolated views of complex issues (Janssen *et al.*, 2006). For instance, vulnerability studies have mostly provided a snapshot of the impacts and responses to a disturbance at a single spatial scale at a given time, without sufficiently addressing the root causes of vulnerability. This gap within the vulnerability literature can be overcome by incorporating insights from socio-ecological resilience that engages with the cross-scalar interactions between multiple changes over time (Miller *et al.*, 2010, Adger, 2006). However, resilience thinking is criticised for its system level bias that does not account for the heterogeneities in power and values of social actors (Brown, 2015, Fabinyi *et al.*, 2014, Cote and Nightingale, 2012). Thus, critiques have increasingly highlighted the need to bring in a political ecology perspective to analyse the role of power dynamics in determining 'which state is desirable and for whom' (Turner, 2013, Davoudi, 2012, Peterson, 2000).

The ability to adapt livelihoods to socio-ecological change is uneven across societies, thus, creating a need for social stratifiers, such as class, gender, or ethnicity (Tucker *et al.*, 2015, Adger *et al.*, 2007). There is a strong link between a household's livelihood adaptive capacity and its poverty level, as established by a large number of livelihood studies (e.g. Gautam and Andersen, 2016, Martin and Lorenzen, 2016, Oumer and de Neergaard, 2011, Van den Berg, 2010, Cramb *et al.*, 2004). While these studies differentiated livelihood strategies by wealth class, they often provided a static picture that veiled the continuous struggles of people in making a living, including the various factors that lead to upward and downward trajectories. Livelihood scholars have repeatedly emphasised the need to analyse livelihoods as a 'moving target' by using livelihood trajectories as a methodological tool (McLean, 2015, Valbuena *et al.*, 2015). Besides economic barriers posed by the household's own poverty level, a number of other ecological, political, cognitive, informational or technological opportunities, barriers and limits can widen or constrain the household's adaptation space (Klein *et al.*, 2014, Adger

et al., 2007). However, the heterogeneous impacts of these factors on different social groups and how adaptation by privileged members of society can impinge on the adaptive capacity of disadvantaged ones seems to be poorly studied (Shackleton *et al.*, 2015). Moreover, the ultimate implications of these changes and responses on people's well-being need to be considered not only in terms of material aspects, but also in terms of subjective and relational dimensions, because well-being means different things to different people (Armitage *et al.*, 2012, Coulthard, 2012).

This study takes a socio-ecological system (SES) approach, whereby insights from vulnerability, resilience, political ecology, livelihoods, adaptation, poverty, and human well-being are combined to overcome disciplinary divides and provide a nuanced understanding of the differential livelihood dynamics and adaptations to socio-ecological change in coastal Bangladesh. Bangladesh is an appropriate case for this research because of its high vulnerability to climate change (MoEF, 2009, Ahmed, 2006) and heavy dependence on shrimp aquaculture, which is the second largest foreign revenue earner after ready-made garments and employs millions of people across the supply chain (Abdullah *et al.*, 2016). The next section provides a brief overview of the state of climatic shocks and stresses and the aquaculture industry in Bangladesh, followed by sections outlining the aims, objectives, and the thesis structure.

1.2 Contextual background

1.2.1 Climatic shocks and stresses in Bangladesh

Located on the lower reaches of the Ganges-Brahmaputra-Meghna (GBM) mega-delta in South Asia (Figure 1.1), each year Bangladesh drains 92% of the total sediment laden run-off from the GBM catchment into the Bay of Bengal, although only 8% of the GBM delta lies within Bangladesh itself (Ahmad *et al.*, 1994). The coastal zone of Bangladesh, which covers 32% of the country's land area and is home to 28% of the population, is an active tidal floodplain crisscrossed by numerous rivers and creeks that extend up to 200km inland, particularly in the south-western region (Ahmed, 2011). These unique hydro-geological characteristics make the coastal region particularly exposed to tropical cyclones in the pre-monsoon and post-monsoon seasons, and increased salinity during the dry season; both of which are expected to be further impacted by climate change (Mahmuduzzaman *et al.*, 2014, Nuruzzaman, 2006).

Two of the most recent cyclones, cyclone Sidr in 2007 and cyclone Aila in 2009, killed thousands of people, damaged embankments, destroyed houses, uprooted trees in the

Sundarban mangrove forest and inundated hundreds of villages, thus, negatively affecting the lives and livelihoods of people in the south-western region (Disaster Management Bureau, 2010). Salinity intrusion is largely a seasonal phenomenon. Melting of Himalayan glaciers and heavy rainfall increase upstream flow during the wet season maintaining freshwater in the rivers and canals in coastal areas, while decreased flow during the dry season causes saline water to move inwards due to the backwater effect of the Bay of Bengal (Mahmuduzzaman *et al.*, 2014, Nuruzzaman, 2006). The construction of the Farakka dam in India in the mid-1970s has significantly increased salinity in tidal rivers of south-western Bangladesh over the past three decades (Islam and Gnauck, 2008).

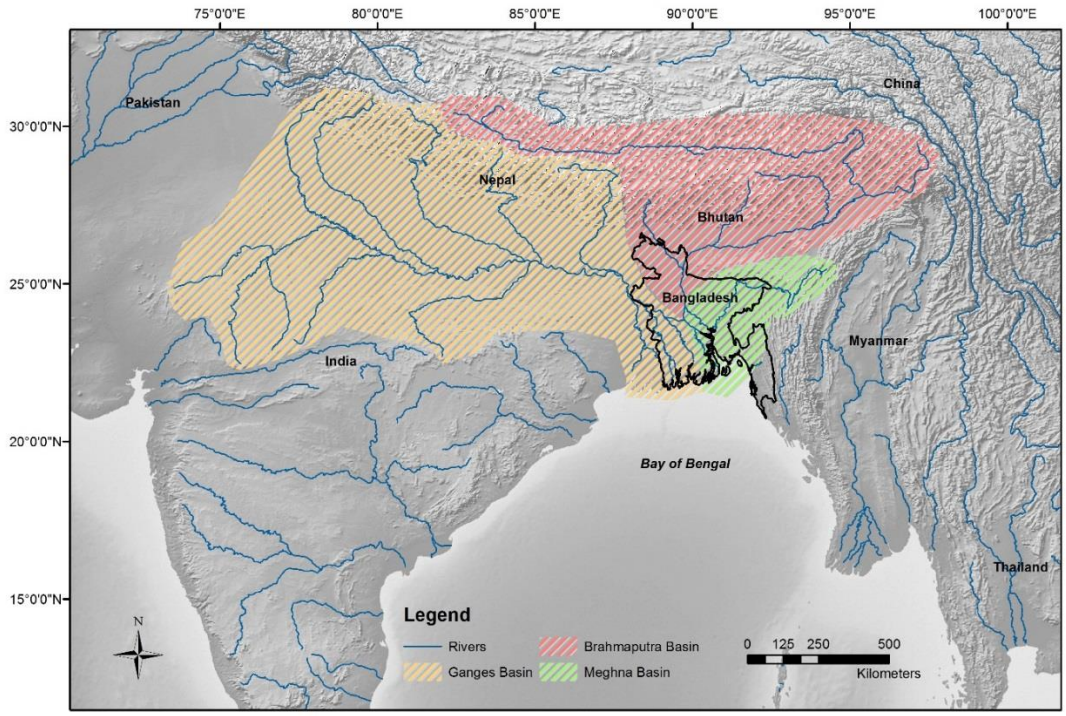


Figure 1.1 Map of Bangladesh showing its location with respect to the Ganges-Brahmaputra-Meghna catchment in South Asia (Author's own illustration using ArcGIS)

In addition, increases in sea surface temperatures and sea level rise due to climate change are highly likely to increase the frequency and intensity of tropical cyclones, causing associated increases in the height of tidal surges. Similarly, fluctuations in rainfall patterns in the GBM catchment area and reduced river flow during the dry season may cause the salinity front to move further inland (Ahmed *et al.*, 2015, Minar *et al.*, 2013). As identified by studies on local perceptions of climate change, coastal communities are also being exposed to increased summer temperatures, shorter and warmer winters with intermittent intense cold spells, late onset of the monsoon, heavy rainfall within a shorter time period and

increases in water levels during high tides (Rahman and Pokrant, 2015, Shameem *et al.*, 2015, Rashid *et al.*, 2014).

1.2.2 Shrimp and prawn aquaculture in Bangladesh

The emergence of shrimp and prawn cultivation in Bangladesh resulted from a number of concurrent changes. During the 1960-70s, hundreds of polders were constructed in the coastal region with the aim of increasing agricultural productivity by keeping saline water out of the farmlands (Pokrant, 2014, Swapan and Gavin, 2011). These infrastructural developments, coupled with the country's export oriented growth policy and high international market demand for shrimp, spurred interests in brackish water shrimp and freshwater prawn cultivation since the 1970-80s (Pokrant, 2014, Tuong *et al.*, 2014). The area of land under shrimp/prawn cultivation increased from 64,246 in 1985 to 141,353 ha in 2003 and 275,232 ha in 2012 (Department of Fisheries, 2013). In 2012, 76% of this land was used for brackish water Bagda shrimp *(Penaeus monodon)* production and 24% for freshwater Galda prawn *(Macrobrachium rosenbergii)* cultivation. The majority of these shrimp farms are located in the south-western coastal region (74%), especially in the districts of Satkhira (23%), Khulna (18%) and Bagerhat (26%) (Department of Fisheries, 2013). In 2012, about 48,000 metric tonnes of frozen shrimp/prawn were exported, earning BDT 36 billion (USD 455 million) or 2.5% of the total export revenue (Department of Fisheries, 2013).

Bagda shrimp are usually cultured in low lying modified rice fields (locally referred to as *'gher'*), where natural and hatchery-bred post-larvae are stocked at low density in brackish water, often without any supplementary feed (Rahman and Hossain, 2013). Freshwater prawn are grown in polyculture ponds along with white fish or integrated with paddy in agricultural fields (USAID, 2006). The increasing salinity gradient from the interior to exposed coastal zone has resulted in different farming systems within the south-western coastal region. Areas where salinity is high for a period of 8 - 9 months can culture shrimp only, those with high salinity for up to 6 months depend on a dry season shrimp and wet season paddy alternate system, while those with low salinity can grow both monsoon and irrigated winter paddy crops along with freshwater prawn (Faruque *et al.*, 2016, Ahmed, 2013b).

While shrimp/prawn cultivation earns significant export revenue for Bangladesh, provides significant employment and is an important component of the country's economic growth, it has uneven impacts on households with different land ownership (Abdullah *et al.*, 2016, Belton, 2016). Past studies have narrated the adverse agro-ecological and socio-economic

impacts of brackish water shrimp farming, with respect to soil degradation, increased water salinity, dwindling paddy yields, mangrove clearance and conflicts among groups of farmers (Pokrant, 2014, Hossain *et al.*, 2013, Swapan and Gavin, 2011, Ali, 2006). Shrimp cultivation disproportionately affects the poor due to a number of reasons; firstly, community wide shrimp farming precludes all forms of subsistence based livelihood activities, such as paddy cultivation, livestock rearing, homestead gardening and open-access fishing; secondly, cash income from shrimp farming conducted on small parcels of land is usually not enough to compensate for the lack of other income sources; thirdly, disease outbreaks on shrimp farms cause increased shrimp mortality, making it a risky business for the poor; and lastly, the poor have limited voice in community level decision making and management of water control structures, making them victims of power plays (Abdullah *et al.*, 2016, Belton, 2016, Pouliotte *et al.*, 2009). On the other hand, freshwater prawn cultivation is considered to be both ecologically and economically sustainable; however, high initial investments and operating costs, along with lower availability of post-larvae and natural feed, have barred the potential growth of this sector (Ahmed *et al.*, 2010, Ahmed and Garnett, 2010).

1.3 Aims and objectives

The aim of this research is *"To explore the drivers, differential livelihood adaptations and well-being outcomes of socio-ecological change in coastal Bangladesh"*.

To fulfil this aim, the study used a case study approach, in which two communities with differential socio-ecological changes, were selected. These communities were Kamarkhola village in Khulna district and Mithakhali village in Bagerhat district of south-western coastal region of Bangladesh. Within each of the communities, households were first disaggregated by their poverty level/ wealth class, which subsequently served as the key lens for differentiating the drivers, responses and distributional effects of socio-ecological change. Thus, in this study, the term 'differential' indicates 'differences between the two communities' as well as 'differences between households of different wealth classes within each community'. The study objectives and the research questions are outlined below.

Objective 1: To compare different methods of multi-dimensional poverty assessment and disaggregate households within the selected communities into different poverty levels.

1. What are the strengths and limitations of the three widely used methods of multi-dimensional poverty assessment at micro level – participatory wealth ranking, principal component analysis and fuzzy set theory?

2. What are the different decisions that need to be taken at various sub-stages of the two quantitative methods - principal component analysis and fuzzy set theory - and how do these affect the overall results?
3. How many poverty groups can be identified in the study communities and what percentages of households belong to each group? How do households at different poverty levels compare in terms of their asset ownership within each community and between the two study communities?

Objective 2: To analyse the underlying drivers of socio-ecological change in the two study communities

1. What were the key changes at various spatial scales that led to differential socio-ecological changes in the two communities?
2. How did power dynamics among farmers influence these changes?

Objective 3: To investigate the livelihood dynamics and human well-being outcomes of households of different poverty levels in the two study communities

1. How did the socio-ecological changes in the two communities affect the livelihood strategies of households at different poverty levels?
2. What factors did households consider in designing their livelihood portfolios?
3. What determined the direction of household livelihood trajectories and why?
4. What were the implications of the socio-ecological changes and livelihood responses for the well-being of households of different poverty levels?

Objective 4: To explore the livelihood adaptation opportunities, barriers and limits faced by households of different poverty levels in the two study communities

1. What opportunities, barriers and limits did households of different poverty levels face in adapting their livelihoods?
2. Did adaptation by one group affect the adaptive capacity of another?
3. How did the different opportunities, barriers and limits interact? How can certain barriers be overcome or reduced?

1.4 Thesis structure

This thesis is divided into eight chapters. Following this introductory chapter, **chapter 2** provides a review of theoretical development and empirical work related to the concepts of

vulnerability, resilience, political ecology, livelihoods, adaptation, poverty, and human well-being and identifies the key research gaps within these knowledge domains. The interrelations among these domains were used to develop a conceptual framework, which was applied to study the research objectives.

Chapter 3 presents the methodological approach and the research methods applied to address the study objectives, and describes the study sites. The chapter first provides a brief overview of the research philosophy, in terms of the ontological and epistemological stance, and the research strategy, involving the use of a case study approach. It then introduces the study sites selected for this research, explaining the criteria and process involved in the selection process. A general overview of the Bangladesh country context is provided, followed by particular focus on the south-western coastal region and the two selected villages. The chapter describes the research methods - a mixed methods approach, comprising participatory wealth ranking, focus group discussions, household questionnaire surveys and livelihood trajectory interviews. This is followed by the data analysis methods used for quantitative and qualitative data respectively. The chapter concludes with reflections on the research experience, including administration of field work, positionality, and ethical considerations.

Chapter 4 is the first results chapter, which addresses the first objective of this study. The chapter disaggregates households in the study communities into different poverty groups, using participatory wealth ranking (PWR), fuzzy set analysis (FSA) and principal component analysis (PCA). Since poverty is used as a central lens in differentiating households in this study, the disaggregation done in this chapter serves as a baseline for structuring data in the subsequent chapters. The chapter also empirically contributes to a better understanding of methodological issues in multi-dimensional poverty assessment. By using one qualitative and two quantitative methods on the same data-set, it demonstrates how the choice of poverty assessment method and the decisions taken at various sub-stages of a given method can affect the overall results.

Chapter 5 addresses the second study objective, which is to analyse the underlying drivers of differential socio-ecological changes in the two study villages. This requires investigation of the long-term conditions and processes operating at different spatial scales and how they interact over time. Previous studies on vulnerability often focused on short-term impacts and responses to a disturbance, without sufficiently engaging with the root causes of vulnerability. Chapter 5 addresses this gap by integrating the concepts of socio-ecological resilience and political ecology. Although several scholars have highlighted the need for this

conceptual convergence, very few studies have empirically demonstrated this approach. The chapter uses the adaptive cycle, a heuristic model within resilience thinking, to examine the cross-scalar interactions among various agro-ecological, socio-political and economic conditions and processes, which led to different directions of change in farming systems in the two villages. It then uses a political ecology approach to analyse the roles of social actors and their power relations in navigating the direction of change. By integrating resilience and political ecology, the chapter demonstrates the need to engage with both system- and actor-oriented perspectives in understanding which state is desirable and for whom.

Chapter 6 addresses the third research objective, which is to investigate the livelihood dynamics and human well-being outcomes of households of different poverty levels in the two study communities. An extensive body of literature has established the link between a household's poverty level and its livelihood adaptive capacity. However, this static view of livelihoods provides a snapshot of a single scale given time and veils the differential impacts of socio-ecological changes over time. Livelihoods are dynamic, meaning that the same household can pursue different strategies at different times due to changes in the context, which, in turn, may be brought about by the livelihood activities of other households. Livelihoods are also path dependent, such that the outcomes of previous strategies may restrict future livelihood options. By quantitatively comparing the livelihood strategies of households at different poverty levels at two time periods and qualitatively analysing individuals' livelihood trajectories, chapter 6 empirically contributes to the literature on livelihood adaptation dynamics. It then analyses the implications of socio-ecological change and livelihood adaptation responses on households of different wealth classes. The social conception of well-being is applied to explore the material, subjective and relational dimensions of well-being, and thus, identify the differential needs and values of farmers in the two villages.

Chapter 7 addresses the fourth research objective. The growing body of literature on barriers to adaptation in rural communities has largely addressed the factors that impede adaptation by smallholder farmers, especially in the context of drought prone regions of Sub-Saharan Africa. However, the heterogeneous impacts of adaptation barriers on different social groups and how adaptation strategies pursued by wealthier members of society can affect the adaptive capacity of poorer households are poorly studied. Chapter 7 addresses this knowledge gap by looking at the disaggregated effects of respective opportunities, barriers and limits on livelihood strategies adopted by households of different poverty levels. The chapter structures the opportunities, barriers and limits into eight categories,

discusses how they interact and reinforce each other, and suggests the ways in which some barriers can be overcome.

Finally, **chapter 8** provides a broader discussion on how the findings of the results chapters (Chapters 4 – 7) enhance our academic understanding of livelihood adaptation to socio-ecological change and what they mean for the coastal regions of Bangladesh and beyond. In doing so, the chapter first revisits the conceptual framework developed in chapter 2 and compares its conceptualisation of social and ecological systems dynamics with other SES frameworks in the literature. It then discusses how the findings from this thesis support and contribute to the recent literature on the drivers, adaptation responses and distributional effects of socio-ecological change. Finally, the chapter concludes this thesis by discussing the implications and future research directions.

Chapter 2. An interdisciplinary approach to exploring socio-ecological change

2.1 Introduction

This PhD research explores the drivers, differential livelihood adaptations and well-being outcomes of socio-ecological change in coastal Bangladesh. In doing so, the thesis adopts a socio-ecological system (SES) approach that integrates insights from a number of concepts, namely vulnerability, resilience, political ecology, livelihoods, adaptation, poverty, and human well-being. The SES approach has gained increased traction during the last decade as a means of understanding complex global environmental changes arising from the spatial and temporal interactions of various social and ecological conditions and processes (McGinnis and Ostrom, 2014, Binder *et al.*, 2013, Folke, 2006, Walker *et al.*, 2006, Berkes *et al.*, 2003). A SES is defined as *"a bio-geophysical unit with its associated social actors and institutions, which are complex, adaptive and delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context"* (Glaeser *et al.*, 2009: 190). Unpacking the complexities of SESs requires integrative interdisciplinary approaches that bridge across several knowledge domains (McGinnis and Ostrom, 2014, Binder *et al.*, 2013). This chapter reviews the theoretical developments and empirical work within the concepts mentioned above, identifies the key research gaps and develops an integrated conceptual framework for this research.

2.2 Vulnerability

2.2.1 Conceptualisation of vulnerability

Vulnerability has received huge recognition in the field of global environmental change, particularly with respect to the effects of climatic variability and change on the livelihoods and well-being of exposed communities. Vulnerability research has been shaped by different epistemological traditions, namely biophysical/risk-hazard, human ecological, political economy and political ecology perspectives, with differences in emphasis, interpretations and approaches (McLaughlin and Dietz, 2008, Adger, 2006, Eakin and Luers, 2006). While the risk-hazards approach was concerned with 'what are the risks? Where and when are they likely to occur?' (e.g. Iglesias *et al.*, 1996, Burton *et al.*, 1993), political economy and political ecology perspectives focused on 'which populations are most vulnerable, how and why?' (e.g. Pelling, 1999, Sen, 1981). These antecedent approaches were followed by more

integrated frameworks (e.g. Reed *et al.*, 2013b, Fraser *et al.*, 2011, Ostrom, 2009, Turner *et al.*, 2003, Scoones, 1998) that aimed to provide a holistic understanding of the nature and impacts of shocks and stresses and the processes through which communities and households respond to them. For instance, according to Turner *et al.* (2003)'s framework, vulnerability of a coupled socio-ecological system comprises its exposure, sensitivity and resilience, which are linked to the broader human and bio-physical conditions and processes operating at different spatial and temporal scales.

While vulnerability has been defined in a number of ways by different authors, the core concept encompasses the degree to which groups or individuals are susceptible to and unable to cope with the adverse effects of external shocks and stresses (Parry *et al.*, 2007, Kelly and Adger, 2000). According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability is a function of exposure, sensitivity, and adaptive capacity; where exposure refers to *"the nature and degree to which a system is exposed to significant climatic variations"* (p.987), sensitivity is *"the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli"* (p.993) and adaptive capacity is *"the ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences"* (p.982) (McCarthy *et al.*, 2001). However, the recent IPCC Fifth assessment report (AR5) report defines vulnerability as the *"propensity or predisposition to be adversely affected"* (p.28), without an exclusive focus on climate change (IPCC, 2014). This seems to be in line with the recent empirical literature (e.g. Bennett *et al.*, 2015, Tucker *et al.*, 2015, McDowell and Hess, 2012, Pouliotte *et al.*, 2009), in which vulnerability is viewed as susceptibility to 'multiple stressors' arising from a wide variety of socio-economic, political and environmental conditions, and climate change is considered as a compounding factor.

Different discourses on global environmental change have resulted in two main interpretations or framings of vulnerability in the climate change literature – termed as 'end-point' or 'outcome' vulnerability and 'starting-point' or 'contextual' vulnerability (O'Brien *et al.*, 2007, Kelly and Adger, 2000). The end-point or outcome approach considers vulnerability as *"a linear result of the projected impacts of climate change on a particular exposure unit (which can be either biophysical or social), offset by adaptation measures"* (O'Brien *et al.*, 2007: 75). The IPCC's definition of vulnerability is an example of this approach. The starting point or contextual approach considers vulnerability as a multidimensional view of climate–society interactions. Both climate variability and change are considered to occur in the context of political, institutional, economic and social structures and changes, which interact

dynamically with contextual conditions associated with a particular 'exposure unit' (O'Brien *et al.*, 2007, Kelly and Adger, 2000).

2.2.2 Assessment of vulnerability

The toolkit for vulnerability analyses includes a wide array of methods, such as household questionnaire surveys, focus group discussion, participatory exercises, and livelihood trajectory interviews, which investigate why certain communities, households or individuals are more susceptible to harm than others and what institutional, socio-economic, political and environmental factors undermine their capacity to maintain livelihoods in the face of shocks and stresses. For example, using focus group discussions, key informant interviews, observation visits and individual semi-structured interviews in a coastal village in Bangladesh, Pouliotte *et al.* (2009) found that exposure to salinity intrusions and changes in production systems from rice to shrimp cultivation disproportionately affected poorer households by decreasing their livelihood options. Similarly, Coirolo and Rahman (2014) used a participatory climate vulnerability and capacity analysis at community level, along with household surveys and individual interviews, and found that the differential vulnerability within groups of poor people was due to issues of power and inequity in resource access. Moreover, in the past decade, there has been a huge surge in the development of indicators and composite indices (e.g. Etwire *et al.*, 2013, Islam *et al.*, 2013, Antwi-Agyei *et al.*, 2012, Hahn *et al.*, 2009), which try to quantitatively compare the relative vulnerability of different groups and understand the factors contributing to differential vulnerability. For example, in their study characterising vulnerability to drought within six communities in Ghana, Antwi-Agyei *et al.* (2012) applied a livelihood vulnerability index that conceptualised vulnerability as a function of a household's access to the five livelihood capital assets and the extent to which the household had diversified its livelihood activities.

Recently, Tucker *et al.* (2015) reviewed the literature on social vulnerability in three high-poverty climatic hotspots (Africa, Central Asia and South Asia), focusing on delta, semi-arid regions, and glacier and snowpack-dependent river basins. With respect to deltas, which is the broader geographical focus of this PhD research, Tucker *et al.* (2015) found that the main indicators of exposure included low lying lands exposed to sea-level rise, salinity and cyclones, densely populated environments experiencing rapid growth, concentration of economic and commercial activities, and presence of high value infrastructure and natural capital. In addition, deltaic communities were particularly sensitive because of their high dependence on natural resource based livelihoods, intensive land-use and coastal development, and the degradation of natural ecosystems, such as mangroves, beaches and

grasslands, which provide important ecosystem services. Most of the studies highlighted the importance of livelihood diversification, fostered by local innovation and social networks, as an important adaptation strategy. However, intensive development and commercial farming practices seemed to limit adaptation options for poor subsistence based farmers, as access to land and water were often not well-governed (Tucker *et al.*, 2015).

2.2.3 Research gaps

Vulnerability studies have been criticised for their lack of engagement with the roots causes of vulnerability in the study areas. Since the concept of vulnerability originated within the social sciences, the key research questions and the methodological approaches guiding the concept often adhere to an actor oriented focus concerned with the impacts on communities and households and their responses to socio-ecological change (Miller *et al.*, 2010, Adger, 2006). Miller *et al.* (2010) argues that compared to the large body of literature that presents a snapshot of vulnerability at a given time, there are few longitudinal or historical studies. Tucker *et al.* (2015)'s review on social vulnerability in three high-poverty climatic hotspots highlighted that there is a need for greater understanding of the underlying drivers of vulnerability, including the interaction between multiple stressors, and how they change over time. The authors argue that vulnerability analysis should incorporate long-term socio-economic trends and the dynamic ways in which households respond to shocks and stresses. The review specifically mentioned that studies conducted on delta regions mainly focus on assessing the characteristics of the exposed population and their assets, instead of addressing the root causes of vulnerability (Tucker *et al.*, 2015). This gap within the vulnerability research domain can be tackled by incorporating insights from resilience thinking, which offers a system oriented approach and looks at the interaction of multiple domains over long periods of time. The following section discusses the conceptualisation of socio-ecological resilience, its link to vulnerability and its critiques.

2.3 Resilience

2.3.1 Conceptualisation of socio-ecological resilience

The resilience concept has captured interest in social science oriented environmental research by analysing human-nature interactions in the face of socio-ecological and economic changes (Speranza *et al.*, 2014, Leach, 2008). Originating from the ecological sciences in the 1970s, resilience was initially defined as the ability of a system to re-organise within its own state and thus maintain its existing structures and functions in the face of disturbance. Based on studies of predator-prey populations and their functional responses

to ecological stability theory, Holling (1973: 14) first defined resilience as *"a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables"*. Social scientists attempting to apply the concepts of ecological systems to human systems also focused on this narrow definition and conceptualised resilience as 'resistance and maintenance' or the 'buffer capacity' of the system. Walker *et al.* (2004: Abstract), for instance, defined resilience as *"the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"*.

However, unlike natural systems governed by deterministic laws, human beings can exercise their intention and foresight and can act as important agents of change. This recognition led to the scholarly expansion of resilience thinking from its narrow ecological domain to broader SESs. Within the SES domain, resilience is defined as a system's capacity to absorb disturbance and conserve its existing structures, as well as advance its current state through learning and adaptation (Cutter *et al.*, 2008, Folke, 2006, Carpenter *et al.*, 2001). The first part of this definition refers to the 'buffer capacity' or resistance to change, while the last part deals with 'adaptation' and 'transformation' or the capacity to learn and self-organise. In physical systems, adjustments or self-organisation occur without any intent or centralised control; however, as humans have foresight and capacity for deliberate actions, adaptation in SESs is a function of individual or collective human actions that occur either intentionally or unintentionally (Walker *et al.*, 2006).

For a SES to adapt to and shape change, it needs to possess certain key sources of social resilience, such as social learning and memory (Folke *et al.*, 2005). Social learning involves developing the capacity of individuals to learn from experience and building knowledge and skills that permit adaptive management. Social memory is the accumulated experience and history of the system that allows it to re-organise after a disturbance (Berkes *et al.*, 2003). Moreover, as identified by Folke *et al.* (2005), leadership serves an essential role in shaping change and reorganisation by providing key functions, such as making sense, managing conflict, linking actors and breaking the inertia in SESs. Finally, surprise and crisis, such as natural hazards, create opportunities for reorganisation, renewal and novelty (Folke *et al.*, 2005). Disturbance provides an avenue for a community to deploy its problem solving skills in debates and decision making processes and create suitable strategies for coping with change. The key elements of resilience can enable a SES to shift to a new regime when the current state becomes undesirable (Walker *et al.*, 2006, Walker *et al.*, 2004). This capacity to create a fundamentally new system when the existing economic, ecological or social

structure becomes untenable is referred to as 'transformability'. Transformation leads to untried beginnings characterised by uncertainty, novelty and experimentation.

2.3.2 Adaptive renewal cycle

Resilience thinking accepts that change is inevitable; all complex systems starting from cells to ecosystems and human societies are dynamic and tend to move through four recurring phases forming the adaptive cycle (Gunderson and Holling, 2002). The two salient dimensions determining change in an adaptive cycle are: (1) connectedness which refers to the ability of a system to internally control its own destiny and potential; and (2) potential which refers to the wealth of the system and the alternative options available for the future (Holling, 2001).

A system generally moves from a fast exponential exploitation phase (r) characterised by abundant resources, accumulation of structure and high resilience to a slow conservation phase (K), during which the system is highly interconnected, less flexible and increasingly susceptible to external disturbances (Folke, 2006, Holling, 2001). During the slow transition from exploitation to conservation phase, the system's connectedness increases and capital such as nutrients, biomass and physical structure is accumulated. Within the social sphere, human agency reinforces and becomes aligned with dominant social structures and institutions, marginalising alternative behaviour (Pelling and Manuel-Navarrete, 2011). Eventually, the system becomes over connected and rigid in its control, making it more susceptible to disturbances. When a disturbance does occur, the resources consolidated are suddenly released and the tight organisation is lost. This phase is a chaotic collapse and release phase (Ω), during which bound-up resources are released and accumulated structure collapses. Social capital and behaviour break away from normalised routines, creating space for new values to emerge. This is followed by a re-organisation and renewal phase (α), during which contradictory and supportive discourses and institutions coexist in overlapping emergent regimes (Pelling and Manuel-Navarrete, 2011). Social capital hardens around discrete value positions and experimentation and innovation can lead to another growth phase in a new cycle (Folke, 2006, Holling, 2001). In reality, a system is generally part of a set of systems spanning several spatial scales, having their own complex dynamics and interacting with each other over time. These cross-scale interactions led to the development of the 'panarchy' concept by Gunderson and Holling (2002), which suggests that the dynamics of a system at a particular scale of interest cannot be understood without accounting for the top-down and bottom-up interactions with other scales.

A number of studies, mainly in the fisheries sector (e.g. Prado *et al.*, 2015, Goulden *et al.*, 2013, Beymer-Farris *et al.*, 2012, Garschagen, 2010, Seixas and Berkes, 2003), have used the adaptive cycle to explain how livelihoods change over time in response to various drivers operating at multiple spatial scales. For example, Prado *et al.* (2015) analysed the 50-year livelihood system pathway of a Brazilian coastal community to understand the resilience building strategies undertaken at household and community levels in response to long-term ecosystem degradation, tourism growth and changes in government policies. One of the findings was that when changes affecting the whole community were at play, such as eviction threats or camping prohibitions, the SES showed self-organisation and political agency by creating a community-based organisation to fight for their rights and thus, maintained resilience. Similarly, studying the impacts of climatic variability on livelihood resilience in two lakeshore villages of Uganda, Goulden *et al.* (2013) concluded that the adaptive cycle model had explanatory power in examining how changes in ecological resilience of lake systems influenced social resilience of households that depended on the lakes' fisheries. The authors found that social capital and livelihood diversification played key roles in determining households' social resilience, and that resilience of the social system can be higher than that of the ecological system due to adaptation. These case studies demonstrate the effectiveness of using the adaptive cycle as a structuring heuristic model. By separating the chronology of events into phases of exploitation, conservation, collapse and reorganisation, the adaptive cycle clearly shows the system level changes and characteristics defining each phase of development. This study uses the adaptive cycle to illustrate the evolution of shrimp industry in Bangladesh by focusing on the cross-scale interactions between changes within various domains (Objective 2, chapter 5).

2.3.3 Linking vulnerability and resilience

The definitions of vulnerability and resilience highlight some common elements of interest within both domains, that is, the shocks and stressors faced by the socio-ecological system, the response of the system to these events and its capacity for adaptive action (Adger, 2006). However, owing to their different epistemological origins in the natural and social sciences, respectively, these two concepts are often driven by different guiding questions and research frameworks when dealing with similar themes and problems (Miller *et al.*, 2010). As discussed above, resilience is thought to have a system oriented approach, focused on the complex interactions between multiple domains operating at various spatial and temporal scales. Vulnerability research often adopts a more actor oriented approach concerned with the impacts on communities and households and their responses to socio-

ecological change (Miller *et al.*, 2010). The common criticism is that while social dimensions of socio-ecological change are underrepresented within the resilience community, the ecological aspects are insufficiently dealt with within the vulnerability community (Engle, 2011).

The disciplinary divide between the two concepts has led to academic debates on the mutual links between them. Some scholars adhere to a narrowly defined paradigm which views resilience as the flip side of vulnerability, stating that *"the two concepts can by and large be seen as the two ends of a spectrum"* (Cannon, 2008: 10). This implies that people with high levels of resilience have low vulnerability, and vice versa. In contrast, supporters of a broader paradigm argue that although a resilient system is less vulnerable than a non-resilient one, they are not merely opposite sides of the same coin (Engle, 2011, Gallopín, 2006). The academic debates broadly suggest that either resilience is a subset of vulnerability (Gallopín, 2006, Turner *et al.*, 2003) or the two are different concepts with some overlapping characteristics (Engle, 2011, Cutter *et al.*, 2008). Which of these hypotheses is true depends on how coping/ response capacity and adaptive capacity are conceptualised. If coping and adaptive capacity are synonymous, then resilience is a subset of vulnerability and if they refer to short-term survival ability and long-term adjustments respectively, then resilience and vulnerability are distinct concepts with coping capacity as a common feature (Gallopín, 2006).

The difference in origins and historical developments of resilience and vulnerability, and the resulting lack of consensus on the mutual links between them have contributed to a bottleneck in the cross-fertilisation of these concepts and has led to parallel research tracks in the interdisciplinary field of human dimensions of global environmental change (Janssen *et al.*, 2006). A bibliometric analysis of vulnerability and resilience research domains by Janssen *et al.* (2006) found that there were few interlinkages between these two knowledge domains, in terms of citations of major publications in one domain by authors of another. A conceptual convergence of vulnerability and resilience domains can greatly enhance the analysis of the multiple processes that drive socio-ecological change in coupled human-environmental systems (Miller *et al.*, 2010, Turner, 2010, Adger, 2006). Thus, to address the gaps in vulnerability research, as discussed in section 2.2.3, this study uses the concept of socio-ecological resilience as a tool for understanding the roots causes of differential vulnerability contexts in the two study communities (Objective 2, chapter 5).

2.3.4 Critique of resilience thinking and research gaps

Despite the increased contribution of resilience thinking in reconciling ecological and social systems and trying to analyse changes from a holistic perspective, the resilience concept has been criticised on a number of grounds. The most widely used criticism is that within resilience thinking, the ecological aspects have been more dominant and better theorised than the social dimensions (Armitage *et al.*, 2012). Social and ecological systems exhibit essential differences in behaviour, processes and structures; hence, attempts to directly transfer resilience concepts from ecology to social science may fail to account for these differences (Adger, 2000).

The resilience concept primarily adopts a systems level perspective, which limits its scope for understanding social systems. For resilience scholars, the 'system' is the scale of enquiry, which fits well with attempts to predict or model socio-ecological change. However, a system level framework puts less emphasis on the entities that comprise a system unless they are captured within the system's structure (Turner, 2013). It tends to homogenise social complexity and assume that all actors within the system have similar interests, expectations and behaviour (Fabinyi *et al.*, 2014). Application of a resilience perspective on SESs often undermines the basic issues of power, politics, and agency and debates over fundamental questions such as 'what is desirable?' and 'for whom?' (Cote and Nightingale, 2012, Davoudi, 2012). In the process of enhancing resilience by making desirable adjustments, some people will gain while others will lose out. As Walker *et al.* (2006) pointed out, certain system regimes may be considered more desirable by one segment of society than another. Contrarily, some systems can be very resilient yet undesirable. Thus, when dealing with the social context, it is important to consider issues of inequity both in terms of decision-making procedures and the distribution of costs and benefits resulting from change (Davoudi, 2012).

The resilience concept is also criticised for its lack of a normative element (Turner, 2013, Leach, 2008). Resilience thinking is based on observations of SESs and the desirable outcome of resilience is sustainability or persistence of the system. Ecologists can maintain an 'unbiased' position when studying the growth, collapse and re-organisation of organisms and ecosystems. However, analyses within the social sciences assume a normative commitment with a strong human-centric orientation. Social scientists consciously embrace normative positions with regard to the perceptions and values of the study populations and the implications of change on social and environmental justice (Turner, 2013). Within the social context, desirability is always tied to normative judgments (Davoudi, 2012). Owing to

the rising dissatisfaction with the inability of the resilience concept to capture the heterogeneities in socio-ecological dynamics, a number of scholars (cf. Fabinyi *et al.*, 2014, Turner, 2013, Beymer-Farris *et al.*, 2012, Cote and Nightingale, 2012, Peterson, 2000) have called for integration of political ecology perspectives into resilience thinking. The following section reviews the origins and development of political ecology and how it can contribute to this thesis.

2.4 Political ecology

A political ecology approach highlights how power relations influence the access, control and management of resources, and places politics at the forefront of analysis to identify social origins of environmental degradation and the plurality of perceptions (Bryant, 1998, Peet and Watts, 1996). The roots of modern day political ecology can be traced back to the works of geographers over the past century, especially with respect to cultural ecology in the early-mid 20th century and the development of third world political ecology in the 1970-80s (Robbins, 2012, Neumann, 2005). Cultural ecology aimed to explain human-environment interactions in terms of adaptive behaviour of human cultures within a closed ecosystem (e.g. Hardesty, 1986, Orlove, 1980, Sauer and Leighly, 1965, Steward, 1955). For example, Rappaport (1968) argued that the ecosystem maintained itself through a regulatory force. In his study, the author emphasised that the study tribe's ritual of sacrificing pigs, to acquit themselves of the debts of the supernatural, maintained the pigs to human ratio, distributed pork to the local community and prevented land degradation. Cultural ecology, however, was later criticised for its focus on isolated systems and its emphasis on the homeostatic and apolitical nature of human-environment relations. This led to calls for integrating anthropological insights with analysis of the broader political and economic structures to explain the influence of external activities on a local system (Vayda, 1983, Hjort, 1982).

The late 1970s and early 1980s saw the first phase of third world political ecology, during which scholars made use of Marxist political economy to understand the influence of 'non-place' based factors, such as international demand for certain food products, on 'place based' activities, such as local production systems (Robbins, 2012, Neumann, 2005, Bryant, 1998). Marxism is based on the idea that local environmental and social stress results from unsustainable regimes of accumulation imposed by external producers; in other words, capitalist production, which involves the control of nature and labour, offers causal explanation for environmental degradation and dependencies of local economies on global markets (Marx, 1867-1894). One of the notable works in this field was Watts (1983)'s study

on the vulnerability of peasant societies to drought in northern Nigeria, in which the author argued that pre-capitalist modes of production articulated with the colonial economy disrupted the production cycle of peasant households, whose maladaptive behaviour of cultivating groundnuts instead of food crops ultimately resulted in food shortage. Similarly, Blaikie (1985)'s work on soil erosion in developing countries expressed environmental degradation as an outcome of capital accumulation by elite class interests. The author argued that poverty and degradation were closely linked as poor farmers were often relegated to fragile unproductive land by large capitalist enterprises focused on modes of surplus extraction. However, the Marxist basis of third world political ecology was later criticised for neglecting the roles of local politics and conflicts in enabling the politically or economically weaker grassroots actors to resist their marginal status (Bryant, 1998).

During the second phase, that is, the late 1980s, research within political ecology started to take shape, starting with Blaikie and Brookfield (1987)'s notable work on land degradation in third world countries. In an attempt to develop and extend the methods and theoretical basis for political ecology, Blaikie and Brookfield (1987: 17) first defined 'political ecology' as an interdisciplinary field that *"combines the concerns of ecology and a broadly defined political economy"* and includes the *"constantly shifting focus between society and land-based resources, and also within classes and groups within society itself"*. Using the example of a land manager whose decisions were influenced by the broader social relations of production, the authors argued that the 'chains of explanation' for environmental degradation should be traced back to higher spatial and backward temporal scales. Blaikie and Brookfield (1987)'s study was followed by a number of studies that sought to better conceptualise this emerging field and include political ecology perspectives in their specific cases (e.g. Bryant, 1992, Neumann, 1992, Stonich, 1989, Bassett, 1988). Bryant (1992) proposed that the framework for understanding the emerging research agenda of third world political ecology should include three areas of inquiry, that is, the contextual sources of environmental change, conflicts over access, and political ramifications of environmental change.

By offering an interdisciplinary understanding of nature-society interactions, political ecology incorporated and advanced important developments in social theory during the late 20th century (Neumann, 2005). Social constructivism, which emphasised the roles of discourse, imagery and representation in defining our knowledge of nature, provided critical insights into the development of feminist and post-structural political ecology (Neumann, 2005). Feminist development theorists argued that the divergent social and cultural roles of

men and women led to gendered differences in knowledge, access and activism (e.g. Rocheleau *et al.*, 1996, Schroeder, 1993, Carney and Watts, 1991). Post-structural political ecologists (Escobar, 1998, 1996, Fairhead and Leach, 1995) argued that interactions between nature and society must consider the discourses and practices through which nature is produced and known. Using Foucault (1980) and Said (1979)'s work as a starting point, Escobar (1998, 1996) argued that even after the end of colonialism, 'First World' countries systematically controlled the 'Third World' though development planning that set the terms for how people in poor countries could live.

Research in political ecology is based on the notion that social and environmental conditions and processes are established though unequal power relations (Bryant, 1998). Contentions among social and political scientists have generated various perspectives of power (Giddens, 1984, Foucault, 1980, Lukes, 1974, Bachrach and Baratz, 1962, Dahl, 1957, Weber, 1947). A one-dimensional view of power dominated the early literature, with power being viewed as the ability of an actor within a social relation to carry out his own will despite resistance from others (Dahl, 1957, Weber, 1947). This overt approach focuses on observable behaviour, investigating who participates in decision-making, who profits and who loses. The two-dimensional approach introduced the covert face of power, which is the ability to set the agenda or prevent the discussion of controversial issues, thus explaining non-participation in decision making as a manifestation of fear and weakness of the powerless (Bachrach and Baratz, 1962). This was followed by a third dimension – the ability to shape others' perceptions and preferences in ways that cause them to act contrary to their own interests (Lukes, 1974). These three dimensions, however, exclusively focus on the exercise of 'power over' others - as critiqued by Morriss (2002) and Lukes (2005) himself. Morriss (2002) argues that power should be viewed as a dispositional concept, which acknowledges the 'power to' effect outcomes, whether it is exercised or not.

A political ecology approach, thus, helps to investigate the roles of power dynamics in bringing about socio-ecological change. The above conceptions of power reflect the direct, indirect and hidden ways in which a group of actors can control the use and access to resources by another group, thus, shaping the processes and outcomes of change. Integration of a political ecology perspective with the concept of resilience, discussed in section 2.3, can overcome the system oriented bias inherent in resilience thinking and better conceptualise the 'social' drivers of socio-ecological change. This study, thus, combines these two approaches in exploring the root causes of differential vulnerability contexts within the two study communities (Objective 2, chapter 5). Changes in a community's

vulnerability context can have heterogeneous impacts on households' livelihood dynamics, owing to their differential resource endowments and entitlements. The following section reviews the theoretical developments and empirical work within the livelihoods literature, outlines the critiques of a livelihood approach, and establishes its links with poverty.

2.5 Livelihoods

2.5.1 Conceptualisation of livelihoods

The genealogies of livelihood thinking can be traced back to mono-disciplinary perspectives offered by economists and geographers who engaged with macro-level political and economic relations of capitalism in post-colonial societies (Scoones, 2009). Later, during the 1980s and 1990s, wider shifts in development approaches, from a focus on economic growth towards human well-being and sustainability, fostered the development of livelihoods thinking (De Haan and Zoomers, 2005, Solesbury, 2003). These views were cemented by the publication of the 1987 Brundtland Report (Brundtland *et al.*, 1987) and United Nation Development Programme (UNDP)'s first Human Development Report in 1990 (UNDP, 1990), the latter being influenced by Sen's views on development as an expansion of human capabilities (Sen, 1985, 1983). However, the term 'livelihood' came to the limelight in the early 1990s with Chambers and Conway (1992)'s seminal paper on 'sustainable rural livelihoods (SRL)', that produced the most widely used definition of livelihood.

> "A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term" (p.6).

The sustainable livelihood approach gained prominence throughout the 1990s through the work of scholars at the Institute of Development Studies (IDS) and Overseas Development Institute (ODI), UK (Leach *et al.*, 1999, Ellis, 1998, Hussein and Nelson, 1998, Scoones, 1998), and the adoption of the sustainable livelihoods framework (SLF) by the Department of International Development (DFID) as a core theme of its development policy (DFID, 1999). The main tenet of SLF is a departure from top-down interventions to a people-centred approach that seeks to support households and communities in ways that are meaningful to their daily lives (De Haan and Zoomers, 2005). According to SLF, individuals or households operate within a given vulnerability context (determined by their bio-physical and socio-economic environment) and have access to five capital assets (i.e. human, social, natural, physical and financial capital), which are also governed by the prevailing institutional and

political structures, including formal and informal laws and policies, activities of local governments and NGOs, cultural norms and beliefs (DFID, 1999, Scoones, 1998). The interaction between these local contexts, access to resources and transforming structures and processes determine an individual's or household's ability to adopt certain livelihood strategies, which, in turn, translate into livelihood outcomes, such as increased income, better health or reduced vulnerability (DFID, 1999, Scoones, 1998).

There is an extensive body of literature on SRL and SLF, although the volume of grey literature in the form of project reports is much greater than peer reviewed academic papers, indicating that SLF was promoted mainly as a tool for development practitioners (Morse and McNamara, 2013, Small, 2007). During the late 1990s, academics often engaged with particular aspects of livelihoods rather than using SLF as a whole; for example, Ellis (2000, 1998) focused on livelihood diversification, Moser (1998) developed an asset vulnerability approach to urban poverty reduction, and Chambers (1995) continued to develop participatory approaches to understand rural poverty. Since the turn of the millennium, livelihoods analyses have been integral in climate vulnerability and adaptation research, with a wide range of applications, such as exploring the role of diversification as a risk reduction strategy (Gautam and Andersen, 2016, Martin and Lorenzen, 2016, Assan, 2014), developing livelihood vulnerability indices (Antwi-Agyei *et al.*, 2012, Hahn *et al.*, 2009), investigating the roles of social capital in coping and adaptation (Pelling and High, 2005, Adger, 2003), and understanding the importance of institutions in determining access to resources (Berman *et al.*, 2012, Agrawal, 2010, Eakin, 2005).

There have been several attempts to categorise livelihood strategies; for example, Scoones (1998) grouped rural livelihood strategies into agricultural intensification or extensification, livelihood diversification, and migration; Ellis (2000) categorised strategies as farm, off-farm and non-farm; and Zoomers (1999) distinguished between accumulation, consolidation, compensatory and security strategies. However, Zoomers (1999) argues that a livelihood strategy should be conceptualised as a stage instead of a structural category, meaning that the same person can pursue different strategies at different periods. de Bruijn and van Dijk (2004) differentiate between a strategy and a pathway; unlike a livelihood strategy, which is designed to obtain a pre-determined objective based on rational evaluation of the actor's preferences, a livelihood pathway is an iterative process in which the goals, preference and means are constantly reassessed in relation to past experiences and current conditions. *"A pathway evolves over time as a combination of contextual factors, the way in which the social actors perceive these factors and the cultural and psychological predispositions and*

assets owned by the actor" (de Bruijn and van Dijk, 2004: 360). This conceptual difference often translates into methodological differences in identifying livelihood responses to shocks and stressors. While strategies can be clustered into specific typologies based on statistical analysis of quantitative data, understanding of pathways requires in-depth qualitative exploration often through livelihood trajectory interviews (De Haan and Zoomers, 2005, de Bruijn and van Dijk, 2004). For example, in their study of rural livelihoods in Botswana, Sallu *et al.* (2010) used quantitative household survey data to cluster households into accumulator, diversifier and dependent categories and qualitative data from livelihood trajectories to investigate the factors that resulted in differential outcomes.

2.5.2 Critique of sustainable rural livelihoods

The core principle of the SRL approach is to promote the active engagement of people in designing development interventions, and to use participatory processes to assess people's priorities in a given context (Carney, 1998). SRL has been successful in promoting a holistic approach to poverty reduction by recognising the multiple dimensions that need to be considered when analysing people's livelihood preferences, capabilities and outcomes (Morse and McNamara, 2013, Small, 2007). It steered the focus of development practitioners from a narrow understanding of poverty as a lack of income towards a broader consideration of other vital aspects such as vulnerability to shocks and stresses and the social processes that determine access to resources (Morse and McNamara, 2013). It has been highlighted that SLF should be viewed as an integrating tool that combines different perspectives that contribute to a people-centred approach; it should be used in conjunction with the core principles of SRL (Farrington *et al.*, 1999, Carney, 1998).

Despite its apparent holism, SRL has been criticised for its lack of engagement with a number of relevant issues. Given its core focus on poverty reduction, SRL is biased towards understanding the asset use patterns of poor people and does not account for the actions of wealthier people who can have a significant influence on social structures and power relations (Small, 2007). Critiques argue that the SRL approach focuses more on actor's agency that on structure and emphasises neutral strategies more than failed access due to inequalities in power (De Haan, 2012). It can be argued that power is implicitly present everywhere within the framework, as it states that access to resources, livelihood strategies and outcomes are all mediated by institutions, policies and processes (Scoones, 2009). Moreover, inclusion of social capital as one of the assets implies the need to address power relations. Indeed, proponents of the approach highlight that capital assets should not only be viewed as things that people use in the production process but also as a source of power

(Bebbington, 1999). As stated by Bebbington (1999), capitals are the vehicles for making a living, making living meaningful and challenging the structures under which one makes a living.

Moreover, SRL takes an ahistoric approach by emphasising the current context instead of identifying the events that resulted in the existing situation. Scoones (2009) argues that due to an overemphasis on the micro-level, livelihood studies fail to deal with long-term shifts in rural economies, agrarian transformation and global environmental changes. According to Small (2007), these issues can be attributed to the fact that the SRL approach is not formally linked to any theories of socio-economic or ecological change; rather it is based on a range of current development concepts and values. Thus, a research design based on SLF carries the risk of ignoring the complexity of rural livelihoods and poverty, and lacking depth and analytic clarity (Morse and McNamara, 2013).

These weaknesses in livelihoods approaches can be overcome through an explicit engagement with academic theories from different disciplines. For example, work within political ecology and gender studies have explored the links between micro and macro political-economic structures and how livelihoods are socially differentiated by relations of class, caste, gender and ethnicity (De Haan, 2012, Scoones, 2009). Studies have also linked socio-ecological resilience theories with livelihood perspectives to analyse livelihood adaptation in relation to scale dynamics (e.g. Moshy *et al.*, 2015, Prado *et al.*, 2015, Goulden *et al.*, 2013, Hanazaki *et al.*, 2013, Marschke and Berkes, 2006). These criticisms and approaches to overcome them support the conceptual stance taken in this study; whereby resilience and political ecology are combined to understand the historical drivers of vulnerability and poverty is used as a lens to differentiate the livelihood dynamics of different groups of households.

2.5.3 Linking livelihoods and poverty

A huge body of literature has demonstrated the links between households' poverty levels and their livelihood strategies in a number of different contexts (e.g. Gautam and Andersen, 2016, Martin and Lorenzen, 2016, Oumer and de Neergaard, 2011, Van den Berg, 2010, Cramb *et al.*, 2004). For example, studying two rural districts in Uganda, Smith *et al.* (2001) found that 'very poor' people, who lacked the means of engaging in any economic activity other than begging or wage labouring, were unable to diversify, while the highest wealth group chose to concentrate on one or two main activities, mostly agriculture related. In contrast, the 'poor' and 'average' income groups engaged in a wide range of activities, such

as small-scale service enterprises, fish trading, livestock production and sale and farm labouring, to supplement their subsistence crop production. Reardon *et al.* (1992), in their study in three zones of Burkina Faso, found that greater livestock holdings led to greater diversification, as animals could be used as collateral for loans and sale of animal products could generate revenue for investment in non-farm enterprises. Conversely, poorer households found it difficult to diversify away from subsistence agriculture due to their relative lack of capital and access to credit. They also had few opportunities for wage labour and off-farm self-employment. The authors emphasised that liquidity or cash in hand is central to determining diversification and income growth and hence, argue that contrary to popular belief, household poverty does not lead to greater diversification.

These findings have been reconfirmed by more recent studies. For example, studying Himalayan communities in Nepal, Gautam and Andersen (2016) found that rich households had good human and social capital, which enabled them to diversify into high return sectors such as trade and salaried jobs, leading to further asset accumulation. In contrast, poorer households lacked specialised skills or financial capital for investment, forcing them to engage in patron-client relationships with households of higher caste or to migrate as seasonal labour to India. Similarly, Martin and Lorenzen (2016) found that wealthier households in rural Laos with high land ownership could use their income from agriculture to diversify into complementary non-farm activities, while land-poverty posed a significant barrier to poorer households in expanding their livelihood portfolio. Martin and Lorenzen (2016) emphasised that while non-poor households carry out 'progressive diversification', poor households pursue 'distress diversification'. Such findings provide further evidence for the difference between 'diversification for survival' and 'diversification for accumulation' (Assan, 2014, Dimova and Sen, 2010, Whitehead and Kabeer, 2001, Dercon and Krishnan, 1996, Reardon *et al.*, 1992). 'Diversification for survival' arises from desperation such as lack of assets, natural shocks and stresses, or liquidity crisis, while 'diversification for accumulation' is a strategic decision for enhancing standards of living through wealth creation.

Studies have also analysed the relationship between the contribution of non-farm income and a household's wealth status; however, there is variation in empirical evidence from different parts of the world. Based on a review by Reardon *et al.* (2000), Ellis (2000) described three patterns for three different contexts. Firstly, in Asia and Latin America, where land is the main asset differentiating the rural poor and non-poor, a linear negative relationship exists between non-farm income share and total household income or land

ownership. Secondly, in rural Africa, where livestock and human capital are the key assets determining wealth class, there is a linear positive relationship between share of non-farm income and total household income (e.g. Reardon, 1997, Reardon *et al.*, 1992). Thirdly, in rural areas where the poor are landless and the rich are large landowners generating most of their income from land, a U-curve relationship exists. In the latter case, the non -farm income share is relatively high for small farms and poor households, declines in the middle income farm size range, and rises at the higher end of farm sizes and total incomes.

2.6 Adaptation

The literature on 'livelihoods' and 'adaptation' developed quite separately, with the former focusing on development and poverty reduction and the latter gaining prominence within climate change studies. However, these concepts are intrinsically linked; since the turn of the millennium, livelihood adaptation has become an integral aspect of research within the field of global environmental change. This section reviews the literature on adaptation, particularly focusing on livelihood responses to socio-ecological change.

2.6.1 Conceptualisation of adaptation

Since the first decade of the 21st century, adaptation to climate change received increasing focus in the scientific literature as well as national and international policy and planning documents. However, the term 'adaptation' has a long multidisciplinary history of investigation, which has resulted in differences in definitions and meaning. For instance, in ecological or biological terms, adaptation denotes the changes in an organism or species to better fit to its environment (Abercrombie et al., 1997, Lawrence, 1995), while in social sciences, it refers to the adjustments by individuals and the collective behaviour of socio-economic systems (Hardesty, 1986, Denevan, 1983). With reference to climate change, the IPCC defines adaptation as an *"adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"* (Parry et al., 2007: 869) and this is the most widely cited definition to date. However, it is increasingly being recognised that in practice adaptation actions rarely refer to climate change alone, but are rather undertaken in the context of multiple socio-economic, political and environmental stressors (McDowell and Hess, 2012, Moser and Ekstrom, 2010). Hence, Moser and Ekstrom (2010: 22026) define adaptation as *"changes in socio-ecological systems in response to actual and expected impacts of climate change in the context of interacting non-climatic changes"* and also acknowledge that adaptive strategies may not always moderate harm or exploit beneficial opportunities. Specifically from a

livelihoods perspective, adaptation involves the activities undertaken by households and individuals to improve their livelihood security and reduce poverty, as well as respond to climatic drivers (Williams *et al.*, 2015, Sabates-Wheeler *et al.*, 2008).

Adaptive capacity

Closely linked to adaptation is the term 'adaptive capacity' which is *"is the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences"* (IPCC, 2014: 2). Scholars have attempted to distinguish between the terms 'coping' and 'adaptation', with respect to temporal scales. Coping usually refers to short term responses to immediate climatic hazards within existing institutional arrangements, while adaptation is used to describe medium or long term changes in socio-economic or institutional environment that address the root causes of differential vulnerability and enhance people's capacity to adjust to actual or potential climatic stimuli (Lemos and Tompkins, 2008, Eriksen *et al.*, 2005). Despite the success of this temporal distinction, some critiques argue that such simplistic and artificially neatly constructed duality does not reflect the reality for those individuals and households who are actually adjusting their livelihoods to shocks and stresses (Osbahr *et al.*, 2008).

The factors that determine adaptive capacities of communities and households have been the focus of a large number of studies. Similar to the livelihood studies reviewed in section 2.5.3, which established the links between a household's livelihood strategies and its poverty level, an extensive body of empirical work has identified assets or wealth as core determinants of households' adaptive capacities (e.g. Wood *et al.*, 2014, Goldman and Riosmena, 2013, Below *et al.*, 2012, Adger and Kelly, 1999, Pelling, 1999). Besides these economic/financial factors, adaptive capacities are also determined by technology, information and skills, infrastructure, and institutions and equity (Smit *et al.*, 2001). Adger (2003) and Pelling and High (2005) emphasised the roles of social capital in allowing individuals to draw on their relationships with other actors for their own and collective benefits. Studies have also highlighted the importance of psychological or cognitive factors, such as perceptions of risk and effectiveness of adaptive actions, and local customs and traditions as important determinants of adaptive capacity (Kuruppu and Liverman, 2011, Grothmann and Patt, 2005). The greatest attention perhaps has been given to the roles of institutions, governance networks and management in enhancing the efficiency of autonomous adaptation and implementing planned adaptation strategies (Berman *et al.*, 2012, Agrawal, 2010). The literature also recognises that adaptive capacity of individuals and groups is uneven within and across societies. It is differentiated by age, socio-economic

class, gender, and ethnicity, creating a greater need for more local context specific studies (Adger *et al.*, 2007).

Incremental and transformational adaptation

Adaptation has been typically conceptualised as actions or behaviours that reduce the losses or enhance the benefits from climatic variability and change; thus, focusing on accommodating change rather than contesting it. However, given the increased threats and uncertainties associated with global environmental change, such 'incremental adaptations' may not be enough to sustain socio-ecological systems (Kates *et al.*, 2012, O'Brien, 2012). This has led to increased attention to 'transformational adaptation', which involves the creation of a fundamentally new system when the socio-political, ecological and economic conditions make the existing system untenable (Park *et al.*, 2012). Transformational adaptation entails changes in goals, through enlarging the scale or intensity of an existing activity, doing something fundamentally new within the same place, as well as changes in location, through population migration or spatial relocation of an activity (Kates *et al.*, 2012, Rickards and Howden, 2012). In reality, the distinction between incremental and transformational adaptation may not be clear-cut; using the example of adaptation of agricultural systems to climate change, Howden *et al.* (2010) conceptualised incremental adaption, involving small changes in crop varieties or planting dates, and transformational adaptation, such as major land use change, as opposite ends of a spectrum, with systems adaptation, such as adoption of climate resilient crops and diversification towards non-farm activities, in between. Incremental adaptation involves experimentation and constant evaluation of outcomes, which ultimately results in knowledge and skills required for system transformation (Park *et al.*, 2012). Park *et al.* (2012) developed an 'adaptation action cycles framework', whereby incremental and transformational adaptation are viewed as a continuous process depicted by two concentric and distinct, yet linked, action learning cycles.

Although transformational adaptation usually entails purposeful decision-making, it can result from both intended and unintended consequences of actions (Park *et al.*, 2012). However, the recent literature is increasingly focusing on deliberate transformation, which is being touted as a potential 'solution' to ensuring human well-being and ecosystem sustainability in the face of change (Moore *et al.*, 2014, O'Brien, 2012). The concepts of socio-ecological resilience and adaptive cycles are being used by academics and practitioners to conceptualise the different phases of transformation, so that decision makers are equipped with the tools to successfully navigate the process (Moore *et al.*, 2014, Park *et al.*,

2012, Pelling and Manuel-Navarrete, 2011, Olsson *et al.*, 2006). Moore *et al.* (2014) outlined four distinct phases of transformation – 1) Triggers or pre-transformation, characterised by a perturbation or crisis that opens up windows of opportunity; 2) Preparing for change, which entails making sense of the current situation, envisioning alternative scenarios, and learning through experimentation and innovation; 3) Navigating the transition, which involves selecting the change pathway and promoting wider uptake of strategies that proved successful during the experimentation phase; and 4) Institutionalising the new trajectory, by routinizing newer practices and strengthening cross-scalar interactions.

The conceptualisation of adaptation as a dynamic process characterised by uncertainty and inter-temporal complexity has led to the emergence of 'adaptation pathways' as a decision making tool (Fazey *et al.*, 2015, Wise *et al.*, 2014, Haasnoot *et al.*, 2013). Thus, adaptation is viewed as a pathway of change and response, punctuated by decision and intervention points that help navigate the direction of change (Wise *et al.*, 2014). Pathway thinking acknowledges that adaptation processes are embedded within the broader socio-economic and political context, and characterised by historical determinism and path dependencies (Fazey *et al.*, 2015, Wise *et al.*, 2014). It emphasises the roles of differential values, interests and power in enabling or constraining societal processes (Wise *et al.*, 2014). The livelihood literature, reviewed in section 2.5.1, has also evolved from a static, isolated focus on a single scale at a given point in time to a broader dynamic perspective, embracing the notions of pathways and trajectories.

2.6.2 Adaptation opportunities, barriers and limits

While the literature on adaptation to current and projected impacts of climate change has been increasing, many studies have started to focus on the social factors and conditions that make adaptation efforts less effective or more costly (Antwi-Agyei *et al.*, 2015, Shackleton *et al.*, 2015, Eisenack *et al.*, 2014, Islam *et al.*, 2014, Klein *et al.*, 2014, Biesbroek *et al.*, 2013, Moser and Ekstrom, 2010). This has led to an expanding body of case study based literature on the 'limits' and 'barriers' to adaptation. Based on a systematic review of 81 studies, Biesbroek *et al.* (2013) found that most studies were focused on local or regional levels and were grounded in qualitative case studies with small sample sizes that used interviews, workshops and surveys as data collection methods.

While some authors use the terms 'limits' and 'barriers' interchangeably, they have different meanings. The recent IPCC AR5 conceptualises adaptation barriers (synonymous with constraints) as factors that *"restrict the variety and effectiveness of options for an actor(s) to*

secure their existing objectives" (Klein *et al.*, 2014: 8) and limits as *"the point at which an actor's objectives cannot be secured from intolerable risks through adaptation actions"* (Klein *et al.*, 2014: 8). While barriers can be overcome, avoided or reduced with concerted effort, creative management, changed ways of thinking, political will, and reprioritization of resources, land uses and institutions (Moser and Ekstrom, 2010), limits are unsurmountable with incremental adaptations and require transformational adaptations based on redefinition of actors' objectives (Dow *et al.*, 2013). Eisenack *et al.* (2014) further elaborates the concept of barriers by defining them as an *"impediment to specific adaptations for specified actors in their given context that arise from a set of conditions"* (p.868). This definition emphasises that different actors may value barriers differently, with one group of actors viewing certain conditions as barriers while other may perceive them as beneficial (Eisenack *et al.*, 2014). This latter conceptualisation is particularly important for this study, which looks into the differential opportunities, barriers and limits of different poverty groups. As defined by IPCC AR5, adaptation opportunities comprise factors that *"enhance the ability of actor(s) to secure their existing objectives"* (Klein *et al.*, 2014: 8).

Given that research on barriers and limits to adaptation is still at its nascent stage, there have been few attempts to develop conceptual frameworks that can lead to a unified understanding of the terms and guide research in appropriate directions. Moser and Ekstrom (2010), for instance, developed a policy framework in relation to planned adaptation processes and categorised barriers as being specific to each stage of the adaptation cycle, namely, understanding, planning and managing phases. Biesbroek *et al.* (2013) conceptualised barriers and opportunities as lying on opposite ends of a continuum of process and outputs. Whether a factor is viewed as a barrier or an opportunity by an actor depends on its influence on the outcome of adaptation.

The growing body of case studies and theoretical work has generated a number of different types of barriers, particularly in the context of livelihood adaptation to shocks and stresses. For instance, in their study on social barriers to adaptation in Western Nepal, Jones and Boyd (2011) found that cognitive and psychological barriers, in the form of discrimination against lower castes, made it difficult for lower castes to gain temporary employment and send remittance to their families in times of rainfall stress. In South Africa, Quinn *et al.* (2011) found that coexistence of different governance structures and poor communication between levels of government, as well as between the government and local communities, posed a significant adaptation barrier, as people did not understand the roles and responsibilities of different government spheres and lacked knowledge on whom to

approach for support. Similarly, the study on livelihood dynamics in Botswana by Sallu *et al.* (2010) found that land degradation, manifested as soil erosion, salinization and vegetation changes, especially near settlements, cattle posts and transport routes, increased livelihood stress for herders who had to travel further to access water and grass for their livestock. Based on such empirical work, there have been attempts to group commonly reported barriers into different categories. For instance, the IPCC AR4 reported five main categories of limits and barriers, such as physical and ecological, technological, financial, informational and cognitive, and social and cultural (Adger *et al.*, 2007), which was later extended to eight categories in IPCC AR5 by further disaggregating the old ones and adding new categories, such as governance and institutional constraints (Klein *et al.*, 2014). While such categories provide a useful structuring heuristic, empirical studies often propose alternative categories that adhere to the study objectives and context (Biesbroek *et al.*, 2013).

Moreover, a few recent studies have reported the co-occurrence of multiple barriers, where barriers from different categories interact or reinforce each other (e.g. Antwi-Agyei *et al.*, 2015, Islam *et al.*, 2014). Studying the adaptation of Bangladeshi coastal fishing communities, Islam *et al.* (2014) found that technological barriers, such as absence of offshore radio forecasts, inaccurate cyclone forecasts and technologically poor boats, indirectly increased exposure to cyclones and constrained completion of fishing trips. These technological barriers were often created or reinforced by financial or institutional barriers that resulted in lack of investment or access to credit for boat repair. Similarly, based on a systematic review of agriculture dependent households in northeast Ghana, Antwi-Agyei *et al.* (2015) found that weak institutional structures, in terms of lack of collaboration between meteorological departments and extension services for forecasts, resulted in informational barriers for farmers, who failed to receive timely forecasts on rainfall patterns.

Literature reviews by Shackleton *et al.* (2015) and Biesbroek *et al.* (2013) found that while some factors, such as the uncertainties related to climate change, the dependence on particular scientific models to identify the problems and solutions, and the tensions between short-term politics and decision making vs long-term climatic impacts, can be directly attributed to climate change, most barriers are related to general development factors. In developing country contexts, barriers are often related to poverty, marginalisation, social inequalities, weak institutional capacity and low prioritization of climate adaptation compared to more immediate social problems (Shackleton *et al.*, 2015, Biesbroek *et al.*, 2013).

2.6.3 Research gaps

Livelihood adaptation to socio-ecological change is affected by a number of factors at multiple scales, which can act individually or together to impede the planning, implementation or effectiveness of adaptation strategies (Shackleton *et al.*, 2015). While these factors have been implicitly recognised in adaptation studies over a long time, 'barriers' to adaptation have received specific focus in the academic literature in recent years. However, studies in this genre have generally considered barriers as having a uniform adverse effect on all actors, largely overlooking the particular nature and impact of such barriers on different actors (Mersha and Van Laerhoven, 2016). This leads to a greater need to study the diverse influences of barriers on different social groups, stratified by wealth status, gender, ethnicity or other demographic factors. Moreover, given the existence of power imbalances and conflicts in interests, it is also necessary to understand how strategies undertaken by one group impinges on the adaptive capacity of another (Shackleton *et al.*, 2015). While a couple of recent studies (Antwi-Agyei *et al.*, 2015, Islam *et al.*, 2014) have demonstrated how barriers can combine to hinder adaptation or increase exposure, more work is needed on the synergistic impacts of barriers on different actors. Adaptation decisions are highly context specific; although a considerable amount of work has focused on Sub-Saharan Africa, there is a dearth of literature on adaptation opportunities and barriers in coastal communities of Asia.

The above reviews show that livelihood adaptation dynamics undertaken by households are strongly determined by their own poverty levels, as well as the activities of other households and the various opportunities and barriers operating at higher scales. This study, thus, disaggregates households within each community into different poverty levels (alternatively, referred to as wealth classes) (Objective 1, chapter 4), which serve as a baseline for analysing data on livelihood dynamics, adaptation opportunities and barriers and well-being outcomes (Objectives 3 and 4, chapters 5 and 6). The following section reviews the literature on the conceptualisation and assessment of poverty, and outlines its implications in designing this study.

2.7 Poverty

2.7.1 Conceptualisation of poverty

Changes in development paradigms have led to considerable advances in the conceptualisation of poverty over the past century. While different definitions of poverty emphasised different dimensions, it generally shifted from a reductionist, uni-dimensional

concept measuring income and consumption to a broader multi-dimensional concept embracing a number of objective and subjective aspects of human life.

In the early 20th century, poverty was viewed as a lack of resources required to meet essential physical needs, such as, food, clothing and shelter (Rowntree, 1901, Booth, 1886-1903). Rowntree (1922, 1901) used income based methods to construct the first formal poverty lines – thresholds that separated the poor from the non-poor. This monetary approach dominated the development discourse until the 1960s; in the years following the second World War, economic growth was considered the sole engine for poverty reduction (Niemietz, 2011, Misturelli and Heffernan, 2008). During the 1970s, the International Labour Organisation formulated the basic needs approach, which further extended the earlier notion of poverty as 'subsistence' (Streeten *et al.*, 1984). In addition to the minimum requirements for physical survival, the basic needs approach also included essential services provided by and for the community at large, such as safe drinking water, sanitation, public transport, health care, education and cultural facilities (Streeten *et al.*, 1984).

The individual perspective adopted by the monetary and basic needs approaches, however, ignored the social norms that impeded individuals from fully participating in the society in which they lived. As such, the Council of the European Union introduced the social exclusion approach, which defined the poor as *"individuals or families whose resources are so small as to exclude them from the minimum acceptable way of life of the Member State in which they live"* (European Commission, 1981: 16). Social exclusion is the *"process through which individuals or groups are wholly or partially excluded from full participation in the society in which they live"* (Deakin *et al.*, 1995: 129). This approach was in line with Peter Townsend's notion of 'relative deprivation', a condition characterised by the *"lack the resources to obtain the type of diet, participate in the activities and have the living conditions and the amenities which are customary, or at least widely encouraged or approved in the societies to which they belong"* (Townsend, 1979: 31). Thus, as societies became wealthier, new obligations and expectations were placed on individual members to remain integrated into society (Townsend, 1979).

In the late 20th century, the development discourse started to focus on how the poor themselves perceived poverty and well-being, and what 'beings and doings' they valued most. This was facilitated by the emergence of Amartya Sen's 'capabilities approach' – which views poverty and well-being in terms of individuals' abilities to transform resources into valuable achievements (functionings), such as being nourished, being entertained and being sheltered, and their freedom to choose between different functioning combinations (Sen,

1999, 1993, 1985). Following Sen's work, there have been numerous attempts to develop a specific list of basic capabilities (Alkire, 2002, Saith, 2001, Nussbaum, 2000), the most prominent one being Nussbaum (2000)'s list of central human capabilities that includes life, health, bodily integrity, senses, emotions, practical reasons, affiliation, other species, play and control. Sen's capabilities approach provided the conceptual foundation for United Nations Development Programme (UNDP)'s human development reports, which monitor progress through the human development index (HDI) - a composite measure comprising of indicators along three dimensions: life expectancy, educational attainment and command over resources for a decent living (UNDP, 2013).

Sen's work initiated the conceptualisation of poverty as a multi-dimensional phenomenon, which was further cemented by the development of participatory rural appraisal methods and the sustainable livelihoods approach (reviewed in section 2.5.1) during the 1990s. Pioneered by Robert Chambers, participatory rural appraisal refers *"a family of approaches and methods [that] enable rural people to share, enhance, and analyse their knowledge of life and conditions, to plan and to act"* (Chambers, 1994: 953). One of the significant publications is a three-part series entitled 'Voices of the Poor'- an extensive multi-country exercise conducted by the World Bank– which aimed to understand how poor people view poverty and well-being, their problems and priorities, and their experience with the institutions of the state, markets, and civil society (Narayan and Petesch, 2002, Narayan *et al.*, 2000a, Narayan *et al.*, 2000b). Similarly, the five capital assets of the SLF provided a people-centered means of characterising the poor, based on context specific indicators.

Although there is no consensus on the definition of poverty to date, academics and development practitioners now acknowledge the complex multi-dimensional nature of poverty. For instance, United Nations (1998: 1) underscores that

> "Poverty is a denial of choices and opportunities, a violation of human dignity. It means lack of basic capacity to participate effectively in society. It means not having enough to feed and clothe a family, not having a school or clinic to go to, not having the land on which to grow one's food or a job to earn one's living, not having access to credit. It means insecurity, powerlessness and exclusion of individuals, households and communities. It means susceptibility to violence, and it often implies living on marginal or fragile environments, without access to clean water or sanitation."

However, this habit of viewing poverty as a 'condition', characterised by a broad range of symptoms, ignores how actors, social relations, and structural conditions create and perpetuate poverty (Engberg-Pedersen and Munk Ravnborg, 2010). Research in the new millennium has addressed these relational aspects of poverty by looking at the social

processes that facilitate and stabilise exploitation and subordination (Mosse, 2010, Wood, 2003). Mosse (2010) argues that economic growth and integration into global markets may deepen poverty and inequality in some cases. For instance, evidence shows that implementation of neoliberal policies in the late 20th century often intensified power relations and constrained the agency of poor people in rural areas (Mosse, 2010).

Formulation of appropriate poverty reduction policies also necessitates an understanding of poverty dynamics and inequality (Norton *et al.*, 2012). The Chronic Poverty Research Centre (CPRC) at the University of Manchester, in partnership with Bangladesh Institute of Development Studies (BIDS), made significant contributions to understanding the different types and causes of poverty (Ali *et al.*, 2006, Sen and Hulme, 2006, Kabeer, 2005, Hulme and Shepherd, 2003). Poverty can be a result of structural, life-cycle or crisis factors (Sen and Hulme, 2006, Hulme and Shepherd, 2003). Structural factors refer to the depletion of the asset base and deteriorating market conditions for employment or income; life-cycle factors include an increase in the number of dependants, splitting up of families reducing the number of earners and being widowed or elderly; and crisis factors include natural disasters, ill-health, impairment and robbery (Sen and Hulme, 2006). All these factors can lead to 'transitory' or 'chronic' poverty, depending on the baseline conditions of the household. As exemplified by Sen and Hulme (2006), in case of a household with adequate assets, the death of the main bread earner or a poor crop yield may result in transitory poverty, but for a household that lacks a balanced asset base, the same incident can lead to chronic poverty. Hence, when poverty is transient and the poor demonstrate a higher likelihood of enhancing their situation, appropriate interventions would involve social safety nets (such as unemployment allowances, social grants, micro-credit and new skills acquisition programs) that enable people to deal with their present deprivation and rapidly return to a non-poor status. However, when poverty is a chronic phenomenon, policies should aim at redistribution of assets, direct investment toward basic physical infrastructure, reduction of social exclusion and provision of long-term social security (Hulme and Shepherd, 2003). High levels of inequality can impede sustainable poverty reduction strategies by undermining the institutional fabric of a competitive economy and a cohesive society (Norton *et al.*, 2012).

2.7.2 Assessment of poverty

While the inclusion of physical, material, economic, social, institutional, political and psychological dimensions have contributed to a broader understanding of poverty, such complexity poses practical difficulties in measuring and comparing poverty. Thus, poverty assessments at national and international levels still adhere to the earlier monetary and

basic needs approaches that rely on simple objective measures. An example is the World Bank's USD 1 a day poverty line, which formed the basis of Goal 1-Target 1 of the Millennium Development Goals (MDGs) - *"to halve, between 1990 and 2015, the proportion of people whose income is less than USD 1 a day"* (United Nations, 2000: 5). Similarly, the Bangladesh Bureau of Statistics (BBS) uses the cost-of-basic-needs (CBN) method to calculate the national upper and lower poverty lines that determine the numbers of moderate and extreme poor people, respectively. Similar to Rowntree's calculations, this method measures the level of per capita expenditure at which a household can be expected to meet their basic needs. This involves estimating a food poverty line in terms of the cost of a fixed food bundle that can provide the minimal nutritional requirements of 2122 kcal/day/person and then adding an allowance for non-food consumption to the food poverty line (WFP, 2013). Several multi-dimensional indices have also been developed to compare living conditions across countries and regions. For example, the Oxford Poverty and Human Development Initiative (OPHI) formulated the Multidimensional Poverty Index (MPI), which is composed of ten indicators corresponding to three dimensions of the HDI: Education, Health and Standard of Living. In 2010, it has been applied to 104 countries to track the progress of MDGs and design policies to address the overlapping deprivations experienced by the poor (Alkire and Santos, 2010).

The conceptual understanding of multi-dimensional poverty highlights that poverty is not simply a reflection of what people have, but also entails what people can do with the resources they have. It encompasses both ownership and access to resources, the latter being determined by the networks and links households have with the state, market or civil society (Bebbington, 1999). This links back to Sen's work on the 'theory of entitlement' (Sen, 1981) and the 'capabilities approach' (Sen, 1999, 1993, 1985), and the sustainable livelihoods approach (DFID, 1999, Scoones, 1998, Chambers and Conway, 1992). According to Sen, an individual's entitlement set, comprised of his original bundle of assets ('endowments') and the various alternative bundles that he can acquire through trade and production ('exchange entitlement'), determines his 'capability' to choose among different 'functionings' (Sen, 1999, 1985, 1981). Similarly, the sustainable livelihoods framework also suggests that transforming structures and processes play an important role in enabling households to convert their assets into favourable livelihood strategies (DFID, 1999).

Despite these theoretical understandings, assessment of multi-dimensional poverty is usually restricted to measurement of asset ownership, particularly durable goods (TV, furniture, phones), dwelling characteristics (housing materials, water and sanitation

facilities, energy sources), education level (years of schooling) and productive resources (agricultural land, livestock) (Johnston and Abreu, 2013). Intangible factors, such as social networks, market access, and institutional support, which determine access to resources are often excluded. The reliance on asset ownership measures (referred to hereafter as asset indices) as a proxy for long-term wealth resulted from the dependence of early studies on Demographic and Health Surveys (DHS), which collected data on material living standards only (e.g. Vyas and Kumaranayake, 2006, Houweling *et al.*, 2003, Sahn and Stifel, 2003, Filmer and Pritchett, 2001). Since these studies provided much of the theoretical and methodological development of asset indices at household level, the material aspects of living conditions became the most widely used indicators in poverty measurement (Howe *et al.*, 2012).

Although factors determining access are often excluded in poverty assessment and may raise questions on the discrepancies between conceptual understanding and assessment methods, a number of studies have established that asset indices based on ownership of tangible assets serve as a robust proxy for poverty or socio-economic status (Johnston and Abreu, 2013, Howe *et al.*, 2012). Indeed, Alkire and Santos (2010) argue that although living standard indicators are means rather than ends (that is, the functionings people want to achieve), they are instrumental in facilitating the ends. Similarly, Bebbington (1999) also states that assets are not simply resources that people have, rather they give them the capability to be and to act.

2.7.3 Methodological issues in multi-dimensional poverty assessment

Multi-dimensional poverty assessment methods involve three fundamental steps: 1) selecting the space for poverty analysis, which is defined by the conceptual understanding of poverty; 2) identifying who is poor, which involves selection of a group of indicators that define poverty and determination of cut-off points to separate the poor from the non-poor; and 3) aggregating information about the poor across a society, which involves decisions on the relative weights of individual indicators and selection of the process of combining them (Alkire *et al.*, 2015, Sen, 1976). The space of poverty analysis is defined by the different approaches reviewed in section 2.7.1. The identification and aggregation steps can be conducted using different qualitative and quantitative methods, such as participatory wealth ranking (PWR) (e.g. Hargreaves *et al.*, 2007a, Hargreaves *et al.*, 2007b, Van Campenhout, 2007, Adams *et al.*, 1997, Scoones, 1995), principal component analysis (PCA) (e.g. Ansoms and McKay, 2010, Vyas and Kumaranayake, 2006, McKenzie, 2005, Filmer and Pritchett, 2001) and fuzzy set analysis (FSA) (e.g. Neff, 2013, Chiappero Martinetti, 2006, Qizilbash and

Clark, 2005, Ragin, 2000, Cheli and Lemmi, 1995). A crucial issue in development of asset indices is the selection of indicators, which are both reflective of the wealth status in a given context, and also fulfil the quantitative criteria underpinning the method of identification and aggregation (Johnston and Abreu, 2013, Howe *et al.*, 2012).

Asset indices constructed using multivariate statistical measures, like PCA, completely rely on an empirically-derived model of what the poverty spectrum looks like in terms of the 'patterns' of asset ownership (Johnston and Abreu, 2013). These methods do not focus on how different assets relate to poverty; rather they are pre-occupied with how each asset correlates with other assets and how much variance it shows among the sample households. Similarly, within FSA, different calibration and aggregation methods can have considerable effects on the final results. Alkire *et al.* (2015) and Lelli (2001) argue that although disaggregation of households into wealth classes form a baseline for different studies and the decisions taken at various sub-stages in PCA and FSA can have significant implications on the final results, researchers are often unaware of the various rules and consequences. There is need to empirically demonstrate these issues using the same data-set; yet there are no studies that compared the effects of different methods and different decisions within each method on the final results. Since poverty is used as a central lens in differentiating households in this study, it is imperative to ensure the robustness and validity of the results of wealth stratification. This study, thus, disaggregates the households within the two communities into different poverty levels, by triangulating the results of three different methods (PWR, FSA and PCA) of multi-dimensional poverty assessment. In doing so, the study also demonstrates the methodological issues and strengths and limitations of each of these methods (Objective 1, chapter 4).

2.8 Human well-being

2.8.1 Conceptualisation of well-being

Poverty is now widely recognised as a multi-dimensional concept comprised of a number of monetary and non-monetary deprivations. However, it still relies on the objective measurement of what people should have or be able to do, rather than what people think and feel about what they have or do (McGregor, 2007). The concept of human well-being offers an alternative to these objective views of poverty and tries to understand people's experiences and evaluations of their own lives, embedded in particular socio-cultural contexts. While the origins of 'well-being' can be traced back to development economics and social psychology, significant contributions have been made by the Research Group of 'Well-

being in Developing Countries (WeD)', a major multi-country interdisciplinary study funded by the Economic and Social Research Council (ESRC) and led by the University of Bath, UK (White, 2009, Gough and McGregor, 2007). WeD defines well-being as *"a state of being with others, where human needs are met, where one can act meaningfully to pursue one's goals, and where one enjoys a satisfactory quality of life"* (WeD, 2007: 1). In other words, well-being is a combination of what people have, what they can do with what they have, and how they think about what they have and can do (McGregor, 2007). It emphasises a person's freedom to act in a way that is consistent with his own values and aspirations, which are, in turn, shaped by his perceptions of the surrounding environment and understandings of what constitutes a good life (Copestake, 2008).

White (2010, 2009) later framed it as the 'social conception of well-being' - a three-dimensional concept comprised of the dynamic interactions between material, relational and subjective dimensions. Material well-being refers to the objectively observable outcomes that people are able to achieve and includes factors such as food, shelter, health, assets and standard of living (Sumner and Mallett, 2013, White, 2009, Copestake, 2008, McGregor, 2007). Relational well-being refers to the extent to which people are able to engage with others in order to achieve their particular needs and goals. Key determinants of relational well-being include personal relationships, networks of support and obligations, socio-political and cultural identities and inequalities, violence and conflict, and scope for personal and collective action and influence (Sumner and Mallett, 2013, White, 2009, Copestake, 2008, McGregor, 2007). Finally, subjective well-being refers to the meaning that people give to the goals they achieve and the process in which they engage. It involves life satisfaction, fears and aspirations, trust and confidence, and sense of meaning (Sumner and Mallett, 2013, White, 2009, Copestake, 2008, McGregor, 2007). Although the social conception of well-being categorises well-being into three separate dimensions, it should be noted that these dimensions are interlinked and their demarcations are highly fluid (Sumner and Mallett, 2013). This study uses the three-dimensional social conception of well-being to understand the heterogeneous needs of different wealth classes and the differential outcomes of socio-ecological change in the study villages (Objective 3, chapter 6).

The social conception of well-being closely adheres to Sen's capabilities approach, which emphasises that social arrangements should respect people's agency and expand their freedom to undertake valuable doings and beings (Sen, 1999, 1993). However, while Sen conceives human freedom in an individual light, the social conception views well-being as being socially and psychologically constructed, as the meanings used for individual reasoning

are consciously and subconsciously generated through social interactions (Deneulin and McGregor, 2010). Moreover, the freedoms that some people have reason to value may be detrimental to others; thus, an explicit focus on individual freedoms to inform public policy may deny the opportunities for well-being for others. Thus, rather than focusing on 'living well' only, the social conception emphasises on 'living well together' and thus encompasses the social and political nature of human well-being as well as the economic and psychological aspects (Deneulin and McGregor, 2010, White, 2010).

2.8.2 Assessment of well-being

The well-being approach deals with a "person of flesh and blood in her circumstance"; hence, well-being appraisals should take a more positive approach, that is, an assessment by the person as she is, instead of a normative approach, whereby a researcher decides what a person ought to be have to live a good life (Rojas, 2007). Unpacking the complexity of well-being often necessitates the use of pure qualitative methods, involving participatory or ethnography approaches, or mixed methods, whereby qualitative tools can better inform or improve accuracy of pure quantitative methods (Camfield *et al.*, 2009). For instance, Rojas (2007) applied the 'domains of life satisfaction approach', whereby respondents assigned cardinal ranks of 1 (extremely unsatisfied) to 7 (extremely satisfied) to various aspects of life. Regression analysis was used to determine the relationships of each of the aspects of life with overall life satisfaction.

The concept of well-being has gained increased attention in recent years, as a means of analysing the distributional impacts of socio-ecological change (e.g. Belton, 2016, Hossain *et al.*, 2016a, Armitage *et al.*, 2012, Coulthard *et al.*, 2011). The processes and outcomes of socio-ecological change, particularly where the interest of some actors are privileged over others, are likely to involve trade-offs and create winners and losers (Ingalls and Stedman, 2016). Although the concept of well-being emphasises the centrality of a person in her context, researchers often resort to objective and aggregate measures of poverty to analyse well-being outcome of socio-ecological change. For example, Hossain *et al.* (2016a), Hossain *et al.* (2016b)used indicators such as, percentage of population below poverty line, gross domestic product, child mortality, education level and access to water and sanitation, to study the links between ecosystem services and human well-being in coastal Bangladesh. As argued by Dawson and Martin (2015), such reductionist approaches fail to acknowledge the conflicting objectives of different interest groups, the power relations and trade-offs associated with changes in ecosystem services. In studying the well-being of fishing communities in Northern Ireland, Britton and Coulthard (2013) applied the three-

dimensional concept of well-being, whereby material well-being was assessed in terms of fishermen's access to resources (e.g. education, species targeted, fishing gears, involvement in community associations), relational well-being was analysed in terms of people's level of satisfaction with the relationships important for influencing fishing behaviour (e.g. government, EU markets, crew), and subjective well-being was assessed in terms of people's level of satisfaction with the things needed to live a good life (e.g. health, job satisfaction, material security, social connections). Such mixed methods approaches generated context specific rich understandings of well-being and also highlight that, in practice, the indicators of different dimensions of well-being often overlap.

2.9 Conceptual framework

This study adopts a socio-ecological system approach, which integrates the concepts of vulnerability, resilience, political ecology, livelihoods, poverty, human well-being and adaptation for analysing the influence of socio-ecological change on livelihood adaptation of households of different poverty levels in coastal Bangladesh. The above literature review led to the development of a conceptual framework (Figure 2.1) - an integrated, interdisciplinary framework to analyse the different components of the SES and their relationships. Socio-ecological change arises from cross-scalar interactions of various changes in conditions and processes. This study combines the strengths of resilience and political ecology to investigate the underlying drivers of socio-ecological change that led to different vulnerability contexts in the two study communities (objective 2). Households within a community differ in terms of their resource endowments and entitlements; this study differentiates these households using multidimensional poverty measures (objective 1). Households' poverty levels determine their ability to adapt their livelihoods to the given vulnerability context. Livelihood dynamics are investigated in two ways: firstly, the study quantitatively examines how households of different poverty groups adapted their livelihood strategies to the changing contexts; and secondly, it qualitatively analyses the factors influencing the directions of livelihood trajectories (objective 3). A social conception of well-being lens is then applied to understand the implications of these changes on the material, subjective and relational dimensions of well-being (objective 3). While poverty level is integral in determining a household's ability to adapt its livelihoods, it is also affected by various opportunities, barriers and limits present across different spatial scales. This study uses qualitative data from livelihood trajectory interviews and focus group discussions to investigate the differential opportunities, barriers and limits experienced by households of different poverty levels and their interactions with each other (objective 4).

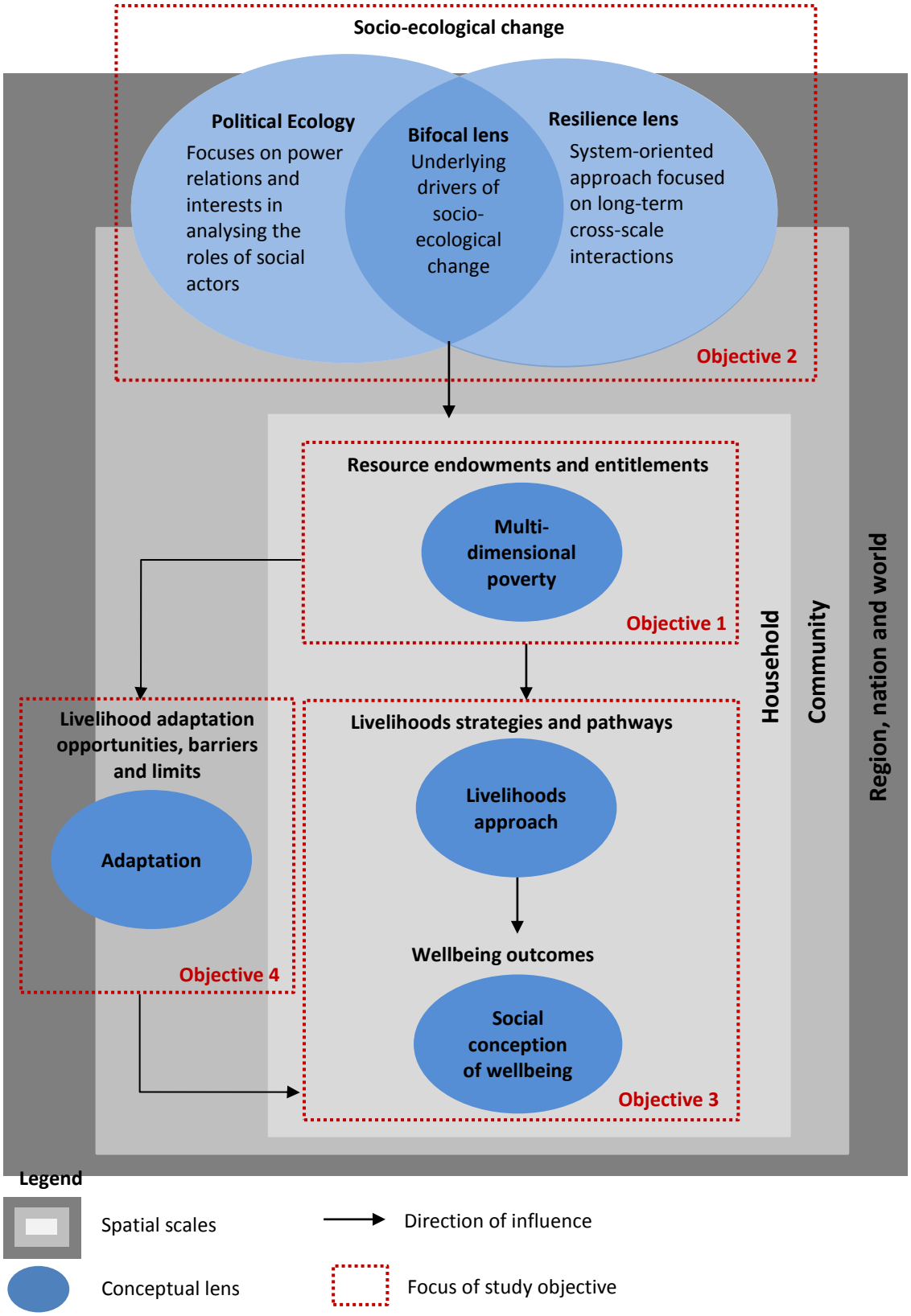


Figure 2.1 Conceptual framework for this PhD research

2.10 Conclusion

The processes and outcomes of socio-ecological change are determined by the complex interactions within and between multiple social and ecological components operating at different spatial and temporal scales. A comprehensive understanding of the drivers, differential livelihood adaptation responses and distributional effects of socio-ecological change requires an interdisciplinary approach that integrates key concepts from different knowledge domains. As such, this study adopts a SES approach, combining insights from vulnerability, resilience, political ecology, livelihoods, adaptation, poverty, and human well-being. This chapter reviewed the theoretical developments and empirical work related to these concepts and integrated them to form the conceptual framework for this PhD research. However, bridging across disciplines is not straightforward; as highlighted in this chapter, there are considerable tensions regarding the definitions and key questions guiding each of the concepts and the ways in which the concepts relate to one another. This chapter attempted to acknowledge these tensions and link each of the terms to develop a framework that can guide the narrative of this research. As shown in Figure 2.1, each of the four study objectives focuses on different aspects of the framework (Chapters 4-7). The findings of the results chapters are then combined to construct a thorough picture of the differential livelihood adaptation to socio-ecological change in coastal Bangladesh (Chapter 8). The following chapter discusses the research methodologies used to operationalise this conceptual framework and address the study aim. It also introduces the study sites, outlining the selection criteria and proving descriptions of the national, sub-national and local contexts.

Chapter 3. Research methods and study sites

3.1 Introduction

Chapter 2 reviewed the theoretical development and empirical work related to a number of concepts – vulnerability, resilience, political ecology, livelihoods, adaptation, poverty, and human well-being – and linked them to form a conceptual framework for this study. The literature review highlighted some of the potential research gaps, especially in terms of methodological issues in assessing multi-dimensional poverty, analysing the underlying drivers of socio-ecological change by combining insights from resilience and political ecology, investigating the differential impacts on livelihood dynamics and well-being outcomes, and identifying the heterogeneous impacts of adaptation opportunities, barriers and limits on different social groups.

This chapter discusses the methodological approach and the research methods applied to address the research objectives stated in chapter 1, and introduces the study sites. Section 3.2 briefly outlines the research philosophy, in terms of the ontological and epistemological stance, and the research strategy, involving the use of a case study approach. Section 3.3 then introduces the study sites, explaining the criteria and process involved in the selection process. A general overview of the Bangladesh country context is provided followed by particular focus on the south-western coastal region and the two selected villages. Section 3.4 describes the research methods - a mixed methods approach, comprising participatory wealth ranking, focus group discussions, household questionnaire surveys and livelihood trajectory interviews. This is followed by section 3.5 which describes the data analysis methods used for quantitative and qualitative data respectively. Section 3.6 reflects on the research experience, in terms of administration of field work, positionality and ethical considerations.

3.2 Methodological approach

3.2.1 Ontological and epistemological stance

The study takes a critical realist ontological stance to investigate the research questions using a case study approach. Unlike positivists or realists who consider that an external reality exists independently of people's beliefs, and constructivists or idealists who believe that there is no single reality and that all knowledge is linked to social construction, critical realists assume that an external reality exists independent of our beliefs, but is only

knowable through people's representations or socially constructed meanings (Ritchie and Lewis, 2003). Like positivism, critical realism is interested in the objective world focused on finding patterns, generalisation and causalities, but it diverges from it in considering that studying only the observable is too superficial as it fails to acknowledge the enduring structures and generative mechanisms underlying and producing the observable phenomena (Bhaskar, 2011, Alvesson and Sköldberg, 2009). Critical realists acknowledge that cause and effect relationships are complex and contextual; hence, they prefer to generate tendencies rather than universal, predictable patterns (Alvesson and Sköldberg, 2009). A critical realist approach is particularly suited to this research, which seeks to explore the complex drivers of socio-ecological change, differential livelihood adaptation responses and well-being outcomes of households in selected communities and also understand the unobservable generative mechanisms, such as power dynamics, that produce the study phenomenon.

It is worth noting that the critical realism stance of the current study requires its research strategy to be 'retroduction', which is a blend of induction and deduction (Bhaskar and Lawson, 1998). Induction or 'theory seeking' research looks for patterns and associations derived from observations of the world and uses evidence for the genesis of a conclusion, while deduction or 'theory testing' research generates propositions and hypotheses theoretically through a logically derived process and uses evidence in support of a conclusion (Ritchie and Lewis, 2003). Perry *et al.* (1999) argues that purely inductive studies are unable to benefit from the initial understanding of existing theory; whereas purely deductive studies support theory testing but not development of new and useful theories. Retroduction, which entails the idea of going beyond observed patterns or regularities to discover what produces them (Blaikie, 2004), can achieve better explanatory power by taking a middle ground between these two extreme strategies of theory development. Hence, this study uses a mixed methods approach, whereby quantitative and qualitative data are combined to provide further evidence for existing concepts and also generate newer ideas regarding the phenomenon under study.

3.2.2 Case study approach

From the critical realist stance, the case study research approach appears to be especially appropriate (Perry *et al.*, 1999). In social science, the use of case studies for the development of new theories was first introduced by Glaser and Strauss (1967). Later Yin (1984) defined case study as a research strategy and developed a typology of case study designs. Yin (2009: 18) defines a case study as *"an empirical inquiry that investigates a*

contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident". Unlike traditional positivist methods that seek to separate phenomenon from context by using 'controls' to isolate the effects of a small number of variables, case study embraces the complexity of multiple variables and potentially uses a wide range of methods and sources of evidence to shed light on the phenomenon being investigated (Yin, 2003). Case study research is useful when a 'how' or 'why' question is asked about a contemporary set of events over which the investigator has little control (Yin, 2009).

Although the term 'case' is mostly associated with a location, such as a community, a case can also constitute an individual person, an organisation, or an event (Bryman, 2012). Yin (2009) proposes a two-by-two matrix comprising four types of case study designs. According to the matrix, a case study design may consist of single or multiple cases which can be analysed at either a holistic level (i.e. the selected case is examined as one unit) or at an embedded level (i.e. individual sub-units are also examined within the selected case). This research involves a multiple embedded case study design, whereby, two communities were selected and within each community a number of households and individuals were surveyed and interviewed, respectively. Multiple-case analysis allows cross-case comparisons of the findings and helps to find patterns and themes which aid development of a better explanatory theory. Choosing multiple cases enables the researcher to look for within group similarities and intergroup differences for a selected dimension (Eisenhardt, 1989). In this research, for example, individuals' livelihood trajectories were analysed to differentiate the asset ownership patterns and livelihood adaptation dynamics of different wealth groups. Moreover, comparison of two communities within the same geographical region led to a better understanding of the differential drivers, responses and distributional effects of socio-ecological change.

3.3 The case study

Two villages located in the south-western coastal region of Bangladesh were selected for this study. These were Kamarkhola village within Kamarkhola union in Dacope upazila (sub-district) in Khulna district and Mithakhali village within Mithakhali union in Mongla upazila in Bagerhat district. The study sites were selected using a purposive sampling approach at three levels - national, to decide on which country to study; sub-national, to select the region or districts for the research; and local, to choose the exact villages or communities to be focused on. In a purposive sampling approach, cases are chosen because they possess

particular characteristics that will enable the researcher to conduct a detailed exploration of the central themes and objectives of the study (Ritchie and Lewis, 2003). During the third level, a diverse case approach was adopted to select two communities that are similar with respect to certain basic features, such as geographical location and exposure to natural hazards, but differ in terms of a key factor, that is, their farming system trajectory. A diverse case method provides a deeper understanding by identifying the central themes that cut across the cases (Ritchie and Lewis, 2003). Table 3.1 shows the criteria used for selecting the cases at three different levels, while the following sub-sections describe the national, sub-national and local contexts.

Table 3.1 Case study selection criteria at three levels

Level	Purposive sampling criteria	Case context
National	1. High vulnerability to natural shocks and stresses, which are exacerbated by the impacts of climatic variability and change 2. High levels of poverty 3. High dependence on natural resource based livelihoods 4. Researcher knowledge on the context	Located in the lower reaches of the Ganges-Meghna-Brahmaputra mega-delta, Bangladesh is highly susceptible to a number of natural shocks and stresses, such as cyclones, salinity intrusion, floods and droughts, and is recognised as one of the most vulnerable countries to climate change. Although Bangladesh has recently achieved the status of a lower middle income country, poverty is rampant in many parts of the nation, especially in those which are exposed to natural hazards. Rural farm-based livelihoods are highly dependent on natural resources, such land and water, the access to which is shaped by a number of socio-economic and political factors. The researcher is a Bangladeshi national with significant previous experience in conducting field research in different parts of the country.
Sub-national (Region, district and sub-district)	1. Located within the exposed coastal region, and frequently exposed to cyclones and salinity intrusion 2. Anthropogenic effects of long-term brackish water shrimp cultivation 3. Availability of logistical support, such as local key contact persons	National government reports (CDMP, 2009, 2008) have provided detailed climatic hazards and livelihood scenarios for selected districts (that is, Khulna and Bagerhat) in the south-western coastal region of Bangladesh. The sub-districts (Dacope and Mongla) were selected after consultation with the researcher's contacts in a NGO, a government research organisation and a university in Bangladesh.

Level	Purposive sampling criteria	Case context
Local (Village)	1. One village should depend on subsistence based livelihoods, such as paddy, livestock and homestead gardening. 2. Another village should depend on cash crops, such as brackish water shrimp and white fish.	The villages were chosen based on discussion with local contacts in the chosen sub-districts. For instance, discussions with the secondary school headmaster and his colleagues, who were significantly involved in community development activities in Dacope, revealed that Kamarkhola union could be selected as the final study site as it met the selection criteria. Similarly, consultation with the employees of a development organisation that has been working in Mongla upazila under Bagerhat district for the past decade, led to the selection of Mithakhali union as the second study site.

3.3.1 Bangladesh

Bangladesh is a sub-tropical developing country located in South Asia, bordered by India to the west, north and east, by Myanmar to the south-east, and by the Bay of Bengal to the south. Administratively, Bangladesh is divided into eight divisions - Dhaka, Chittagong, Khulna, Sylhet, Rangpur, Barisal, and Mymensingh. These divisions are subdivided into districts, which are further broken down to upazilas or sub-districts. With the exception of metropolitan areas, the sub-districts are divided into unions. There are 64 districts, 489 sub-districts and 4550 unions in the country (Cabinet Division, 2016).

With a population of 155 million within an area of 148,460 km^2 and a Gross domestic product (GDP) of USD 1086 per capita in 2014 (World Bank, 2014), Bangladesh is categorised as a densely populated lower middle income country. The country has an annual population growth rate of 1.2% and an adult (15+) literacy rate of 59.7%. Over the past decade, Bangladesh has maintained a steady 6% GDP growth rate and achieved an average poverty decline of 1.74% per year (World Bank, 2014). With an estimated 24.8% of the population living below the national upper poverty line in 2015, Bangladesh has successfully achieved the Millennium Development Goal of halving the number of people in poverty by 2015 from the 1991-92 baseline rate of 56.7% (General Economics Division, 2015). With 59% of the country's total land area being arable land, agriculture is the most important source of rural livelihood, accounting for 16% of GDP and generating employment for 48% of the population. By its 50^{th} independence anniversary in 2021, Bangladesh aims to become a middle income country through acceleration of economic growth and reduction of poverty (General Economics Division, 2012).

However, a range of natural shocks and stresses, which are being exacerbated by the effects of climatic variability and change, pose a major challenge in achieving the 2021 vision (Ahmed *et al.*, 2015). A number of hydro-geological and socio-economic factors make Bangladesh one of the most vulnerable countries to climate change. These include: (a) its geographical location in South Asia – Bangladesh occupies about 7% of the combined catchment area of three mighty rivers (Ganges, Brahmaputra and Meghna) but drains over 92% of the rainfall run-off within a short period of four and a half months (June to mid-October) (Figure 1.1); (b) its flat deltaic topography with the majority of landmass lying within 10m above sea level; (c) its extreme climate variability that is governed by the monsoon and which results in acute variation in water distribution over space and time; (d) its funnel shaped coastline configuration which creates a breeding ground for tropical cyclones, usually occurring in late May or in early November (e) its neap tides during the peak monsoon period which are high enough to flood the entire embankment protected area by saline water; (f) its high population density and poverty incidence; and (g) its dependence on crop agriculture which is highly influenced by climatic variability (Ahmed *et al.*, 2015, Ahmed, 2006, Ali, 1999, Karim *et al.*, 1998). While the southern coastal region is susceptible to cyclones, salinity intrusions and sea level rise, the low-lying floodplains suffer from riverine floods and erosion, the north-west region is exposed to drought and the hilly regions of the north-east are vulnerable to flash floods.

3.3.2 South-western coastal region

Geography and demography

The south-western coastal area of Bangladesh consists of six districts (Khulna, Satkhira, Bagerhat, Gopalganj, Narail, and Jessore) out of the 19 districts that comprise the official coastal zone. According to the Coastal Zone Policy 2005, the landward boundaries of the coastal zone of Bangladesh are determined by three factors - influence of tidal waters, salinity intrusion and cyclones/storm surges (MWR, 2005). Within the 19 districts, 48 upazilas in 12 districts are further categorised as 'exposed coast' and the remaining 99 upazilas are categorised as the 'interior coast' (Figure 3.1) (Uddin and Kaudstaal, 2003). The two sites selected for this study are located within the exposed coastal zone; in both Mongla and Dacope upazila the soil salinity is >15 dS/m, the surface and groundwater salinity is >10 dS/m, the average tidal fluctuation is >2 m over the year and the cyclone risk is high (Uddin and Kaudstaal, 2003).

As the study sites are located within Dacope upazila of Khulna district and Mongla upazila of Bagerhat district, the administrative, demographic and socio-economic contexts of these districts and upazilas are discussed in this paragraph. Khulna district comprises nine upazilas and one City Corporation, with a total area of 4389 km^2. Within the district, Dacope upazila has an area of 991 km^2, of which Sundarban reserve forest covers 494 km^2, land area comprises 286 km^2, and water bodies account for 210 km^2 (Bangladesh Bureau of Statistics, 2013b). Bagerhat also comprises nine upazilas, with a total area of 3959 km^2. Within the district, Mongla upazila has an area of 1461 km^2, most of which is land area (Bangladesh Bureau of Statistics, 2013a). In 2011, Dacope and Mongla had a total population of about 152,000 and 137,000 respectively. While about 56% of the people in Dacope are Hindu, Mongla has a Muslim majority of 79% (Bangladesh Bureau of Statistics, 2013a, b). These areas are mainly dependent on a single paddy crop each year. The gross cultivable area in Dacope and Mongla is about 60,000 ha and 20,000 ha respectively, of which more than 55,000 ha and 13,000 ha is single cropped. The age 7+ literacy level in Dacope has increased from 49% in 2001 to 56% in 2011, while in Mongla it has remained steady at 57% throughout the decade (Bangladesh Bureau of Statistics, 2013a, b). Based on the headcount ratio calculated using the cost of basic needs (CBN) method, in 2005, an estimated 73% of the population in Dacope upazila and 56% of the people in Mongla upazila were below the upper poverty line, compared to 35.2% of the national rural population (Bangladesh Bureau of Statistics, 2011).

Natural hydrology and human interventions

The landscape is crisscrossed by innumerable tidal rivers and creeks that extend up to 200 km inland. The tide along the Bangladesh coast is semi-diurnal with two high tides and two low tides every 24 hours and 50 minutes. The tidal range is highest during the new and full moon (called spring tide) and is lowest during the quarter of the moon (neap tide) (Nuruzzaman, 2006). During the monsoon season, the flow of water from upstream rivers pushes the saline sea water southwards, thus maintaining freshwater in the rivers and canals in the coastal area. In the dry season, when the flow decreases, backwater effects push the salinity front further inwards, making the rivers and canals saline. In this natural state, the fluctuation in tidal height, which is more pronounced during the monsoon, leads to inundation of surrounding land during the high tides. Based on indigenous knowledge, local communities used to construct temporary earthen embankments or *'ostomashi badh'* (embankment for eight months) to protect agricultural land from flooding and saline water intrusion (Islam and Kibria, 2006). During the wet season (July to December), farmers could

cultivate a tall, low yielding variety (2 - 3.5 tons per hectare) of *Aman* paddy that could survive stagnant flooding of 0.3 - 0.5 m depth for weeks to months (Tuong *et al.*, 2014). The embankments were breached during the dry season (January to June) to allow the tidal water to deposit silt on the land, which increased soil fertility and also raised the land level (Islam and Kibria, 2006).

In the 1960s (that is, before the liberation war, when Bangladesh was known as 'East Pakistan'), the East Pakistan Water and Power Development Board, in association with international financial institutions, began the 'Coastal Embankment Project' that involved construction of a number of 'polders' in this region. The Dutch term 'polder' refers to a tract of land, enclosed on all sides by dykes or embankments, in which sluice gates are used to artificially control the discharge and supply of surface water. The construction of polders was part of the 'green revolution' that sought to intensify crop production and increase food security by protecting agricultural land from tidal floods and salinity intrusion (Islam and Kibria, 2006). Currently, there are 139 polders in the coastal region, covering a total of 1.2 million hectares of land and individually ranging from a few hundred hectares to over 30,000 hectares in size (Tuong *et al.*, 2014). About 62% the coastal land has an elevation of up to 3m and 83% up to 5m above mean sea level (BWDB, 2013).

Natural shocks and stresses and potential impacts of climate change

Bangladesh is a hotspot for tropical cyclones, with the greatest damage occurring from inundation caused by cyclone induced tidal surges ranging from 1.5-10m in height (Dasgupta *et al.*, 2014). While a 10m high cyclonic surge has a return period of 20 years, a 7m high surge occurs once every five years. The country disproportionately bears about two-fifths of the world's total impact from cyclones and tidal surges (Dasgupta *et al.*, 2014). In the last 200 years, over 70 severe cyclones hit the coast of Bangladesh and about 900,000 people died due to catastrophic cyclones in late 20th century (Islam and Ahmad, 2004). About 40% of these cyclones hit the Noakhali-Chittagong coast (south-central) and 27% hit the Chittagong-Cox's Bazar coast (south-east), while the Khulna-Barisal coast (south-west) was relatively less exposed due to the Sundarbans (Minar *et al.*, 2013). Some of the most notable recent cyclones are the April 1991 cyclone (wind speed – 225km/hr; casualties – 140,000), the November 2007 cyclone Sidr (wind speed – 223 km/hr; casualties - 3500) and the May 2009 cyclone Aila (wind speed – 92 km/hr; casualties - 200) (Ministry of Disaster Management and Relief, 2012). Between 1985 and 2009, the sea surface temperature in the Bay of Bengal has increased by about 0.20 - 0.46 °C during the day and 0.30 - 0.48 °C during

the night; by 2050, the day and night time temperatures are expected to increase by 0.35 - 0.72 °C and 0.50 - 0.80 °C respectively (Chowdhury *et al.*, 2012). While global seal level is rising by 2-3mm every year, the sea level along the southwestern coast of Bangladesh is increasing by 15.9 – 17.2mm each year owing to glacier melting in the Himalayas and land subsidence in the delta (Schiermeier, 2014). The combined effect of sea-level rise and sea surface warming is likely to invigorate tidal surges, causing inundation of a larger area with greater intensity (Ahmed *et al.*, 2015).

The south-western coastal area is also exposed to soil and water salinity, which adversely affects agricultural production and fishing activities and reduces availability of freshwater for domestic purposes (Mahmuduzzaman *et al.*, 2014, Islam *et al.*, 2012). Although the salinity regime is largely determined by the discharge of water from upstream rivers, the construction of the Farakka Barrage on the Ganges River in India significantly reduced the flow. Moreover, the fluvio-morphological activities of the Ganges and Brahmaputra rivers, the two most sediment laden rivers in the world, lead to siltation of river beds and upstream drainage congestion (Mahmuduzzaman *et al.*, 2014). Within the coastal region, the construction of polders interferes with the natural diurnal tidal flooding of the rivers, leading to further sedimentation. In addition, over extraction of groundwater through tube-wells has caused saline water to occupy the underground aquifers (Mahmuduzzaman *et al.*, 2014). One of the most notable causes of the increase in soil salinity in this region is the massive conversion of agricultural fields to brackish water shrimp farms during the last three decades (Pokrant, 2014). Saline water from the Bay of Bengal has already intruded over 100km upstream through the numerous rivers and creeks (Allison *et al.*, 2003). The water salinity in coastal rivers is about 4 parts per trillion (ppt) during the monsoon and 13 ppt during the dry season (Khan *et al.*, 2011). The total amount of agricultural land affected by various degrees of salinity has risen from 0.83 million hectares to 1.05 million hectares in the past four decades (Islam *et al.*, 2012). Increased intensity of cyclones is likely to push more saline water from the deeper layers of the sea onto the continental shelf and in to coastal areas (Dasgupta *et al.*, 2014).

While scientific studies are trying to predict future directions of change, these are increasingly being supplemented with studies on local perceptions of change (e.g. Rahman and Pokrant, 2015, Shameem *et al.*, 2015, Rashid *et al.*, 2014), particularly to fill the gap in high resolution local level forecasts. Studying two villages of Satkhira district in south-western Bangladesh, Rahman and Pokrant (2015) found that over the past decade local farmers experienced increased summer and monsoon temperatures, more intense rainfall

and flooding in late monsoon, heightened water levels during high tides in late or post-monsoon, increased soil salinity extending further inwards during the dry season and shorter and warmer winters with intermittent intense cold spells as major weather related changes. Similar findings were made by Shameem *et al.* (2015) in Bagerhat district, where respondents also mentioned increased occurrence of tropical cyclones with stronger winds and higher tidal surges. However, meteorological data showed no increase in decadal cyclone frequency or intensity, showing that perceptions may be based on people's recent experiences of two consecutive cyclones in 2007 and 2009.

Cyclone Sidr and cyclone Aila

Since cyclone Sidr and Aila are particularly relevant for the study sites selected in this research, they are discussed in detail in the following paragraphs. Cyclone Sidr struck the south-central coastal districts in November 2007 affecting about 8.5 million people in 200 sub-districts in 30 districts, killing about 4,000 people and injuring about 55,000 people (Riquet, 2012). Sidr was a category 4 cyclone with wind speeds up to 220 km per hour and tidal surges of 4-5m in height, which destroyed 1700 km of roads, 1875 km of embankments and 1850 culverts, damaged more than 4 million trees including those in the Sundarbans, killed 1.8 million livestock and poultry and fully damaged 565,000 houses (MoFDM, 2008). The worst affected areas were Bagerhat, Pirojpur, Barguna and Patuakhali districts. The Bangladesh Meteorological Department, with volunteers from the Cyclone preparedness Programme, issued the highest warning signal which helped to evacuate 3 million people and accommodate 1.5 million in cyclone shelters (MoFDM, 2008). However, due to lack of experience, many people failed to interpret the on the ground risks associated with the signal, some disregarded it as a false warning, while others were reluctant to move to shelters and leave their cattle behind. Moreover, as the cyclone hit during the night, many people were caught up on their way to safe shelters.

Cyclone Aila hit the south-western coastal districts of Bangladesh in May 2009. Despite being a Category 1 cyclone, the impacts of cyclone Aila were initially assumed to be minor as the wind speed during landfall and the death toll was comparatively much lower than cyclone Sidr (Walton-Ellery, 2009). According to the local affected communities, the casualties were low mainly due to the fact that cyclone Aila occurred during the day time. However, as the cyclone hit the coast during high tide, it was accompanied by a deadly tidal surge of up to 6.5 m, forcing the embankments to collapse at vulnerable points and flooding the coastal areas with saline water. The whole incident occurred within a few minutes, which just gave enough time for people to move to higher areas, mainly the embankment, leaving all their

belongings behind. The immediate impacts included 190 casualties, 7,100 injuries, death of 150,000 livestock, complete damage to 243,000 houses, destruction of 1742 km of embankment and full or partial damage to nearly 350,000 acres of crop land (Riquet, 2012). While a total of 3.9 million people in 64 upazilas in 11 districts were affected, the worst impacts occurred in Shyamnagar and Assasuni upazilas of Satkhira district and Dacope and Koyra upazilas of Khulna district (Riquet, 2012).

However, the devastating impacts of cyclone Aila started to become more apparent in the weeks and months following the disaster, when continued breaches in the embankments and delays in repair prevented thousands of households from returning to their houses and resuming normal livelihood activities. The breaches became severe during the daily high tides and particularly during the fortnightly spring tides (UN, 2010). Although several initial attempts were made to repair the embankments by the communities themselves or through cash for work programmes, many of these initiatives failed due to high tides and rain brought about by the monsoon (ECHO, 2009). As a result, even a year after the disaster about 125,000 continued to live in makeshift houses on the embankments. The cyclone caused spontaneous mass movement of people, who left their settlements either temporarily with the intention to return after the flood water receded or permanently to gain better income generating activities, increased access to resources and greater safety from natural events (ECHO, 2009). The embankments were finally repaired after two years, which allowed most people to return to their homestead land.

3.3.3 Study sites

Figure 3.1 shows the location of the two villages selected for this study. Kamarkhola village is the largest of the 14 villages within Kamarkhola union and consists of 2,917 people or approximately 600 households (GoB, 2011a). About 60% of the population is Hindu, while the rest are Muslim. Mithakhali village, one of the 18 villages in Mithakhali union, has a population of 2,750 and comprises about 600 households (GoB, 2011b). All the households are Muslim and there are no minority groups within the village. Chapter 4 provides further details on the demographic profile of the two villages, based on findings from the household questionnaire surveys.

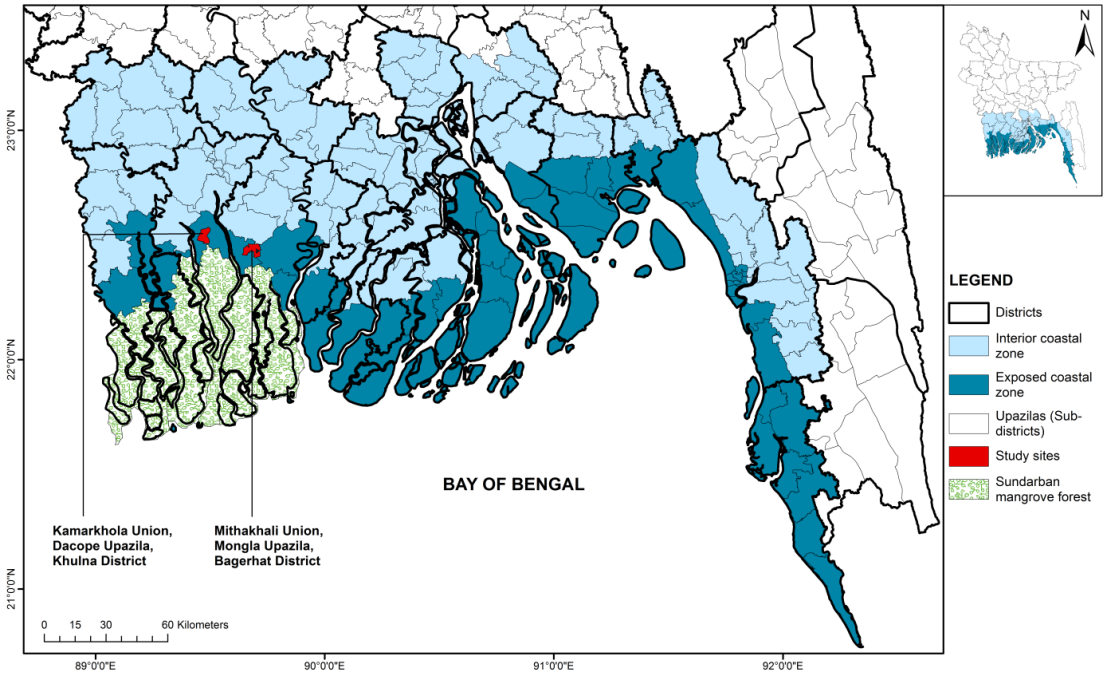


Figure 3.1 Map of Bangladesh showing the two study sites (Author's own illustration using ArcGIS)

In terms of distance, both Kamarkhola and Mithakhali unions are 170 km (measured in a straight line) from the capital city Dhaka and about 33km and 40 km from nearby Khulna city respectively. Roads and transport facilities are quite poor in both sites; however, connectivity with the nearby Khulna city is worse for Kamarkhola compared to Mithakhali. During fieldwork, it took about one hour to travel from Khulna city to Pankhali ferry terminal by road, then 10 -15 minutes to cross the river by boat or ferry and another 30 minutes to travel to Chalna union in Dacope upazila by motorized van or local buses. From Chalna union, Kamarkhola union could be reached only by motorcycle, which again had to board a boat to cross a canal. Within Kamarkhola union, the embankment served as the only road, which was unpaved and hence, not suitable for motorcycles or vans during the wet season. For Mithakhali union, public or private transport by road was available till Mongla town, which was the main market and business hub for all villages in Mongla sub-district. From Mongla town centre, Mithakhali village could be reached by a 10 minute boat ride, followed by a 20 minute motorized van ride. The village had only one brick laden road, which was developed in the mid-2000s. The construction of this road as well as good transport facilities to Mongla town centre had significantly contributed to trade and economic development of the area.

Table 3.2 shows the land use characteristics of Kamarkhola and Mithakhali unions. Kamarkhola predominantly depends on a single rain-fed paddy crop, often integrated with

white fish and freshwater Galda prawn. Most of the agricultural land remain fallow during the dry season due to lack of fresh water for irrigation. Only a small percentage of households with access to an adjacent freshwater canal can grow Boro paddy in winter. A variety of seasonal vegetables are grown in homestead gardens, while polyculture of prawn and white fish is carried out in homestead ponds. In Mithakhali union, yearlong aquaculture of brackish water Bagda shrimp and white fish is the main livelihood activity. Some villages follow a dry season shrimp – wet season Aman paddy rotational system. Homestead ponds are also used for shrimp-white fish polyculture. The reasons for this difference in farming systems are elaborately discussed in chapter 5.

Table 3.2 Land use characteristics in Kamarkhola and Mithakhali Union (Ministry of Land, 2011)

	Kamarkhola Union	Mithakhali Union
Total land area	2921 ha	3444 ha
Net cultivable area	1900 ha	2410 ha
Present land use	Agriculture – 65% Aquaculture (Bagda shrimp with White Fish) – 8% Settlement – 13% Water body – 15%	Agriculture – 27% Aquaculture (Bagda shrimp with White Fish) – 50% Settlement – 17% Water body – 6%
Major Cropping Patterns (% of net cultivable area)	Fallow – Aman paddy with fisheries – 97% Boro paddy – Fallow – Aman paddy – 2% Rabi vegetables – Kharif – I vegetables – Kharif – II vegetables – 1%	Bagda shrimp and white fish – 65% Bagda with white fish – Aman paddy – 33% Rabi vegetables – Fallow - Aman paddy – 2%

Note: In South Asia, the crop calendar is divided into Kharif – I (March – May), Kharif – II (June – November) and Rabi (December – February) and the paddy crops grown in these seasons are referred to as Aus, Aman and Boro, respectively.

3.4 Mixed methods research

While the terms 'case study' and 'qualitative' are often used synonymously, a case study approach can involve either qualitative or quantitative methods or both (Eisenhardt, 1989, Yin, 1984). This research uses a mixed methods approach involving both qualitative and quantitative methods of primary data collection. Each of these two methods provides a distinctive kind of evidence and interlocking both types allows an extended understanding that neither method alone can offer (Ritchie and Lewis, 2003). In mixed methods research, qualitative research may precede statistical enquiry, may accompany statistical investigation or may be used to follow up the findings from the quantitative exercises (Ritchie and Lewis, 2003). Preliminary qualitative research can be valuable in identifying the underlying social constructs and designing structured questions for quantitative surveys (Ritchie and Lewis,

2003). When both methods are used to study the same phenomenon, quantitative methods can provide generalizable statistical data, while qualitative methods can provide a rich, in-depth understanding of the nature of the phenomenon (Ritchie and Lewis, 2003).

In this study, participatory wealth ranking (PWR) and focus group discussions (FGDs) were carried out to get an overview of the local context in terms of resources available, wealth differentiation, main livelihood activities, socio-political situation and major shocks and stresses. Besides providing a general idea about the nature of the local phenomena, these exercises supported the fine-tuning of household questionnaires in accordance to specific livelihood practices. The household questionnaire surveys provided statistical data on asset ownership patterns, changes in livelihood strategies and overall well-being of different wealth groups. These were followed by livelihood trajectory interviews that provided detailed narratives on the lives of individuals and helped to shed light on how initial asset ownership affects asset management strategies and livelihood decisions in the face of shocks and stresses. Combining quantitative and qualitative methods resulted in a number of important functions, especially with respect to triangulation, completeness and explanation. As explained by Bryman (2012), triangulation refers to the comparison of results from different sources to ensure greater validity; completeness refers to obtaining a comprehensive account of the area of inquiry by building on the strengths and offsetting the weaknesses of different research methods; and explanation refers to the process of using one method to explain findings from another. The following sub-sections discuss the research tools used to collect primary data from the study sites. Figure 3.2 outlines the methodological framework, showing how these different data collection methods relate to each of the research objectives.

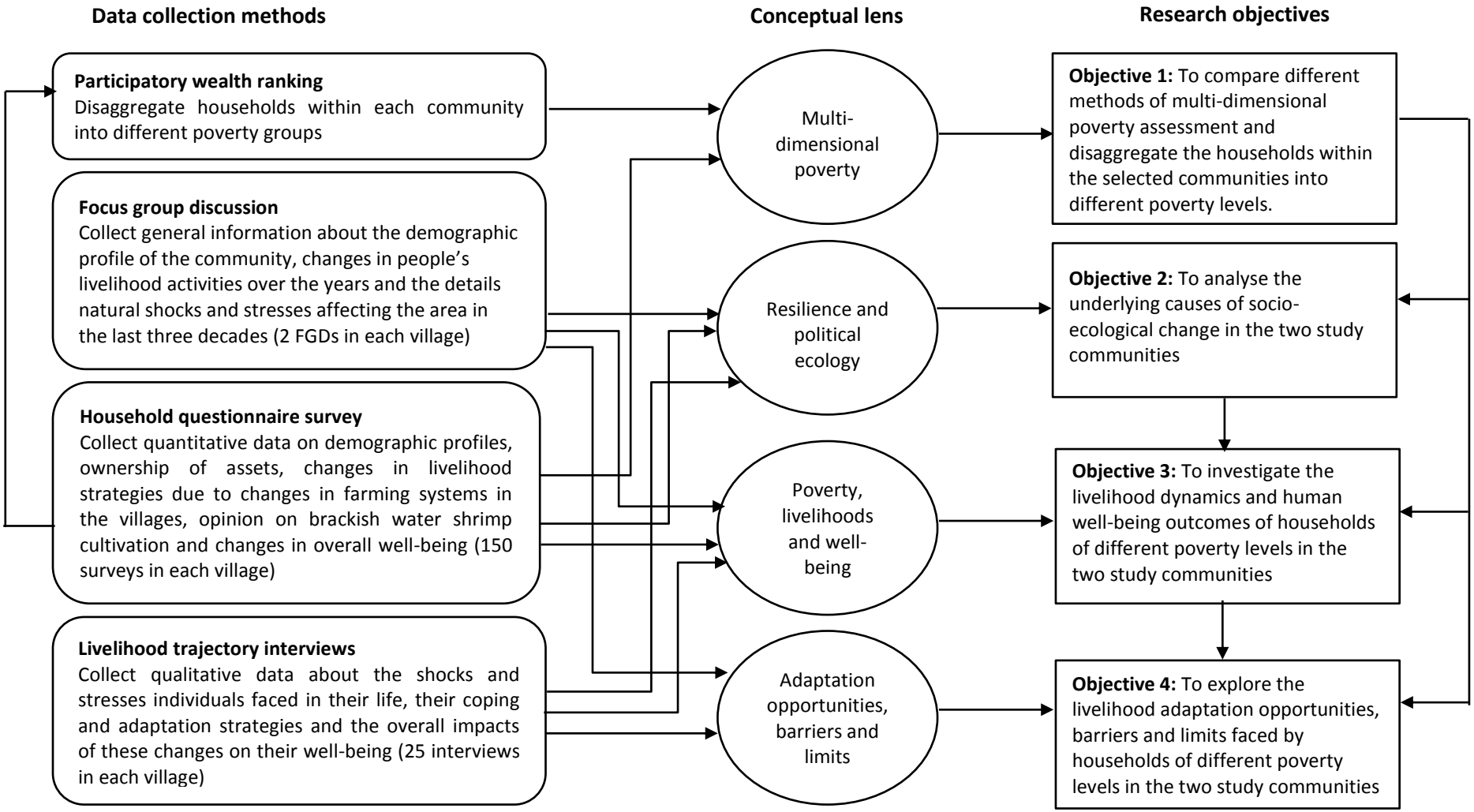


Figure 3.2 Methodological framework showing links between the data collection methods, the conceptual lens and research objectives

3.4.1 Focus group discussions

In social science research, FGDs provide valuable insight into the social nature of knowledge and enable the researcher to elicit information about the history of the community, collective experiences and shared concerns (Goss and Leinbach, 1996). Focus groups typically comprise six to ten members, ensuring that the diversity in the group composition is adequate to aid discussion, but not too much to inhibit it (Finch and Lewis, 2003). If the group is too homogenous, respondents might assume that others know what they are talking about and hence, may not articulate their experiences sufficiently. Conversely, significant imbalances in social power and status within the group may discourage participants from speaking up. In FGDs, the group is synergistic and contributions by participants are refined by what they hear others say (Finch and Lewis, 2003). Interjections and arguments during the discussions allow participants to reach a representative consensus on relevant issues, thus enriching the information obtained.

In this study, the FGDs obtained a general overview of the local context of the study villages and built the knowledge base for operationalising subsequent research tools. The FGDs collected information about the demographic profile of the community, changes in people's livelihood activities over the years, land ownership patterns, current level of education, availability and quality of health facilities, the level of infrastructural development, and the details of natural shocks and stresses affecting the area in the last three decades.

Two FGDs were conducted in each of the villages, with male and female respondents, respectively. Since this research aims to understand and compare the situations of households of different wealth classes, it was ensured that the respondents were heterogeneous in terms of their poverty levels. However, in one of the study sites, it was not possible to recruit members from the rich households, as they were reluctant to join these sessions. Members of these households were interviewed separately while conducting the livelihood trajectories. The respondents in the male group were typically farmers, who practiced crop cultivation, shrimp farming or both, depending on the local context; while the female respondents mainly comprised of housewives. The male FGDs were held in open spaces, while the female ones were carried out within someone's house or courtyard. Each FGD involved about 8-10 participants and took about two hours.

3.4.2 Participatory wealth ranking

The first objective of this research seeks to disaggregate the households within each community into different wealth classes. However, as poverty assessment and wealth

stratification is a complex task and as variations in research methods can lead to different results, two sources of evidence were used to address this research question. The first method was a participatory wealth ranking (PWR) exercise, which gave a general overview of the wealth differentiation within the community, and the second was a quantitative household survey (see section 3.4.3), which provided detailed information on the assets owned by individual households. This sub-section discusses the PWR method.

Generating numbers from participatory methods, such as wealth ranking, have traditionally been considered as less scientific, less valid, and hence less applicable, for comparisons than quantitative measures like surveys (Rajaratnam *et al.*, 1992). However, over the past three decades, the work of social scientists (for example, 'whose reality counts?' by Chambers (1995)) have ascertained the validity, generalizability and rigour of participatory statistics and established them as a complementary and stand-alone research method. Participatory research respects local knowledge and facilitates local ownership and control over data generation and analysis (Holland, 2013). PWR is, in fact, a quick and effective means of assessing wealth status, perhaps more detailed and intuitive than surveys (Chambers, 1994).

The PWR exercise comprised two stages, one of which was conducted before the household survey and the other after. The first step involved categorising the households within each community into different wealth groups and identifying the core characteristics that differentiate one group from another. This first step was conducted once in each village with a group of 3-4 key informants, who had good knowledge about the wealth status of households within their community. Coincidentally, respondents in both the communities came up with a five part categorisation, that is, rich, upper middle, lower middle poor and extreme poor households. Certain common criteria, such as area of agricultural land owned, occupations, education level of adults and children, food security and housing were selected by the respondents in both communities. However, the values or description within each criterion varied between the two communities; for example, in Kamarkhola, households owning land greater than 8.25 acres were considered as rich, whereas in Mithakhali rich households were those that owned more than 13.2 acres of land. The participants were then asked to give rough numbers of households within each group.

Following the household survey, which comprised of 150 households randomly selected from a total of approximately 600 households in each site, the names of the 150 household heads were listed down in alphabetical order. This list was then presented before the same group of respondents who participated in the first step of the PWR exercise. The respondents were then asked to assign one of the five wealth categories to each of the 150

households. The usual way to conduct this PWR would involve listing down the names of all the households in the village, assigning them wealth classes and then selecting households from this census for the household survey. However, instead of applying this procedure, in this study the survey was done prior to the wealth ranking for three reasons: firstly, there were limited resources in terms of time and manpower to list down the names of all 600 households in each site and then rank them; secondly, my previous experience has shown that it is often difficult for respondents to remember the names of all the household heads from scratch; thirdly, it avoided any bias in selecting households for the survey. Moreover, as the main aim was to compare the poverty levels of the selected households using different methods, only the wealth ranks of the 150 households surveyed were required.

3.4.3 Household questionnaire surveys

As mentioned in section 3.4.2, one of the purposes of the household surveys was to complement the PWR exercise in order to address the first objective of this study. For this purpose, the survey collected data on education level, demographic profiles and occupations of household members, ownership of homestead and agricultural land, numbers of livestock owned, housing materials and condition, water and sanitation facilities, and ownership of consumer durables and production equipment. Data were also collected on changes in livelihood strategies due to changes in farming systems in the villages, the respondent's opinion on brackish water shrimp cultivation and changes in overall well-being (refer to the household questionnaire in Appendix B). These data provided quantitative evidence for the second and third objectives of this research, as presented in chapters 5 and 6.

Determination of the sample size and the selection of households are crucial in quantitative surveys. Due to limitations of manpower and resources, it was not practical to survey more than 200 households in each site; but at the same time, to ensure that there were enough households from each wealth category for further statistical analysis it was necessary to survey more than 100 households per site. Since the total number of households in both communities was approximately 600, a 25% criterion was applied and the sample size was fixed at 150 for both sites.

A random route sampling method was used to select households for the survey (cf. Hoffmeyer-Zlotnik, 2003, Hoffmeyer-Zlotnik and Krebs, 1996). Each of the villages was divided into neighbourhoods (locally known as *'para'*), and within each neighbourhood households were selected via the 'random walk' method. For instance, in Kamarkhola, there were five approximately equal sized neighbourhoods, with each containing about 120

households. For each neighbourhood, a particular house was designated as the starting point for the walk and every fourth household along the route was selected; thus, recruiting a total of 30 households in each neighbourhood. In Mithakhali, 40 households were recruited from each of the three larger neighbourhoods and 30 from the relatively smaller one. This method ensured representation from all parts of the villages. One of the conditions was that the household should have resided in the village for more than two decades, as new migrants would not be able to respond to questions associated with 'changes' in farming systems and livelihood strategies over time. If any household did not meet this criterion, the one next door was chosen as a replacement.

A draft questionnaire for the household survey was prepared before commencing fieldwork, ensuring that all questions necessary to collect the required data were present. However, following initial field visits, qualitative exercises and some pilot surveys, the questionnaire was amended. The amendments were necessary to take contextual factors into account and to adjust the sequence of questions in a way that made it easier for the research assistants and the respondents to generate the data. There were also slight differences in the questionnaire used in each of the study sites. For example, as people in Mithakhali are all engaged in shrimp cultivation, it was necessary to disaggregate this occupation further, to know whether the farmer farms shrimp on his own land, leases in land from others, leases out land in exchange for rent, or engages in a co-operative farm. The final questionnaire was then translated to Bangla.

The household questionnaire survey was administered by myself and two research assistants (one in each site) during November and December 2014. To ensure that the research assistants maintained consistency in filling in the questionnaires, a two hour training session was held with each of them to explain all the questions; later field demonstrations were also done by myself to settle any confusion. For example, there were different notions of what differentiates a 'kacha' from a 'pakka' toilet. After a few pilot surveys, it was finalised that any household with a 'ring slab' in their toilet would be considered as having a 'pakka' toilet, even if the walls were made of palm leaves/bamboo. Another example is the unit of measurement for land. In rural Bangladesh, 'bigha' is mainly used as a unit of land; however, the area covered by one bigha varies from place to place. In Mithakhali, one bigha of land usually means 66 decimals (0.66 acres), while in Kamarkhola a bigha is equal to 33 decimals (0.33 acres). Hence, it was essential for the surveyors to clarify which unit of measurement the respondents were referring to.

During the survey, the household heads were the preferred respondents, as they have good knowledge about the household's assets and livelihoods. If the household heads were not available, other knowledgeable adult members were used as respondents. It was often noticed that one member did not have information about all the questions asked; hence, the participation of any willing household members was welcomed to obtain more accurate data.

3.4.4 Livelihood trajectory interviews

While household surveys were used to obtain quantitative data on the assets, livelihood strategies and well-being of households based on wealth status, livelihood trajectory interviews were used to collect in-depth information about what shocks and stresses individuals faced in their life, how they managed their assets and livelihood activities to cope with these events and what were the overall impacts of these changes on their well-being. Thus, livelihood trajectory interviews served as one of the main research methods to address the second, third and fourth objectives.

Livelihood trajectories refer to *"the consequences of the changing ways in which individuals construct a livelihood over time"* (Bagchi *et al.*, 1998: 457) and allow analysis of an individual's *"strategic behaviour embedded both in a historical repertoire and in social differentiation"* (De Haan and Zoomers, 2005: 43). Construction of a livelihood trajectory involves an open-ended interview of an individual who narrates his/her own life history with reference to changes in livelihood activities and well-being that were chosen by him/herself in the context of external socio-economic and environmental circumstances. According to De Haan and Zoomers (2005), while a 'life history' is a description of the chronology of events in an individual's life, a 'livelihood trajectory' involves a deeper analysis of an individual's beliefs, needs, aspirations and limitations, contextualised in relation to power and institutions. Livelihood trajectories are increasingly used to explore the shocks and stresses that affect people's lives and understand the strategies adopted to deal with them (e.g. Orchard *et al.*, 2016, Davis and Baulch, 2011, Sallu *et al.*, 2010).

In this study, the livelihood trajectory interviews involved an 'unstructured' format, whereby a biographical or narrative approach was adopted to collect context specific in-depth information related to particular themes, topics or issues. These themes included – the individual's current and past livelihood activities, changes in ownership or access to productive resources, the opportunities and barriers related to pursuing desired livelihood activities, his hopes, values and fears, and changes in well-being. The actual questions asked

during the interview were spontaneous and depended on the interviewee's responses. Probing was an essential part of the interview, particularly when the interviewees came up with unanticipated but relevant information. In some cases, interviewees gave a tour of their house and farms to better describe the issues. An example of a livelihood trajectory interview is given in Appendix C. As shown in the example, the first part of the interview involved detailed understanding of the interviewee's current livelihood activities, in relation to the local farming practices, while the second part involved questions on past activities and how those differed from the present. The aim was to engage the interviewee in a conversation, instead of following a strict chronological order. The example also shows that as the interview proceeded, the interviewee became more comfortable and provided longer, elaborate explanations.

Unlike the quantitative household survey, the respondents in this method were not chosen by random sampling. According to Eisenhardt (1989), when the purpose is to build theories from case studies, sampling of cases is neither required nor desirable; instead the aim should be to choose cases that are likely to replicate or extend the emergent theory. Hence, a 'theoretical sampling' procedure was used to select respondents for the livelihood trajectory interviews. Developed by Glaser and Strauss (1967), theoretical sampling is done in order to discover categories and their properties and suggest their interrelationships to a theory. Based on the theoretical sampling procedure, the individuals for the interviews were selected based on pre-determined criteria in order to obtain the data required for this research. For instance, it was ensured that the selected interviewees represented people from all wealth classes, individuals whose poverty levels have changed over the last three decades and individuals with different livelihood strategies. A total of 25 interviews were carried out in each of the communities.

The respondents for the interview were adults over the age of 35 and historical markers (such as the 1988 floods, the 2009 cyclone Aila or national election years) were used to determine the years that particular events occurred. The temporal scale of data collection mainly focused on the last 25 years, although a number of elderly respondents started their narrations from the liberation war of 1971. The interviews were conducted in the individual's own house or in a place that did not draw attention from others. The goal was to make the respondent comfortable and ensure him/her that the information collected would be confidential. All the interviews were recorded with prior consent of the interviewee.

3.5 Data analysis

3.5.1 Qualitative data

Analysis of qualitative data involved two main steps: preparing and organising the data for analysis; and reducing the data into themes through a process of coding (Creswell, 2013: 180). During the first step, the primary data available as audio recordings and field notes were translated from Bangla to English and transcribed, retaining selected phrases in Bangla so that they did not lose their cultural nuances during translation. Different sources of primary data, such as audio files, photographs and transcribed texts, and secondary data such as newspaper reports, were then organised by individual interviewee and study site.

During the second step, each transcript was read thoroughly and 'chunks' of text (i.e. words, phrases or sentences) were assigned 'codes'. Coding involves tagging portions of the text, so that small pieces of information belonging to similar themes can be grouped together and reflected upon later (Bazeley and Jackson, 2013, Creswell, 2013). The development of codes followed a combination of inductive and deductive approaches. Some of the codes were generated from the literature review, the researcher's own experience about the phenomena under study and the categories embedded in the research questions (a priori approach), while others were generated from raw data (inductive approach) (Strauss, 1987). For example, the literature review highlighted a number of categories for grouping adaptation opportunities and barriers, such as ecological, economic, institutional and informational. Initially, chunks of text relating to these factors were coded under the appropriate theme. However, the primary data from the livelihood trajectory interviews and focus group discussions, also gave rise to some new categories, such as socio-political and gender, and reflected interactions between the various forms of barriers, thus, resulting in additional codes.

The codes were then structured into broader themes and sub-themes. Organising the codes helped to create order out of the randomness, clarify ideas and identify patterns associated between groups of nodes (Bazeley and Jackson, 2013). Themes and sub-themes were identified by the scrutiny techniques developed by Ryan and Bernard (2003) - looking for repetitions, indigenous typologies, metaphors and analogies, transitions, similarities and differences and linguistic connectors. The themes were then linked to theoretical concepts and sorted as per the research objectives and questions they seemed to fulfil. For instance, while analysing the changes in well-being of the study households, the texts from the primary data were first grouped under the broader theme of perceptions and causes of

changes in well-being. These texts were then broken down into sub-themes, such as material, relational and subjective dimensions of well-being.

3.5.2 Quantitative data

The quantitative data collected from the household questionnaire survey were entered into IBM SPSS 22 software, using numerical codes in the case of categorical variables. The initial task was to disaggregate the households in each site into different wealth classes based on the ownership of key assets. Descriptive statistics (mean, range, variance and frequency distribution) for the key assets were examined and finally 17 variables/indicators grouped under seven dimensions were chosen for further analysis. To demonstrate the methodological issues in multi-dimensional poverty assessment, three iterations of fuzzy set analysis (FSA) and principal component analysis (PCA) were carried out respectively. The methodological steps and results from these procedures are explained in detail in chapter 4. To check the validity and the extent of variation, the results from FSA and PCA were correlated with the data collected from PWR. Moreover, the mean asset ownership of each category was checked for internal coherence, meaning that if most key assets showed increasing ownership with rising wealth status it indicated that the categorisations were valid.

Following the disaggregation of households into different wealth classes, the numbers of households pursuing different livelihood activities both before and after the changes in local farming systems were calculated. The quantitative data were also used to calculate households' perceptions on brackish water shrimp cultivation in each village and their relative changes in well-being.

3.6 Research reflections

3.6.1 Field work

The fieldwork for collection of primary data from the study sites was conducted between October and December 2014. The data collection was carried out in two phases, each phase comprised of one field visit to each of the two study sites. The aim of the first phase was to get an overview of the local context of the study sites, to understand the changes in farming systems and to learn about the extent of natural shocks and stresses affecting the area. The first phase involved data collection through qualitative tools - FGDs, PWR and livelihood trajectory interviews. The purpose of the second phase was to collect quantitative data using household questionnaire survey, and continue with the individual livelihood trajectory interviews to obtain more information. There was a gap of three weeks between the two

phases, during which the household questionnaire was revised to address the local context and translated to Bangla.

During both the phases, a local key person was recruited to arrange local accommodation, transport and introduce me to the study area. A male research assistant was also hired to ensure safety and security and to assist me in selecting, approaching and recruiting participants as well as taking notes during the fieldwork. For the household survey, two surveyors, with previous experience in quantitative data collection, were hired from the study location. During the second phase fieldtrips these surveyors were given hands on training in conducting the survey (see section 3.4.3). The surveyors took around 3-4 weeks to fill out a total of 150 questionnaires in each site.

3.6.2 Positionality

Positionality reflects the positions a researcher chooses to adopt in relation to the topic of inquiry, the participants, the context and the research process. Positionality is important during the data collection process as the interactions between the researcher and the participants are likely to influence the quality of the data collected. During the collection, interpretation and presentation of qualitative data, it is important for the researcher to be as objective and neutral as possible (Ritchie and Lewis, 2003). The researcher should try to minimise the extent to which s/he influences the views of research participants during the course of interviews or focus groups (Ritchie and Lewis, 2003). For example, during the fieldwork it was important for me to ascertain my position as an independent student and that I'm not affiliated with any government or non-government organisations. Otherwise, participants might tend to over exaggerate their sufferings in the hope of getting benefits. In one of the sites (Mithakhali), my local contact was a childhood friend whose father and ancestors have been the most influential people in the village. In this case, it was necessary for me not to disclose my relation to their family; otherwise, the respondents might have felt intimidated and so unable to share their opinions.

The researcher's personal traits such as race, class, family status, ethnicity, gender and other social identities also shape relationships with respondents. Since I'm a Bangladeshi national and can speak the local language, I had the advantage of understanding the cultural context and nuances in meanings of the responses. My gender as a female researcher had both its benefits and drawbacks. Being a female it was unsafe to travel to the study sites alone, for which I had to be accompanied by a male Research Assistant at all times. However, being a

female proved to be advantageous when talking to female respondents and entering people's houses during the research.

3.6.3 Ethical considerations

The ethical approval for this study was obtained from ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee (Reference number – AREA 13 – 122), University of Leeds, in May 2014 (refer to Appendix D). Two main ethical issues – informed consent and data protection – were of particular relevance.

Informed consent

For each of the research exercises, the participants were first informed about the purpose of the study, the nature of information sought, and any possible risks and benefits associated with their participation. Once the participants were clear about their roles, they were asked sign a consent form (written in Bangla). As many of the participants were illiterate, the information in the consent form was read out and verbal consent was obtained. Participants were informed that they could withdraw at any stage while the research team was still in the village. No financial or other forms of incentives were offered, except for refreshments during the group exercises.

Data protection and anonymity

Personal data was collected from several individuals during the household surveys and livelihood trajectory interviews. The data collected was stored in password protected files on my personal computer and the university's server. To maintain confidentiality of individuals' personal information, pseudonyms have been used in all documents written as part of this research. The research assistants recruited for this study also signed a 'confidentiality agreement' to ensure that they did not share the data collected with third parties through any verbal or written means.

3.7 Conclusion

This chapter discussed the methodological approach and research methods applied to address the four objectives and introduced the two study sites selected for this study. Based on a critical realist ontological stance, this study used a multiple embedded case study research design, whereby, two diverse communities were selected to generate insights on differential livelihood dynamics and adaptation. The study employed a mixed methods approach for data collection, involving qualitative tools such as FGDs, PWR and livelihood trajectory interviews as well as quantitative household questionnaire surveys. Qualitative

data analysis involved translating, transcribing and coding the data based on existing and emerging themes and sub-themes. FSA and PCA were applied to the quantitative data to disaggregate the households into different wealth classes and the results were compared with those from PWR. The data from household surveys was also used to generate statistics on households' livelihood strategies, opinions with regard to shrimp farming and changes in well-being. The following chapters (4-7) use the data collected along with theoretical insights from literature review to address each of the four objectives of this research.

Chapter 4. Disaggregating households by poverty levels and comparing methods of multi-dimensional poverty assessment

Abstract

Households' poverty level is used as a central lens in this research to differentiate livelihood dynamics and adaptation within the study communities. The purpose of this chapter is to disaggregate the households surveyed in each community into different poverty levels, which serves as a baseline for structuring data in the subsequent chapters. The chapter also contributes to the methodological understanding of multi-dimensional poverty assessment by comparing three methods – participatory wealth ranking (PWR), fuzzy set analysis (FSA) and principal component analysis (PCA). PWR, which is a qualitative method, was used to determine the number of poverty groups in each community and allocate the households to each group based on relevant context specific characteristics. FSA and PCA, which are quantitative methods, used 17 indicators under seven dimensions to generate an accurate description of the asset portfolio of different groups, calculate a poverty index for each household and also show the degree of variation between households within a group. However, FSA and PCA comprise a number of sub-stages, the decisions taken during which can have considerable implications on the final results. Users of these methods are often unaware of these various rules and consequences, given that the primary goal is to obtain a final aggregate number. Given the rising use of multi-dimensional poverty measures as a baseline in different studies, it is imperative that researchers are aware of the pros and cons of different methodological steps involved. To demonstrate these issues, this chapter performed three different iterations of FSA and PCA, respectively, and triangulated the results with those of PWR. The study showed how different methods of calibration and aggregation, in case of FSA, and different sets of variables, methods of rotation and inputs for cluster analysis, in case of PCA, can lead to different numbers of households being allocated to different poverty groups. The study found that while all three methods can lead to reliable results on their own, just using one method may make it difficult for the researcher to be confident about the validity and robustness of the results. Hence, in cases of small scale in-depth studies like this one, it is better to supplement a qualitative method like PWR with a quantitative method like FSA or PCA. As per the calculation, in Mithakhali, the numbers of households belonging to rich, upper middle, lower middle, poor and extreme poor categories were 7 (4.7%), 18 (12%), 52 (34.7%), 50 (33.3%) and 23 (15.3%)

respectively, while in Kamarkhola the numbers were 9 (6.0%), 13 (8.7%), 56 (37.3%), 43 (28.7%) and 30 (20%). The chapter found that ownership of agricultural land was the most important factor in disaggregating households into different poverty levels. Agricultural land ownership increased exponentially from the lowest to the highest wealth class, with the rich households possessing almost three times as much land as the upper middle class in both sites. This highlighted that a small percentage of households controlled a relatively large percentage of land, particularly in Mithakhali. Moreover, in both villages, the lower middle, poor and extreme poor classes were more homogenous in terms of asset ownership, while the rich and upper middle class households exhibited high degree of within class variation. In Mithakhali, which was a peri-urban community based on cash crop cultivation, households owned more consumptive assets and showed greater inequality in wealth distribution, compared to Kamarkhola, which was a remote community depended on subsistence based livelihoods.

4.1 Introduction

Poverty assessment has evolved from its traditional focus on measuring food intake, income or consumption expenditures to a multi-dimensional approach that uses a large number of variables to assess human well-being or standard of living (refer to literature review in section 2.7). Poverty assessment usually involves identification of who the poor are and aggregation of the information about poverty across a society (Alkire *et al.*, 2015, Sen, 1976). In uni-dimensional methods based on monetary or food deprivations, identification involves a poverty line, such as the World Bank's USD 1.25 a day (Ravallion *et al.*, 2009) or Bangladesh's minimum nutritional intake of 2122 kcal per capita per day (WFP, 2013), which dichotomises the society into poor and non-poor. Aggregation can be done using a number of formulae, such as the Foster-Greer-Thorbecke (FGT) measures of poverty that can calculate the headcount, the poverty gap and inequality (Foster *et al.*, 1984). Multi-dimensional poverty measures, which involve a number of indicators often grouped under different dimensions of deprivations, usually require generation of an overall poverty index based on the weighted aggregate of the level of achievements in all dimensions and deciding on a poverty cut-off line that separates the poor from the non-poor (Alkire *et al.*, 2015). There are various qualitative and quantitative methods to deal with these identification and aggregation issues and each of these methods differ significantly in the steps used to measure poverty. Participatory wealth ranking (PWR), fuzzy set analysis (FSA) and principal

component analysis (PCA) are among the most widely used methods of multi-dimensional poverty assessment at micro-level (Alkire *et al.*, 2015). This chapter provides a methodological comparison of these three methods to analyse how the choice of method affects the results of poverty assessment and at the same time disaggregates the households in the study communities into different poverty groups (also referred to as wealth classes, henceforth).

The study first used PWR in each of the two communities to identify the number of wealth classes present, the characteristics that define the different classes and the percentages of households in each class. PWR is a qualitative method of poverty assessment, which has been extensively used to stratify households within a community based on local perceptions of wealth and contextually relevant dimensions of poverty (e.g. Hargreaves *et al.*, 2007a, Hargreaves *et al.*, 2007b, Van Campenhout, 2007, Adams *et al.*, 1997, Scoones, 1995). The indicators used for differentiating households are context specific and obtained from local respondents. For example, in a recent study in Khulna district of Bangladesh, Afroz *et al.* (2016) used PWR to identify four wealth classes, namely large farmers, middle farmers, small farmers and landless. The authors found that poverty level was mainly determined by the ownership of agricultural land, along with other indicators such as access to diversified income sources, education, cropping pattern and relations with formal institutions. While PWR can identify the number of wealth classes present and assign each household to one of the classes, the results are based on subjective judgments and knowledge of the respondents, which often raises questions about its validity and robustness (Van Campenhout, 2007). Moreover, PWR cannot generate accurate information about the asset ownership of each household and understand to what extent households within a given class differ from each other. To substantiate the validity of PWR results, previous studies have either repeated the same PWR exercise with different groups (Scoones, 1995), or applied statistical tests on quantitative wealth data obtained from household surveys (Van Campenhout, 2007, Adams *et al.*, 1997).

In this study, the results from the PWR served as a baseline for further quantitative analysis, by pre-determining the number of poverty groups and providing data for validating the results from the quantitative methods. Similarly, the results from the quantitative methods, that is, FSA and PCA, were also used to check the validity of the PWR results. FSA and PCA were applied on household questionnaire survey data to disaggregate households into the pre-determined number of poverty groups and empirically demonstrate how decisions taken at sub-stages can affect the overall poverty results. FSA is a quantitative method that

conceptualises poverty as the degree of membership to a poverty set, measured on a scale from 0 to 1, where 1 indicates full membership and 0 means full non-membership (Ragin, 2000). FSA calibrates the variables into deprivation membership scores, which are then aggregated using union, intersection or averaging operators. Instead of using a single cut-off point to disaggregate the poor and non-poor, FSA stratifies the households into continuous gradation of poverty levels (Neff, 2013, Chiappero Martinetti, 2006, Qizilbash and Clark, 2005, Ragin, 2000, Cheli and Lemmi, 1995). PCA is a multivariate statistical technique that uses correlations between sets of variables in the dataset to combine them into a smaller number of factors (called principal components), of which the first component is usually used to segregate households into quartiles, quintiles or clusters (Ansoms and McKay, 2010, Vyas and Kumaranayake, 2006, McKenzie, 2005, Filmer and Pritchett, 2001).

Quantitative methods, such as FSA and PCA, comprise a number of sub-stages, each of which entails certain decisions. Different decisions taken at each stage may lead to different results in poverty measurement (Alkire *et al.*, 2015). In case of FSA, the calibration and aggregation methods used and in case of PCA, the variables used, the number of factors extracted and the type of cluster analysis applied, can significantly affect the results. However, these sub-stages do not receive enough attention in the literature and users of these methods are often unaware of these various rules and consequences, given that the primary goal is to obtain a final aggregate number (Alkire *et al.*, 2015). Lelli (2001) notes that it is very important to assess the validity of results from different methodological approaches, as procedural decisions should not affect overall results and any inconsistencies could lead to serious normative implications. Although previous studies have established the validity of these methods individually, the numerous decisions that have to be taken at different sub-stages and their implications on the final results have not been adequately demonstrated in the literature using empirical examples. To date, there has been no comparison of the FSA and PCA using the same data-set, which is particularly necessary to highlight their relative strengths and weakness.

In this study, a methodological comparison of FSA and PCA was carried out, with particular emphasis on how decisions taken at various sub-stages affect the overall results. Both methods included 17 indicators under seven dimensions (housing materials, consumptive assets, productive assets, livestock, agricultural land, homestead land and pond, and education). Unlike PWR, where the indicators were selected by the key informants, in case of FSA and PCA, the indicators were pre-selected based on certain criteria, as described in section 4.2.2 below. For each of the study sites, three types of FSA were carried out by using

different types of calibration and aggregation methods. FSA1 used a frequency-based method to calibrate each of the variables into membership scores, combined the variables into individual dimensions using empirically generated weights, and then disaggregated households into different wealth classes by counting the number of dimensions on which the households were deprived. FSA2 used a quadratic sigmoid function for calibration, keeping subsequent steps the same as that of FSA1. FSA3, on the other hand, used a frequency-based calibration method like FSA1; however, it aggregated the seven dimensions further to calculate a single poverty index and then used k-means cluster analysis to disaggregate the households into different poverty groups (refer to section 4.2.2 for details).

Similarly, three types of PCA were carried out for each site by varying the number of variables, changing the type of factor rotation and altering the inputs used for cluster analysis. PCA1 was based on all 17 indicators, with no rotation of extracted components and using the factor scores of the first principal component (PC_1) as inputs for k-means cluster analysis. PCA2 was similar to PCA1; however, variables with low correlations with other variables and low variance were excluded resulting in 12 variables for Kamarkhola and 11 for Mithakhali. In PCA3, all 17 variables were used like PCA1; but varimax rotation was applied on the components extracted, which were then combined into a single component using the percentage of variance accounted for as their weights. This single component, which was a weighted average of the five components with eigenvalues >1, was then used as input for k-means cluster analysis (refer to section 4.2.3 below).

By carrying out these different iterations for FSA and PCA and comparing them with the results from PWR, this chapter contributes to better methodological understanding of multi-dimensional poverty assessment and classifies households into different poverty groups for the subsequent chapters. The chapter, thus, addresses the first objective of this PhD research, which is *"To compare different methods of multi-dimensional poverty assessment and disaggregate the households within the selected communities into different poverty levels"*. The research questions under this objective are:

1. What are the strengths and limitations of the three widely used methods of multi-dimensional poverty assessment at micro level – participatory wealth ranking, principal component analysis and fuzzy set analysis?
2. What are the different decisions that need to be taken at various sub-stages of the two quantitative methods - principal component analysis and fuzzy set analysis - and how do these affect the overall results?

3. How many poverty groups can be identified in the study communities and what percentages of households belong to each group? How do households of different poverty groups compare in terms of their asset ownership within each community and between the two study communities?

4.2 Methods

4.2.1 Participatory wealth ranking (PWR)

The PWR exercise (refer to section 3.4.2 for detail) comprised of two stages, one of which was conducted before the household survey and the other after. The first step involved categorising the households within each community into different wealth classes and identifying the core characteristics that differentiate one class from another. In each village, this first step involved a group of 3-4 key informants, such as school teachers, local political party members and mosque leaders. In both study villages, the key informants came up with a five-part categorisation (i.e. rich, upper middle, lower middle, poor, and extreme poor) and used certain common criteria, such as area of agricultural land owned, housing materials, livelihood strategies, education level of adults and children, food security and relative balance between income and expenditure, to characterise each of the wealth classes. They were then asked to give a rough estimate for the percentage of households within each class. During the second step, the names of the heads of the 150 households that were randomly selected for the household questionnaire survey (refer to section 3.4.3) were listed down in alphabetical order. This list was then presented before the same group of people who participated in the first step of the PWR exercise. The respondents were then asked to assign one of the five wealth classes to each of the 150 households.

4.2.2 Fuzzy set analysis (FSA)

Indicator selection

For poverty assessment using FSA, as well as PCA, a total of 17 indicators under seven dimensions were finally included. Data for the indicators were collected using the household questionnaire survey (refer to section 3.4.3 for details). The selection of indicators for these quantitative analyses was based on the following criteria.

Firstly, the indicators should closely adhere to those widely used by the international community, such as the Oxford Poverty and Human Development Initiative (OPHI)'s Multidimensional Poverty Index (MPI) (Alkire and Santos, 2014) and the International Fund

for Agricultural Development (IFAD)'s Multi-dimensional Poverty Assessment tool (MPAT) (Cohen, 2009). The MPI is composed of ten indicators corresponding to three dimensions of the Human Development Index: Education (years of schooling, school attendance), Health (nutrition, child mortality) and Standard of Living (cooking fuel, sanitation, water, electricity, floor, assets) and was applied in 104 countries in 2010 to track the progress of the Millennium Development Goals and design policies to address the overlapping deprivations experienced by the poor (Alkire and Santos, 2010). The MPAT uses household and village level surveys to collect data, which are then valued and organised by indicators. This tool is categorised into six fundamental components (food, water, health, sanitation, housing, energy and education) and four components under assets, exposure and equality (farm assets, non-farm assets, exposure to shocks and gender/social equality), which are, in turn, represented by 3-4 indicators (Cohen, 2009). Inspired by these indices, the questionnaire used in this study consisted of 24 indicators under ten dimensions: education, housing, consumptive assets, productive assets, agricultural land, homestead land and pond, livestock, water and sanitation, energy sources and nutrition. However, the last three dimensions were later excluded for reasons outlined below.

Secondly, the indicators should be relevant to the local context and the study objectives. Greater emphasis was given to indicators related to livelihood generation (i.e. land, pond, productive assets, livestock), as the study focuses on livelihood vulnerability and adaptation in relation to wealth class. It was also ensured that the categories within each indicator were context specific; for instance, as the study villages were dependent on shrimp aquaculture or rice cultivation, productive assets comprised of fishing nets, ploughs axes, shovels and hammers.

Thirdly, due to limitations of time, budget and manpower in this PhD research, the data collection process should not be too time consuming or aim for excess details. For instance, for nutrition, the respondents were simply asked about their degree of food sufficiency and frequency of protein intake. However, large-scale studies, such as the Bangladesh Integrated Household Survey (BIHS) 2011-12 (Ahmed, 2013a), included detailed questions on the households amount of intake of different types of big fish, small fish, meat, eggs, milk and rice during a week.

Finally, following data collection, it was checked whether the variation in responses to indicators reflected differences in wealth category or were simply based on local resource availability irrespective of class. For instance, although four different sources of domestic and drinking water were identified, the sources did not depend on the household's wealth

status; rather they were based on the infrastructural development within the area. In Kamarkhola, due to increased support from NGOs, a number of pond sand filters (PSFs) have been constructed beside community ponds. Hence, all households irrespective of class used water from PSFs if they resided within reasonable distance, otherwise, they depended on untreated pond or river water. For drinking purposes, almost all households used rainwater during the wet season. Similarly, in Mithakhali, regardless of class, households in one area had electricity connection, while others were dependent on solar power. This is supported by Johnston and Abreu (2013), who pointed out that goods and services that are provided communally or that depend on the location should be excluded from asset index calculations as they are not reflective of private wealth. Moreover, the responses to the questions on nutrition were not always related to class. For instance, as half of the residents in Kamarkhola were Hindu, they were vegetarians by choice and did not consume any animal protein. In terms of food adequacy, 87% of the households in Mithakhali answered that they were able to afford three meals a day. This was probably because food was always the first priority and even if the poorer households could not afford other assets, they ensured they had enough food, although the quality of items might differ. Thus, the nutrition dimension would also not have been able to distinguish between wealth classes. Hence, the three dimensions, that is, water and sanitation, energy sources and nutrition, were excluded from subsequent calculations, leaving a total of 17 indicators under seven dimensions.

Calibration of indicators

As mentioned in section 4.1, three iterations of FSA were carried out to demonstrate the effects of different methods of calibrating the variables, aggregating them into dimensions/ overall poverty index, and disaggregating households into distinct wealth classes based on their membership scores (Table 4.1).

Table 4.1 Methodological steps of poverty assessment using fuzzy set analysis

Step	FSA1	FSA2	FSA3
Type of calibration	Frequency based	Quadratic sigmoid	Frequency based
Type of aggregation	Weighted average of indicators into individual dimensions	Weighted average of indicators into individual dimensions	Weighted average of indicators into individual dimensions + weighted average of all dimensions
Determination of wealth classes	Count no. of dimensions deprived	Count no. of dimensions deprived	k-means cluster analysis

In FSA1 and FSA3, the 17 variables were calibrated using Cheli and Lemmi (1995)'s frequency based method with the following formula

$$\mu(x) = \begin{cases} 1 & \text{if } x = x^1;\ k = 1 \\ 1 - \dfrac{F(x^k) - f(x^1)}{1 - f(x^1)} & \text{if } x = x^k;\ k > 1 \\ 0 & \text{if } x = x^K;\ k = K \end{cases}$$

where, $\mu(x)$ is the membership score for each household; $F(x)$ is the cumulative function for variable x; $f(x^1)$ is the frequency associated with the minimum value for the variable x; k is the value taken by the variable x [k=1 means x_{min}, 1<k<K means $x_{min} \leq x \leq x_{max}$, k = K means $x = x_{max}$]. This calibration method is entirely based on empirical evidence and depends on the distribution of achievements of a given variable within a community.

In FSA2, calibration was done using the quadratic sigmoid function, with the following formulae

$$\mu(x) = \begin{cases} 1 & \text{if } x \leq \alpha \\ 1 - \tfrac{1}{2}[(\alpha - x)/(\alpha - \beta)]^2 & \text{if } \alpha \leq x < \beta \\ \tfrac{1}{2}[(\gamma - x)/(\beta - \gamma)]^2 & \text{if } \beta \leq x < \gamma \\ 0 & \text{if } x \geq \gamma \end{cases}$$

where α, β and γ are three break-points in the membership function determined by the researcher's judgement for each variable under a given context. The quadratic function calibrates a variable in such a way that as a household's level of achievement in a given variable decreases, it more than proportionately belongs to the poverty set and below a given point α, it gains full membership of 1. However, unlike the frequency based method, it is not sensitive to what other households in the community have achieved with respect to that variable. In this study, for each variable, the value of α corresponded to the level of achievement reached by at least 5% of the households, while β and γ corresponded to 50% and 95% of achievement levels respectively. This rule was inspired by Ragin (2006)'s direct method, whereby the researcher specifies the values of a variable that correspond to three qualitative anchors that structure a fuzzy set: the threshold for full membership (fuzzy score = 0.95), the threshold for full non-membership (fuzzy score = 0.05), and the cross-over point (fuzzy score = 0.5). Table A.1 in Appendix A shows how these formulae were applied to calibrate the variables, using the example of agricultural land ownership in Kamarkhola. As shown in Table A.1, for agricultural land ownership in Kamarkhola, α = 0, β = 100 and γ = 1000. Since these values are based on the frequency distribution of land among the sample households, they were different in case of Mithakhali.

Aggregation of indicators and assigning weightage

In FSA1 and FSA2, the variables were weighed using the Cheli and Lemmi (1995)'s frequency based weighing formula,

$$w = \ln [(1/n).\sum \mu (x)]$$

where, *w* is the weight of the variable; n is the total number of households and μ (x) is the membership score for each household for that variable. To aggregate the calibrated variables, the weighted average of the indicators under each dimension was calculated to obtain the membership scores of each of the seven dimensions. The seven dimensions were not aggregated further. For example,

> Score for housing material dimension for household n = [(weight of wall material * score for wall material) + [(weight of roof material * score for roof material) + [(weight of floor material * score for floor material) + [(weight of no. of rooms * score for no. of rooms)] / [weight of wall material + weight of roof material + weight of floor material + weight of no. of rooms]

In FSA3, the seven dimensions were further aggregated into one poverty index, using weights determined by the researcher's knowledge of the local context. Agricultural land, homestead land and pond, and housing materials were given a weightage of 3, consumptive assets and education were assigned a weightage of 3 and productive assets and livestock had a weightage of 1. These weightages ensured that the dimensions which were most relevant in poverty determination (as identified during the PWR) were given the highest weightage. Hence,

> Final poverty score = [(score for housing material dimension* 3) + (score for agricultural land dimension * 3) + (score for homestead land and pond dimension * 3) + (score for consumptive assets dimension * 2) + (score for education dimension * 2) + (score for productive assets dimension * 1) + (score for livestock dimension * 1)]/15

Determination of wealth classes

Following calibration and aggregation, the final step in the analysis involved categorising the households into different wealth classes based on the poverty membership scores obtained from the above equation. This step was challenging as the purpose of FSA is to present multi-dimensional poverty as a gradation of membership scores rather than defining clear-cut boundaries between different classes. In previous studies, researchers have either calculated the number of households deprived on a given number of dimensions (e.g. Neff, 2013) or defined cut-off points between the poor and non-poor using questionnaire responses (e.g. Qizilbash and Clark, 2005). However, in this study, in order to compare the

results with PWR and PCA, it was necessary to disaggregate the membership scores into five wealth classes, rather than just poor and non-poor.

In the case of FSA1 and FSA2, the number of dimensions in which each household was deprived (that is, having scores >0.50) were found. In Kamarkhola, households that were deprived in 6 or more dimensions were categorised as extreme poor, and subsequently, those deprived in 4-5, 2-3, one and zero dimensions were labelled as poor, lower middle, upper middle and rich respectively. In case of Mithakhali, households that were deprived in 5 or more dimensions were categorised as extreme poor, and subsequently, those deprived in 3-4, two, one and zero dimensions were labelled as poor, lower middle, upper middle and rich respectively. The number of dimensions in which households were deprived and the wealth class assigned was different for the two communities due to contextual factors. For instance, in Mithakhali, almost all households regardless of class, were deprived on the livestock dimension as the village depended on aquaculture that precluded other subsistence based livelihood options. In FSA3, a k-means cluster analysis was carried out using the final poverty score as input. Thus, the effects of different types of disaggregation methods could be analysed.

4.2.3 Principal component analysis (PCA)

PCA reduces a large number of variables into a smaller number of factors/principal components - the salient unobserved variables capturing important aspects of the complete set (Mooi and Sarstedt, 2011). Each of these factors is a linear weighted combination of the initial variables; the first principal component (PC_1) accounts for the highest proportion of variance in the data-set and is uncorrelated to the other principal components (Mooi and Sarstedt, 2011). Mathematically, for n number of variables,

$$PC_1 = w_1X_1 + w_2X_2 + w_3X_3 + \ldots + w_nX_n$$

$$PC_m = w_{m1}X_1 + w_{m2}X_2 + w_{m3}X_3 + \ldots + w_{mn}X_n$$

where w_{mn} is the weight assigned to the variable X_n in the m^{th} principal component.

As mentioned in section 4.1, three iterations of PCA were carried out to demonstrate the effects of variable selection, type of rotation, and method of cluster analysis on wealth stratification (Table 4.2). The selection of appropriate variables was the first and most important step in PCA. While theoretical or contextual understanding may entail the selection of many variables, certain variables need to be excluded for technical considerations. As the method relies on the correlations between sets of variables,

correlations between individual variables should be greater than absolute 0.30 for the analysis to produce meaningful results (Mooi and Sarstedt, 2011). It is not problematic if single correlations are less; however, when all correlations tend to be around zero, the method stops being useful. The Kaiser-Meyer-Olkin (KMO) statistic, also called the measure of sampling adequacy, indicates whether the correlations between variables can be explained by other variables in the dataset and KMO values greater than 0.70 are usually considered as appropriate (Mooi and Sarstedt, 2011).

Table 4.2 Methodological steps of poverty assessment using principal component analysis

	PCA1	PCA2	PCA3
Number of indicators used	17	12 (Kamarkhola); 11 (Mithakhali)	17
Type of rotation	None	None	Varimax
Type of cluster analysis	k-means using PC_1 factor scores	k-means using PC_1 factor scores	k-means using weighted average of all five components

Variables which have close to zero variance (for example, in Mithakhali motorcycles and radio/CD player had variances of 0.068 and 0.39 respectively) will have no role in differentiating between poverty levels and hence, should not be included. Similarly, assets that are owned/ not owned by a major proportion of households (for example, 80% households in Mithakhali did not have cows/buffalos and 75% did not have goats/sheep) can lead to clumping and hence, should be avoided (McKenzie, 2005). Moreover, it should be noted that variables which show a high degree of variance across households will generate the highest weights or factor loadings[1] in PCA. Thus, the key is to include variables that capture inequality between households. To address these issues, it is best to examine the descriptive statistics of each variable and their correlations prior to their inclusion in the PCA. The descriptive statistics (minimum, maximum, mean and variance) of the 17 variables selected for this study and the correlations between them are shown in Tables A.2, A.3 and A.4 of Appendix A. To demonstrate the effect of variable selection on PCA results, two PCAs were carried out for each community – one using all 17 indicators (PCA1) and another excluding those indicators that did not match the above criteria (PCA2) – keeping all other

[1] The factor loading of each variable on a given component shows the correlation between it and the component; hence, it takes values between -1 and +1.

subsequent steps similar. In PCA2, five indicators (radio, goats, nets, ponds, and education) and six indicators (TV, radio, nets, tools, cows, and goats) were excluded for Kamarkhola and Mithakhali, respectively for having very low variances or very low correlations with indicators.

The factor loadings of each component and hence, the factor scores[2] for each household are highly sensitive to the variables included and the number of components extracted (Coste *et al.*, 2005). If a smaller number of components are extracted, the PCA will account for less variation; consequently, if the number of components is equal to the number of variables, the cumulative variance will be 100%. However, as the main aim of PCA is to reduce the number of variables, the usual norm is to extract all components with eigenvalues[3] >1. The effect of the number of components extracted was not demonstrated in this study; hence, in all the PCAs conducted, the usual rule of thumb of extracting all factors with eigenvalues >1 was used.

In PCA, factor rotation is often carried out to facilitate interpretation of the components extracted. Using the highest absolute factor loadings of each variable, it is possible to 'assign' each variable to a certain component and then label each component such that it represents a group of associated variables. If no rotation is carried out, it implies that all variables are assigned to the first principal component (PC_1) (Mooi and Sarstedt, 2011). Rotation is often not necessary in poverty analysis, if only the factor scores on PC_1 are used for subsequent analysis (see below). If any form of rotation is used, it is wise to include all components in subsequent analysis, as each component will represent a certain group of correlated variables. In this study to test the effect of rotation, a third PCA (PCA3) was carried out using 'varimax' orthogonal rotation. The varimax procedure aims to maximise the dispersion of factor loadings within components (Mooi and Sarstedt, 2011).

[2] The factor score for each unit of analysis is calculated using the factor loading of each variable in conjunction with the original variable values for that unit of analysis.

[3] Eigenvalues describe how much variance is accounted for by a certain factor. For example, if there are 10 variables and if the eigenvalue for the first principal component (PC_1) is 2.20, it means that PC_1 covers information of 2.20 variables and hence, accounts for (2.20/10)*100 = 22% of the variance. For a given principal component, eigenvalue is the summation of the squared factor loadings for all variables.

The next step is disaggregating households according to their poverty level. In most studies, the first principal component (PC_1) factor scores for each household are treated as the overall poverty index. A higher score refers to a greater wealth status. In this study, a k-means cluster analysis using five groups was carried out to disaggregate households into five wealth categories. K-means clustering segments the data in such a way that the within-cluster variation is minimised (Mooi and Sarstedt, 2011). Again, to show the effect of rotation and the disaggregation method on the final results, two methods were used – one where a k-means cluster analysis was carried out using the unrotated PC_1 factor scores (PCA1), and the other where the varimax rotated components extracted were first combined using their eigenvalues as their weights and then a k-means cluster analysis was carried out on the combined component (PCA3). The validity of the results of all three PCAs carried out in each site was checked using two methods: firstly, the wealth ranks obtained from the PCAs and cluster analysis were correlated with those obtained from PWR and FSA; and secondly, the mean asset ownership of each wealth class was calculated and checked for internal coherence (that is, whether or not the ownership of assets increased with wealth status).

4.3 Results

4.3.1 Participatory Wealth Ranking (PWR)

The results from the first step of PWR exercise are outlined in Table 4.3. In both sites, the respondents used ownership of land as the most important factor for distinguishing households of different wealth classes. As both villages are predominantly farming communities, involved in agriculture or aquaculture, land was the most productive asset that generated other forms of capital and activities. Once the range of land ownership for each class was decided, the respondents provided a rough estimate of the numbers of households in each category and described some key characteristics, such as occupation, housing quality, income/savings and food sufficiency, for each category. While some factors such as amount of land and main occupations pursued by households differed between the two communities, other characteristics were very similar, as is the case for rural Bangladesh.

Table 4.3 Characteristics used for wealth stratification using participatory wealth ranking

Wealth category	Characteristics outlined by respondents (Total no. of households = 600 in each village)	
	Kamarkhola	**Mithakhali**
Rich	• Approx. 10 – 15 households • Owns >8.25 acres of agricultural land (About 5 having >50 acres) • Previously owned large shrimp farms; now mainly leased out land to sharecroppers; some engaged in service sector • Mainly inherited property	• Approx. 15 – 20 households • Owns >13.2 acres of agricultural land (About 5 having >66 acres while rest having 25 – 45 acres) • Owners of large shrimp farms, often including land leased in from smaller farmers; also engaged in aquaculture related businesses • Some are rich for generations, while others have purchased land in last three decades
	• Some reside outside the village in nearby towns or cities • Children pursuing tertiary education in cities • Usually have brick houses, motorcycles, TV and good furniture • Union council leader or village chairman are usually from this class • Have good amount of savings, may take loans from banks for investments • Never face food shortage	
Upper middle	• Approx. 50 households • Owns between 3.3 and 8.25 acres of agricultural land • Engaged in crop cultivation, as well as moderate scale Galda prawn/ white fish farming.	• Approx. 30 – 40 households • Owns between 6.6 and 13.2 acres of agricultural land • Owners of medium shrimp farms, either independently or with land leased in from others; some involved in service sector
	• Durable housing with brick/mud walls and floors and tin roofs • Children pursuing tertiary education outside village • Have moderate amount of savings • Never face food shortage	
Lower middle	• Around 200 – 250 households • Owns between 1 and 3.3 acres of agricultural land • Engaged in crop cultivation, as well as small scale Galda prawn/ white fish farming; some involved in small businesses/service sector	• Around 200 – 250 households • Owns between 2 and 6.6 acres of agricultural land • Owners of small shrimp farms, either independently or under co-operative system; some involved in small businesses
	• *Kacha* houses with mud floors, mud/bamboo walls and tin/straw roofs • Have sufficiency of rice, but can afford protein only few times a week • Income same as expenditures; hence, no savings	
Poor	• Around 150 – 200 households • Owns < 1 acre of agricultural land • Engaged in crop cultivation and wage labouring.	• Around 200 households • Owns <2 acres of agricultural land • Mainly lease out land or engage in co-operative farming; many engaged in petty trades and/or wage labouring
	• *Kacha* houses with mud floors, mud/bamboo walls and leaf/straw roofs • Can afford two meals a day, with occasional protein intake • Income usually not enough to meet household expenses; often have loans from NGOs	

Extreme Poor	• Around 100 – 150 households • Do not have any agricultural land, many residing on the embankment • Mainly dependent on wage labouring; some engaged in sharecropping.	• Around 100 households • Do not have any agricultural land • Mainly dependent on wage labouring/petty trades
	• Poor housing with mud floors and walls/roofs made of palm leaves/straw • Always face food shortage, hardly can afford protein items • Income not enough to meet household expenses; often have loans from NGOs	

The results from the second step of the PWR are shown in Table 4.4 below and graphically presented in Figures 4.3 and 4.4 in section 4.4.1 in comparison with the results from FSA and PCA. In order to validate the results from PWR, data from the household survey were used to check whether the ownership of key assets showed internal coherence, that is, whether mean asset ownership increased with wealth class. In both the villages, the mean ownership of all key assets, except for no. of radios and no. of goats/sheep, showed an increasing trend with rising wealth status. This is understandable as richer households usually had TVs instead of radios and preferred to rear cows rather than goats. In Mithakhali, there was a slight dip in the mean values for rooms, furniture, cows and pond as we moved from poor to lower middle class, although the difference was negligible. These results showed that the wealth statistics generated from the participatory process were valid and closely adhere to the criteria initially outlined in Table 4.3. In order to confirm the validity further, the PWR results were correlated with those from FSA and PCA, described below (refer to Tables 4.5 and 4.7).

Table 4.4. Results of poverty assessment using participatory wealth ranking

Wealth Class	Kamarkhola (Total – 150)	Mithakhali (Total – 150)
Rich	10 (6.7%)	8 (5.3%)
Upper middle	11 (4.3%)	17 (12%)
Lower middle	58 (38.7%)	51 (34%)
Poor	40 (26.7%)	49 (32.7%)
Extreme poor	31 (20.7%)	25 (16.7%)

4.3.2 Fuzzy set analysis (FSA)

Three different FSAs were carried out in each site to test for the effects of the type of calibration function, the method of aggregation, and the way of separating households into different poverty groups. As shown in Table 4.5, FSA3 yielded the highest correlations with other methods; hence, it was chosen for further elaboration in the paragraphs below.

Table 4.5 Results of poverty assessment using fuzzy set analysis

Site	Kamarkhola			Mithakhali		
	FSA1	FSA2	FSA3	FSA1	FSA2	FSA3
Percentage of households in each wealth category						
Rich	13	16	21	3	11	16
Upper middle	16	17	25	10	13	28
Lower middle	38	39	47	38	36	49
Poor	55	42	44	59	46	40
Extreme poor	25	36	13	40	44	17
Checking for correlations with other methods						
PWR	0.689	0.703	0.848	0.743	0.756	0.789
PCA1	0.791	0.778	0.847	0.713	0.763	0.804

The process of calibrating the indicators into fuzzy membership scores, as done in FSA3, is illustrated in Table A.1 (Appendix A) using 'agricultural land' in Kamarkhola as an example. For each of the indicators (whether scale or ordinal), the first category (that is, 0 decimals of land in this example) was given a score of 1.00 (highest deprivation) and the last category (that is, 2310 decimals of land) was assigned a score of 0.00 (not deprived). The remaining categories were assigned scores between 0.00 and 1.00 depending on the frequency distribution of the indicator. One of the advantages of this calibration process was that it eliminated irrelevant variations and cancelled the effect of outliers. In this example, although there were large differences in land ownership among the five households having greater than 1500 decimals of land, the calibration process minimised the difference by assigning scores between 0.04 and 0.00. Secondly, by observing which category corresponded to a score of 0.50, the researcher could find out the contextually meaningful median value. In this example, households having less than 200 decimals could be considered to be deprived.

Table 4.6 shows the weightage assigned to each of the indicators and the dimensions in both sites in FSA3. The frequency based weightage formula given in section 4.2.2 put greater weightage on indicators for which lower numbers of households are deprived. For example, in case of agricultural land ownership, 61.3% households in Kamarkhola and 50.7% households in Mithakhali had scores greater than 0.50 (that is, deprived); hence, the latter had a greater weightage than the former. This system also ensured that assets, such as motorcycles, radios and goats/sheep, which were owned by only a few households in the community and assets, such as floor material, which had a very low variance, got low weightages. Moreover, the method took contextual differences into account. In Mithakhali, where 80% of the households did not own any cows/buffalo due to a lack of fodder, cows/buffalos got a low weightage of 0.13, whereas in Kamarkhola, where people had

started to rear livestock after shifting to a crop-based livelihood system, cows/buffalos got a weightage of 0.47.

Table 4.6 Weightage assigned to each of the 17 indicators in both study sites in FSA3

Dimensions	Variables	Kamarkhola	Mithakhali
Housing	Wall material	0.69	1.04
	Roof material	0.73	1.58
	Floor material	0.18	0.10
	No. of rooms	0.96	0.87
Consumptive assets	No. of furniture items	0.69	0.78
	No. of TV	0.45	0.58
	No. of Radio/CD player	0.14	0.04
	No. of mobile phones	0.96	1.02
	No. of motorcycles	0.08	0.08
Productive assets	No. of fishing nets	1.07	0.88
	No. of tools	0.81	0.80
Livestock	No. of cows/buffalos	0.47	0.13
	No. of goats/sheep	0.09	0.16
Agricultural land	Amount of agricultural land	0.49	0.65
Homestead Area	Amount of homestead land	0.68	0.74
	Area of pond	0.62	0.76
Education	Percentage of adult with SSC degree	0.49	0.39

4.3.3 Principal Component Analysis (PCA)

Three PCAs were carried out for each site to test for the effects of changes in the types of variables, factor rotation and clustering method. As shown in Table 4.7, PCA1, which included all 17 indicators and used a k-means cluster analysis using the PC_1 factor scores, showed the highest degree of correlation with other methods and also good internal coherence. PCA2, in which variables with low variance and correlations were excluded, also yielded good results with slightly lower correlations compared to PCA1. However, in PCA2, as the number of variables were reduced, only two components were adequate to account for a large percentage of the variance in the data, whereas other PCAs extracted five components with eigenvalues >1. The wealth categorisations obtained from PCA3 showed lowest correlations with other methods, with very few households assigned to the lower middle class in Kamarkhola, and a large number of households allocated to extreme poor class in Mithakhali. These results clearly demonstrate how slight variations in the sub-stages can lead to very different household classification, and in absence of other methods for triangulation, it would have been very difficult to decide which of the three PCAs yielded the most accurate context specific results. Based on this analysis, PCA1, which yielded the best results, was chosen for further elaboration in the paragraphs below.

Table 4.7 Results of poverty assessment using PCA

Site	Kamarkhola			Mithakhali		
	PCA1	**PCA2**	**PCA3**	**PCA1**	**PCA2**	**PCA3**
Sub-stages						
Number of factors with eigenvalue >1	5	2	5	5	3	5
Variance explained (%) by factors extracted	62.1	53.9	62.1	62.1	59.4	62.1
KMO measures of sampling adequacy	0.820	0.854	0.820	0.762	0.792	0.762
Number of households in each poverty group (n=150)						
Rich	3	6	8	1	1	2
Upper middle	13	10	12	5	13	5
Lower middle	38	36	18	36	52	36
Poor	61	66	67	71	58	50
Extreme poor	35	32	45	37	26	57
Checking for correlations with other methods						
PWR	0.747	0.744	0.669	0.660	0.662	0.585
FSA3	0.847	0.820	0.747	0.804	0.813	0.689
Checking for internal coherence						
Ownership of all assets increased with wealth class, except	TV, cows and goats	Phones, nets, tools, cows, goats	TV, radio, nets, tools, cows, goats	Radio, motorcycles, tools, goats, pond area	Radio, motorcycle, pond area, goats	Wall, floor, TV, radio, tools, goats

Table 4.8 shows the factor loadings of each variable on PC_1 for each site using PCA1; in other words, these values represent the weightage assigned to each variable while calculating the household wealth index (that is, the PC_1 factor scores of each household). It should be noted that as these numbers/factor loadings actually represent the correlations between each variable and PC_1, the weightages were always between -1 and +1, unlike those of FSA where weightages could range from 0 to $+\infty$. As shown, variables such as agricultural land, homestead land, furniture and no. of rooms got higher weightages as these variables showed greater correlation with other variables (see the correlation matrices in Tables A.3 and A.4 in Appendix A). Unlike FSA, where variables like goats and radio had very low weightages as most households didn't own them, in PCA these variables were assigned relatively higher weightages based on their correlations with other variables. For example, in the case of goats, the weightage was 0.36 in Mithakhali while in Kamarkhola it was -0.13, meaning that goat ownership was in fact related to increasing poverty. This was actually true, as shown by the asset ownership data in Tables 4.10 and 4.11; in Kamarkhola goat ownership decreased with increasing wealth while in Mithakhali it increased with wealth status.

Table 4.8 Weightage assigned to each of the 17 indicators in both study sites using PCA1

Dimensions	Variables	Kamarkhola	Mithakhali
Housing	Wall material	0.69	0.56
	Roof material	0.70	0.55
	Floor material	0.60	0.52
	No. of rooms	0.78	0.71
Consumptive assets	No. of furniture items	0.81	0.80
	No. of TV	0.40	0.40
	No. of Radio/CD player	0.26	0.24
	No. of mobile phones	0.59	0.66
	No. of motorcycles	0.56	0.42
Productive assets	No. of fishing nets	0.36	0.45
	No. of tools	0.54	0.32
Livestock	No. of cows/buffalos	0.54	0.32
	No. of goats/sheep	-0.13	0.36
Agricultural land	Amount of agricultural land	0.80	0.78
Homestead Area	Amount of homestead land	0.61	0.71
	Area of pond	0.26	0.39
Education	Percentage of adult with SSC degree	0.39	0.43

In PCA1, a k-means cluster analysis using the PC_1 factor scores was used to disaggregate the households into five poverty groups. Figures 4.1 and 4.2 show the distribution of the PC_1 factor scores in each study site, as well as how the households were clustered into five categories. As shown, the PC_1 factor scores (that is, the household wealth indices) had higher variation in the case of the rich and upper middle class, indicating that households within the three remaining classes, especially the poor, were quite homogenous with respect to asset ownership. It also showed that in Mithakhali there was comparatively greater inequality between the top and bottom classes that in Kamarkhola.

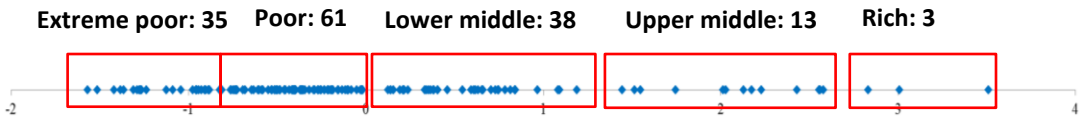


Figure 4.1. Distribution of factor scores of the first principal component and results of cluster analysis of PCA1 in Kamarkhola

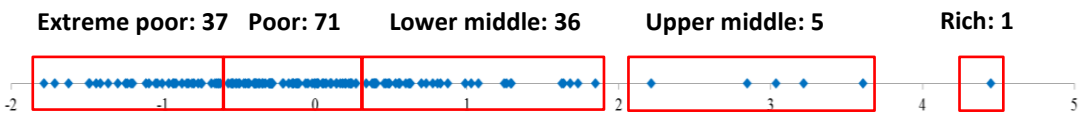


Figure 4.2 Distribution of factor scores of the first principal component and results of cluster analysis of PCA1 in Mithakhali

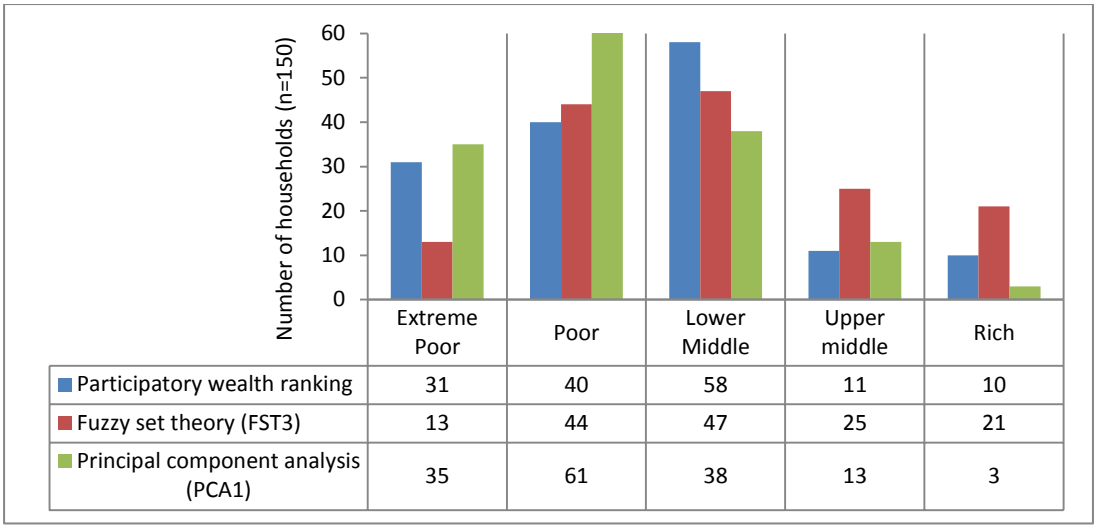
4.4 Discussion

Poverty is now widely recognised as a multi-dimensional concept; yet, methodological approaches for poverty assessment largely rely on quantitative measures of living standards, leaving out psychological, social and political aspects. This analytic preference arises from the difficulty in measuring subjective indicators, like isolation, violence, and mental peace, and combining them with objective indicators to form a single index. Wealth stratification often forms a baseline in studies related to global environmental change and researchers tend to follow established methods without questioning the impacts of methodological differences on wealth ranking methods. This chapter uses primary data from the two study villages in coastal Bangladesh to empirically demonstrate the methodological issues related to three widely used methods – participatory wealth ranking, principal component analysis and fuzzy set theory.

The chapter contributes to the academic literature on multi-dimensional poverty assessment in two ways. Firstly, it highlights that micro-level poverty assessment should not be restricted to separating the population into poor and non-poor. While such dichotomy may be appealing to policy makers seeking to achieve tangible outcomes, it is a simple, reductionist representation of reality. Identification of different wealth classes is important not only to understand how their livelihood adaption activities differ from each other, but also analyse the dynamic interactions between different wealth groups. Secondly, it not only compares methods with different theoretical basis, it also shows the effects of different decisions taken at various sub-stages within each method. It highlights the challenges of incorporating relevant variables that do not necessarily fit the underlying mathematical properties of each method. The following sub-sections discuss the strengths and limitations of the three methods, by assessing the extent to which the results vary depending on the method of analysis.

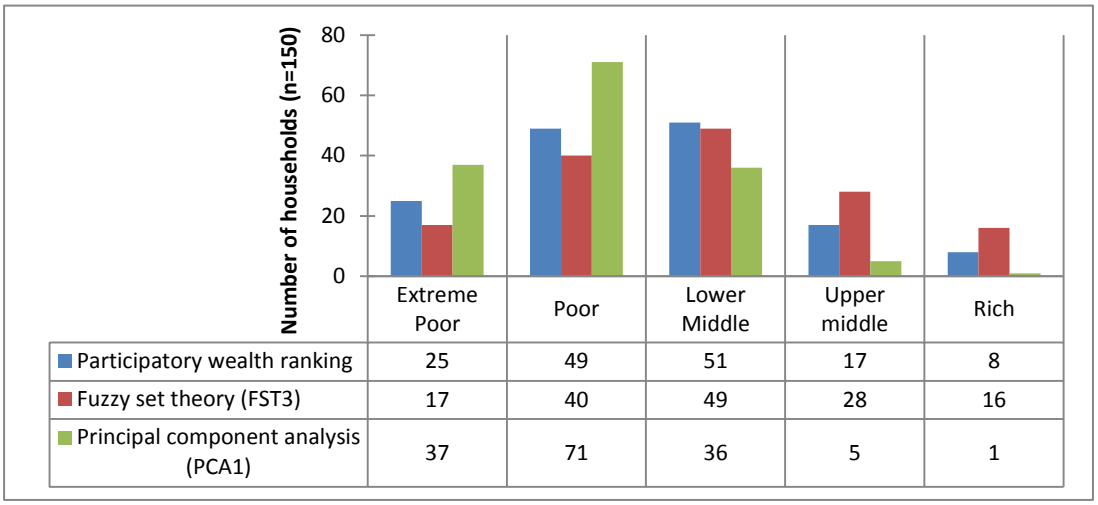
4.4.1 Methodological strengths and limitations

Figures 4.3 and 4.4 present the results of micro level poverty analysis in the two study sites using the three different methods. Table 4.9 summarises and compares the three methods, highlighting the technical considerations, strengths and weaknesses of each.



	Extreme Poor	Poor	Lower Middle	Upper middle	Rich
Participatory wealth ranking	31	40	58	11	10
Fuzzy set theory (FST3)	13	44	47	25	21
Principal component analysis (PCA1)	35	61	38	13	3

Figure 4.3 Number of households in each poverty group in Kamarkhola based on results from participatory wealth ranking, fuzzy set analysis and principal component analysis



	Extreme Poor	Poor	Lower Middle	Upper middle	Rich
Participatory wealth ranking	25	49	51	17	8
Fuzzy set theory (FST3)	17	40	49	28	16
Principal component analysis (PCA1)	37	71	36	5	1

Figure 4.4 Number of households in each poverty group in Mithakhali based on results from participatory wealth ranking, fuzzy set analysis and principal component analysis

Table 4.9 Comparison of multi-dimensional poverty assessment using participatory wealth ranking, fuzzy set analysis and principal component analysis

	Participatory wealth ranking	Fuzzy set analysis	Principal component analysis and cluster analysis
Theoretical basis	Based on local perceptions of wealth and contextually relevant dimensions of poverty	Based on set theory	Form of multivariate statistical analysis
	Group of respondents with good local knowledge are asked to describe the characteristics of different wealth classes and categorise households into each class.	It is a continuous set, ranging from 0 to 1, that is calibrated to indicate the degree of membership of each case in a given set (0 indicates non-membership, 1 indicates full membership)	It is a method of data reduction that relies on the correlation between a larger number of variables to construct a smaller number of latent variables (or components).
Technical considerations	Recruitment of suitable participants and the facilitation process needs to be done carefully to ensure valid results.	Each variable can be individually calibrated using different membership functions and is not linked to others.	Variables which have same values for most cases (low variance) or do not exhibit certain degree of correlation with any other variable may need to be omitted.
	Subjectivity bias can be eliminated if the process is repeated with different groups of participants in the same community.	Qualitative anchors can be used to identify key breakpoints on variables, thus, ensuring correspondence between theoretical concepts and measurement of set membership.	Care must be taken while including/excluding variables, deciding on the number of factors to be extracted, coding ordinal variables and choosing the clustering method, as slight changes may significantly affect results.
	Any number or type of variables can be considered; variables may be ranked in order of importance.	Variables can be aggregated into a single value using logical operators, weighted averages or counting deprivations.	Variables are automatically aggregated into principal components, based on weightage that are entirely data-driven.

	Participatory wealth ranking	Fuzzy set analysis	Principal component analysis and cluster analysis
Strengths	Data are more contextually relevant and information about a range of unquantifiable factors, such as historical changes in poverty levels, socio-political status and support network, can be obtained. Faster and cheaper method, especially suitable for small scale in-depth studies.	Provides flexibility; researcher can calibrate and aggregate variables based on theoretical or contextual understanding. Impact of irrelevant variation within a variable can be reduced. Variables do not need to be correlated with each other; inclusion/exclusion of one variable does not affect another. Wealth indices are generated for individual households which allow differentiation of households within a given wealth class.	Eliminates redundant variables with minimal data loss, by combining homogeneous variables into one component. Can identify the number of dimensions in the data, based on the component on which each variable has the highest weightage. Wealth indices are generated for individual households which allow differentiation of households within a given wealth class.
Limitations	Wealth classification is done based on subjective judgments which can vary according to the respondents chosen. Does not generate accurate data on asset ownership of each household. Households within each category are not differentiated further, unless more complex methods for generating wealth indices are used. Difficult for large scale studies, as comparison and generalisation across sites may involve complex procedures.	Difficult to define cut-off lines between different wealth groups and decide on the number of classes. There is a tendency to normalise the data (i.e. households tend to be symmetrically distributed on either side of the median class).	Depends on correlation between variables and tried to maximise the variance accounted by each component; this may not be theoretically correct. Weightage is based on a variable's variance and correlation with others; might lead to lower weightage on theoretically/contextually relevant variables and higher weightage for scale variables compared to ordinal ones.

Compared to the quantitative methods (FSA and PCA) based on household questionnaire survey data, PWR had a number of advantages. Firstly, the PWR exercise was essential in determining the number of wealth categories in the two villages and the five-part classification obtained from PWR provided the basis for all subsequent analysis using FSA and PCA. Hierarchical cluster analysis based on asset data from household surveys could have given an idea of the number of wealth classes; however, it would have been very difficult to confidently reach a decision. Secondly, PWR identified the key assets that distinguished between households of different poverty levels. Similar to the findings of this study, Martin and Lorenzen (2016) found that agricultural land ownership was the most important determinant of wealth status in rural southern Laos. This is in contrast to Rigg (2006)'s argument of delinking land and poverty due to the rise in non-farm activities in rural areas. Thirdly, although certain general criteria were used to allocate households into different wealth categories, respondents also gave attention to specific factors that might differentiate a particular household from others in the same category. For example, some of the households in both sites did not possess much agricultural land or ponds and earned most of their income through non-farm activities such as service jobs or retails shops. PCA and FSA, which were both based on household asset data, allocated these households into relatively poorer categories, whereas in PWR the participants were able to identify their actual status.

Finally, a range of unquantifiable factors about a household's socio-political influence within the community and its historical changes in poverty were captured, which helped in properly ranking the households. For example, in Kamarkhola, most of the poor people had their houses rebuilt by the government or NGOs after cyclone Aila in 2009, ensuring that the houses can withstand flooding and high wind speeds in case of future events. Hence, the housing materials may be similar to those of better-off people in the area. Thus, FSA or PCA would allocate these households to relatively higher wealth ranks than PWR, whereas respondents knew the current wealth status. This was also observed by Martin and Lorenzen (2016), who mentioned that the PWR exercise included indicators that were important to the local definition of poverty but may not have been measured or may not be possible to measure.

One of the classic shortcomings of PWR was its reliance on the subjective judgment of respondents, which could be overcome by repeating the same exercise with different groups of respondents, as done by Van Campenhout (2007). Another weakness of the PWR method used in this study is that within each wealth group, the individual households were not

ranked as per their wealth status. This was done by Hargreaves *et al.* (2007b) who generated a quantitative wealth index for each household based on scoring of qualitative statements on well-being. However, these methods could not be done in this study due to limitations of resources. Moreover, it was not necessary, as the study objectives did not require the position of each household in relation to others.

As a poverty assessment method, FSA combined some of the strengths of both qualitative and quantitative approaches, and provided flexibility in determining the sub-stages. Although it was based on quantitative data, the researcher had scope to incorporate contextually meaningful issues. For instance, while calibration using the frequency-based approach was entirely data-driven, calibration using the quadratic sigmoid function allowed the researcher to specify breakpoints for each variable. As shown in Table A.1 in Appendix A, these two methods of calibration can significantly differ in the number of households being categorised as deprived (scores >0.5) in a given dimension. In the case of agricultural land in Kamarkhola, the frequency based method (FSA1) considered households with below 2 acres of agricultural land as deprived, while the quadratic method considered the deprivation cut-off point to be 1 acre. After calibration the researcher could decide on the method of combining the variables - whether to aggregate the variables first into dimensions and then aggregate the dimensions or to aggregate all variables at one time into a final poverty score. During aggregation, the researcher could decide whether to use logical operators like intersection or union, or use weightages using a given formula. For instance, in the case of FSA1 in this study, the variables were first combined into dimensions using a weighted average and then the households were disaggregated into different wealth classes based on the number of dimensions deprived. In the latter step, the wealth class corresponding to the number of dimensions deprived was slightly different for the two sites, to make the results more contextually relevant. In contrast, in FSA3, the dimensions were further aggregated into a single poverty score which was then used to disaggregate households into five wealth classes using k-means cluster analysis. Other advantages of FSA, in terms of elimination of irrelevant variation during calibration and assigning low weightages to variables that are not owned by most people, have been discussed in section 4.3.2.

However, FSA also has a number of weaknesses. For instance, in the study sites, although agricultural land was the most important asset distinguishing the better-off from the poor (as described by the PWR respondents), FSA assigned comparatively lower weightage to land than to other relatively less important assets such as tools, nets and no. of rooms. This was because more people were deprived in land compared to these other assets which had

lower variances. To overcome the effects of data-driven weights, FSA3 used context specific weightages assigned by the researcher (based on findings from PWR and FGDs), giving highest weightages to agricultural land, homestead land and pond and consumptive assets, which ultimately resulted in greater correlation with other methods. In the cases of FSA1 and FSA2, which used the counting methods (that is, disaggregating households based on the number of dimensions they are deprived), the depth of deprivation within each dimension was not accounted for. For example, a household which scored 0.55 on a given dimension was considered deprived in the same way as one that scored 0.95. As a result, there were some households which were statistically classified into the same category but differed in terms of their asset endowments in reality. Moreover, this method of disaggregation treated all dimensions equally, meaning that being deprived in land and being deprived in productive assets, such as tools and nets, were considered the same. These issues were overcome in FSA3, which calculated a weighted poverty index combining all dimensions. However, while FSA3 had higher correlations with other methods, it tended to normalise the distribution by allocating approximately equal numbers of households on both sides of the median class (refer to Figures 4.3 and 4.4). According to FSA3, there were higher numbers of rich households in the communities than extreme poor households, which was not the actual case. This tendency to normalise the distribution in one of the drawbacks of calculating an overall poverty index in FSA.

Finally, PCA is a totally data driven method in which there is limited scope for the researcher's conceptual inputs. PCA has a number of technical characteristics, which need to be handled with care to obtain meaningful results. As mentioned earlier, the choice of variables, the number of factors to be extracted, the factor rotation and the clustering method have significant impacts on the results. By eliminating variables with low correlations and low variances, as done in PCA2, a greater percentage of the variance could be accounted for by a lower number of variables. However, the weightages of each of the variables (that is, their factor loading on PC_1) changed, which ultimately led to different results. The difference was greater for Mithakhali than Kamarkhola in this study. Moreover, it intuitively makes less sense to eliminate a contextually important variable like pond ownership just because it does not show high correlations with other variables. As Johnston and Abreu (2013) highlighted, PCA does not measure which assets are actually important for household welfare, but rather looks at the underlying pattern of asset ownership across a sample of households; hence the characteristics of the data set is important in determining whether the asset indices generated are a good proxy of wealth. In PCA3, varimax rotation

was applied so that each of the components could be attributed to a certain set of variables and instead of relying on the first component only, the weighted average of all the components could be included in the cluster analysis. Compared to PCA2, which eliminated variables with low correlations and low variance, PCA3 included all variables; however, as these variables were loaded onto components 4 or 5 (owing to their low correlations), they received less weightage in the combined weighted component. Methodologically, PCA3 seems to make good sense; however, the results showed least correlation with other methods. This again highlights that solely relying on PCA, in absence of complementary methods for comparison, makes it difficult to interpret the poverty analysis results.

During the k-means cluster analysis, the number of clusters was set as 5 to allow comparison with PWR. Unlike PWR and the FSA method used in this study, cluster analysis removed the use of subjective judgment in disaggregating households into different classes. Households were grouped into wealth classes ensuring that the variation was minimised within a given wealth class. Another advantage was that PCA and cluster analysis showed how similar or different the households within each class were (refer to Figures 4.1 and 4.2). In this study, the results showed that there was more homogeneity in asset ownership within the lower middle class, poor and extreme poor households, while the within class variation was high in case of rich and upper middle class households. Martin and Lorenzen (2016), who used PCA to calculate the wealth index of households in rural Laos, also found that the variance in wealth index was highest amongst the rich class and lowest among the poor class. The same could be done with the final poverty score of FSA3, although the variation would be less marked as FSA scores were quite normally distributed.

The above discussion highlights that it is essential for researchers to be aware of the strengths and limitations of the different methods, especially the effects of choices made at various sub-stages on the final results. In micro-level poverty assessment, where the researcher has scope to get an in-depth understanding of the local context, it is recommended that a mixed methods approach is applied, involving both a participatory method and a quantitative method based on household survey data. Triangulation of results from two different sources provides a valid and robust classification of households. For instance, in this study, the PWR helped to decide the number of wealth categories in each village and understand which indicators were most contextually relevant in determining poverty level. It also served as a baseline for comparing the results of the various iterations of FSA and PCA and determining which one yielded the best results. On the other hand, FSA or PCA helped to overcome the subjectivity bias or human errors made by the respondents

during PWR, provided a quantitative index for each household and also showed the distribution of households in each of the categories. These benefits have also been highlighted by Martin and Lorenzen (2016) who used both PWR and PCA to disaggregate households by wealth class, in an attempt to find the association of livelihood diversification patterns and household poverty level.

The wealth categorisation conducted in this chapter served as the base for structuring livelihood, adaptation and well-being data in the subsequent chapters. The results from any of the three methods could be chosen for the subsequent chapters as they showed high levels of correlation with each other. Thus, the wealth classes obtained from PWR were initially chosen. However, to avoid any bias, for each household the wealth classes assigned by each of the three methods were checked individually; compared to PWR, if the class assigned by FSA or PCA differed by more than one class, the household's asset ownership was scrutinised and where necessary the rank was changed. For example, in Kamarkhola, compared to the PWR classes, 3 households (out of 150) and 6 households (out of 150) had a difference of two classes when categorised using FSA3 and PCA1 respectively. These households were re-checked and the classes assigned to 4 households were changed. The final number of households in each of the wealth classes are shown in Tables 4.9 and 4.10.

4.4.2 Comparison of asset ownership by wealth class

This comparison is based on the mean asset ownership of the different wealth classes in the two study villages, as shown in Tables 4.10 and 4.11. In both villages, the highest percentage of households belonged to the lower middle and poor classes, with very few households in the rich class. There was little difference in terms of housing materials between the two villages. The rich households usually had houses with brick/cement walls, floors and roofs, while those in the upper and lower middle classes had tin/corrugated iron walls and roofs. The poor and extreme poor households usually had mud floors, with walls and roofs made of leaves, straw or tin. Possession of consumptive assets, such as TVs, radios and motorcycles, was also similar in the two villages; however, ownership of furniture items and mobile phones seemed to higher for all wealth classes in Mithakhali, compared to Kamarkhola. Moreover, productive assets such as fishing nets were also higher in Mithakhali as the village was mainly dependent on aquaculture.

Households in the two villages differed in terms of ownership of agricultural land, homestead land, ponds, livestock and level of education. In Mithakhali, households of all wealth classes owned considerably more land and pond area than their counterparts in

Kamarkhola. Agricultural land ownership increased exponentially from the lowest to the highest wealth class, with the rich households possessing almost three times as much land as the upper middle class. This highlights the fact that a small percentage of households controlled a relatively large percentage of land, particularly in Mithakhali. Due to the paddy based livelihood system, households in Kamarkhola owned significantly more cattle than those in Mithakhali, where lack of fodder precluded livestock rearing. Goats were mainly reared by the poorer households and goat ownership did not show any trend across wealth classes in both villages. In Mithakhali, the mean goat ownership seemed to be high for the rich households; however, this was due to the fact that one of the 7 rich households specialised in a goat business (having 20 goats) which led to a high average value. Adult education level for all wealth classes in Kamarkhola was greater than that of Mithakhali. This was mainly due to the lack of primary and secondary schools in Mithakhali before the 2000s.

As reflected by the cluster analysis results in Figures 4.1 and 4.2, in both villages, the lower middle, poor and extreme poor classes were more homogenous in terms of asset ownership, while the rich and upper middle class households exhibited high degree of variation. Moreover, the PC_1 scores in Mithakhali showed a higher range (max 4.45 and min -1.78) than Kamarkhola (max 3.59 and min -1.56), indicating that there was greater inequity in asset distribution in Mithakhali. In sum, Mithakhali was a peri-urban community based on cash crop cultivation and households owned more consumptive assets compared to Kamarkhola which was a remote community dependent on subsistence based livelihoods. Although the rich households in Mithakhali were much wealthier than those in Kamarkhola, the poorer households were worse-off. Despite having comparatively higher land endowments, the cash crop based livelihood system, power imbalances in decision making, higher salinity and disease outbreaks, restricted the livelihood options and incomes of the poorer households in Mithakhali. These issues are discussed in detail in the following chapters.

Table 4.10 Mean ownership of assets by wealth class in Kamarkhola based on final poverty categorisation

Dimensions	Indicators	Extreme poor (n=30)	Poor (n=42)	Lower middle (n=56)	Upper middle (n=13)	Rich (n=9)
Housing	Wall material (1 = Leaves/straw/ cardboard/ plastic, 2 = Jute/bamboo, 3 = Mud or unfired brick, 4 = Tin/ corrugated iron, 5 = Concrete/ brick)	2.23	2.75	3.29	4.36	4.90
	Roof material (1 = Leaves/straw/ cardboard, 2 = Tin/ corrugated iron, 3 = Concrete/ brick)	1.53	1.58	1.84	2.36	3.00
	Floor material (1 = Mud or unfired brick, 2 = Wood, 3 = Concrete/ brick)	1.13	1.18	1.21	1.91	2.80
	No. of rooms	1.97	2.13	2.76	3.73	4.40
Consumptive assets	No. of furniture items	3.23	2.88	5.74	11.5	12.2
	No. of TV	0.13	0.33	0.41	0.45	0.80
	No. of Radio/CD player	0.10	0.08	0.16	0.09	0.40
	No. of mobile phones	1.10	1.35	1.74	2.64	2.30
	No. of motorcycles	0.00	0.00	0.07	0.18	0.50
Productive assets	No. of fishing nets	1.00	1.05	1.22	1.82	1.90
	No. of tools	2.94	2.55	3.64	5.64	4.50
Agricultural land	Amount of agricultural land (decimals*)	0.13	57.8	220	597	1554
Homestead area	Amount of homestead land (decimals)	6.87	11.48	22.69	43.55	65.50
	Area of pond (decimals)	7.74	4.53	11.7	21.5	23.8
Livestock	No. of cows/buffalos	0.74	1.40	2.26	4.82	4.30
	No. of goats/sheep	0.35	0.45	0.57	0.00	0.00
Education	Percentage of adult with SSC degree or above	15.8	35.0	46.1	63.6	60.0

***1 acre = 100 decimals**

Table 4.11 Mean ownership of assets by wealth class in Mithakhali based on final poverty categorisation

Dimensions	Indicators	Extreme poor (n=23)	Poor (n=50)	Lower middle (n=52)	Upper middle (n=18)	Rich (n=7)
Housing	Wall material (1 = Leaves/straw/ cardboard/ plastic, 2 = Jute/bamboo, 3 = Mud or unfired brick, 4 = Tin/ corrugated iron, 5 = Concrete/ brick)	3.04	3.38	3.50	3.89	4.29
	Roof material (1 = Leaves/straw/ cardboard, 2 = Tin/ corrugated iron, 3 = Concrete/ brick)	1.52	1.88	1.92	1.94	2.43
	Floor material (1 = Mud or unfired brick, 2 = Wood, 3 = Concrete/ brick)	1.04	1.12	1.15	1.33	2.14
	No. of rooms	3.04	3.94	3.73	4.33	6.14
Consumptive assets	No. of furniture items	7.52	9.78	9.58	12.6	18.1
	No. of TV	0.13	0.34	0.50	0.72	1.00
	No. of Radio/CD player	0.04	0.02	0.04	0.00	0.29
	No. of mobile phones	1.35	2.12	2.13	2.33	3.71
	No. of motorcycles	0.00	0.04	0.04	0.22	0.43
Productive assets	No. of fishing nets	1.13	2.08	2.37	4.44	6.14
	No. of tools	3.57	4.24	4.19	5.17	4.86
Agricultural land	Amount of agricultural land (decimals)	4.22	143	378	736	2253
Homestead area	Amount of homestead land (decimals)	5.48	28.9	32.5	65.9	149
	Area of pond (decimals)	3.30	10.7	9.8	13.7	42.9
Livestock	No. of cows/buffalos	0.00	0.76	0.31	1.00	1.86
	No. of goats/sheep	0.39	1.60	0.56	0.83	5.43
Education	Percentage of adult with SSC degree or above	8.39	20.1	26.4	29.3	46.7

4.5 Conclusion

This chapter compared the different methods of multi-dimensional poverty analysis and disaggregated the households in each site into five different wealth classes, thus, addressing the first objective of this PhD research. Micro-level poverty assessment in the two sites, using three different methods (that is, participatory wealth ranking, fuzzy set analysis and principal component analysis) highlighted the relative strengths and limitations of each method and the effect of the choices made at various sub-stages on the final poverty results. In the case of small-scale studies like this, PWR provides accurate and contextually relevant classification of wealth, and captures a number of unquantifiable factors that are often missed by other methods. However, to triangulate data and ensure validity, quantitative data from household questionnaire surveys are often necessary and methods such as FSA and PCA can be used to generate household wealth indices. These indices allow differentiation of households within each wealth class and also reveal the level of inequality between the classes. In this study, the final results from the three methods show good correlation, and it is recommended that use of a mixed methods approach, involving a participatory method and a quantitative method based on household survey can lead to the most valid results. In this study, the results of the PWR, modified slightly using FSA and PCA results, were selected as the baseline for structuring the data in the subsequent chapters.

Chapter 5. Combining resilience and political ecology to analyse the underlying drivers of socio-ecological change

Abstract

The compounding effects of aquaculture transitions and climatic shocks and stresses in coastal areas of Asia have brought about significant socio-ecological changes at community level and shaped their existing vulnerability contexts in different ways. A better understanding of the underlying causes of change requires integration of both social and ecological approaches that often have different epistemological origins. This chapter combines the system-oriented approach of resilience thinking and the actor-oriented focus of political ecology to investigate the underlying drivers of differential vulnerability contexts in the two villages studied in this research. It uses the wealth stratification of households from the previous chapter to structure data on perceptions on change, and sets the stage for investigating differential livelihood dynamics and well-being outcomes in the next chapter. The adaptive cycle, a heuristic model within the resilience literature, is first used from a system-oriented perspective to conceptualise the changes resulting from interactions between agro-ecological, socio-economic and political domains operating at various spatial scales. An actor-oriented approach, involving a political ecology perspective, is then adopted to analyse how different social actors with conflicting interests interact to navigate change in farming systems. The chapter finds that while inequities in resource ownership and power imbalances can favour the decisions of wealthier people, social resilience amongst poorer groups, achieved through memory, learning, leadership and crisis, can enable them to overcome pressures from powerful stakeholders. The integration of a political ecology perspective with resilience thinking helped to analyse the roles of power dynamics in determining whose desirable state was reached, and thus, address the ecological bias inherent in resilience thinking.

5.1 Introduction

Coastal communities in Asian deltas have experienced significant socio-ecological changes over the past few decades, particularly due to the rapid growth of the aquaculture industry and increased occurrence of natural shocks and stresses (Abdullah *et al.*, 2016, Orchard *et al.*, 2016, Pokrant, 2014). As highlighted in the literature review in chapter 2, understanding the underlying drivers of socio-ecological change or existing vulnerability contexts remains limited (Tucker *et al.*, 2015). Most studies within the climate change literature to date present a snapshot of the vulnerability context at a given time, with particular emphasis on the characteristics that determine households' sensitivities and capacities to respond to shocks and stresses (Tucker *et al.*, 2015, Olsson *et al.*, 2014, Miller *et al.*, 2010). In contrast, the extensive body of literature on aquaculture often provides descriptive narratives of change, farming practices and adverse impacts without engaging with any theoretical lens (e.g. Pokrant, 2014, Paul and Vogl, 2011, Chandra *et al.*, 2010). As argued by Bush and Marschke (2014) and Benessaiah and Sengupta (2014), making sense of aquaculture transitions calls for bridging epistemological divides and integrating social and ecological concepts to better understand change from both from a system and actor oriented perspective. A number of approaches, such as ecosystem services based approach, agrarian change, socio-technical transition or socio-ecological resilience, can facilitate a better conceptualisation of aquaculture transitions (Orchard *et al.*, 2016, Benessaiah and Sengupta, 2014, Bush and Marschke, 2014). This chapter integrates insights from system-oriented resilience thinking and actor-oriented political ecology to investigate socio-ecological change in climate sensitive, aquaculture dependent communities, using empirical evidence from the two study villages representing different vulnerability contexts. The chapter, thus, addresses the second objective of this PhD research, which is *"To investigate the underlying drivers of socio-ecological change in the two study communities"*. The research questions under this objective are:

1. What were the key changes at various spatial scales that led to differential socio-ecological change in the two communities?
2. How did power dynamics and differences in farmers' perceptions influence the changes in vulnerability contexts?

The following paragraphs briefly summarise the literature review on resilience and political ecology (refer to sections 2.3 and 2.4 for details) and how this conceptual convergence can enable a holistic in-depth understanding of change.

Originating from the ecological science, resilience thinking embraces change as an inevitable feature of a system and places emphasis on maintaining its character by absorbing the disturbance or transforming to a new regime when conditions become undesirable (Folke, 2006, Walker *et al.*, 2004). Within this domain, the concepts of adaptive cycle and panarchy suggest that all complex systems undergo four phases of development characterised by distinct structural features and resource utilisation patterns, and are constantly modified through feedbacks of multiple conditions and processes operating at various spatial scales (Gunderson and Holling, 2002). However, resilience thinking is often criticised for its system-oriented approach which tends to homogenise social complexity and assume that all actors within the system have similar interests, expectations and behaviour (Fabinyi *et al.*, 2014, Turner, 2013). Academic literature in the field to date has insufficiently addressed the basic issues of power, politics, and agency and debates over fundamental questions such as 'what is desirable?' and 'for whom?' (Cote and Nightingale, 2012, Davoudi, 2012). Pelling and Manuel-Navarrete (2011) argue that an understanding of how power is held and used is essential in analysing the barriers and drivers of social transformation. The process of resilience building, either though incremental adjustments or through radical transformations, often creates new patterns of winners and losers as certain system regimes may be considered more desirable by one segment of society than another (Walker and Salt, 2006). Thus, it is important to consider issues of inequity both in terms of decision-making procedures and in the distribution of costs and benefits resulting from change (Davoudi, 2012). As such, a number of scholars (cf. Fabinyi *et al.*, 2014, Turner, 2013, Beymer-Farris *et al.*, 2012, Cote and Nightingale, 2012, Peterson, 2000) have called for integrating political ecology perspectives into resilience thinking.

A political ecology approach highlights how power relations influence the access, control and management of resources, and places politics at the forefront of analysis to identify social origins of environmental degradation and the plurality of perceptions (Bryant, 1998, Peet and Watts, 1996). While the 'desirability' of a given state within a socio-ecological system (SES) is often based on its ability to produce the ecosystem services needed for the well-being and development of society, the resilience literature has not adequately addressed 'whose' needs are being met from these goods and services (Beymer-Farris *et al.*, 2012). Competing resource users may have different perspectives on what constitutes a desirable state; hence, political economy of natural resource management and power relations within a SES can lead to unequal outcomes for different stakeholders (Beymer-Farris *et al.*, 2012). Social power can be exercised in a number of ways, as discussed in the literature review on

political ecology in section 2.4. Firstly, there are observable activities such as coercion, intimidation and direct confrontations; secondly, there are less visible activities like shaping the terms and conditions on which people confront each other; and thirdly, there are hidden activities that shape the preferences, belief and desires of other individuals in ways that work in favour of the person in power (Boonstra, 2016).

An understanding of how environmental change is managed and experienced by different people requires incorporation of social stratifiers, such as class, ethnicity and gender, to account for the different perspectives, values and desired states of the people involved (Fabinyi *et al.*, 2014, Cote and Nightingale, 2012). This study uses poverty levels to stratify households within the study community (refer to chapter 4); in this context, power is created and maintained through increased wealth, greater control over key productive assets, such as land and water, and political ties. Despite theoretical progress, there are only a few empirical studies (e.g. Moshy *et al.*, 2015, Beymer-Farris *et al.*, 2012) that have integrated a political ecology approach with resilience thinking to deal with the politics of desirable states, the trade-offs associated with adaptation strategies and who wins and who loses as a result of change. By combining resilience thinking with perspectives from political ecology, this chapter investigates the complex interactions between the agro-ecological, socio-political and economic domains operating at international, national, regional and local levels and also analyses the roles of various social actors and their differential power and interests in navigating socio-ecological change. It, thus, promotes a better understanding of the 'social' dimension of socio-ecological resilience and also contributes to the academic literature on vulnerability and aquaculture transitions, both of which have emphasised the need to overcome disciplinary boundaries to unpack the complexities of dynamic systems.

5.2 Research methods

The study used a mixed methods approach involving participatory wealth ranking, focus group discussions, livelihood trajectory interviews and household questionnaire surveys to collect primary data, between October and December 2014, from Kamarkhola and Mithakhali villages in coastal Bangladesh (refer to chapter 3). Chapter 4 disaggregated the survey households in each village into five poverty levels (rich, upper middle, lower middle, poor and extreme poor) by triangulating the results from participatory wealth ranking, fuzzy set analysis and principal component analysis. This categorisation is used in this chapter to differentiate households' opinions on brackish water shrimp cultivation, the data for which was collected using the household questionnaire surveys.

Following the translation and transcription processes, qualitative data from FGDs and livelihood trajectories were scrutinised and chunks of text related to historical events were coded as per the spatial scale (international, national, regional and local) and the domain in which they occurred (socio-political, agro-ecological and economic). These codes were not pre-determined, rather they emerged from the data. Categorisation of data by spatial scale and domain helped to illustrate the cross-scale interactions between multiple conditions and processes; thus, ensuring clarity without eclipsing the complex dynamics. The events closely adhered to the characteristics defining each of the four phases of the adaptive cycle, in terms of the system's potential (that is, the wealth of the system) and connectedness (that is, the internal controllability of the system) (refer to Table 5.1 below). The events were then arranged chronologically, demarcating boundaries between the phases for the two villages respectively (refer Figure 5.1 for a timeline of events). While this demarcation aided structuring and analysis of data, it should be noted that these boundaries are highly flexible and represent broader time periods instead of rigid start and end dates.

Table 5.1 Characteristics used for structuring and analysing data in relation to the adaptive cycle

	Characteristics of a SES in terms of its potential and connectedness	**Characteristics of the shrimp industry as identified from empirical evidence**
Exploitation phase	• Abundance of resources, allowing competition among alternative social or ecological groups and formation of new hierarchies; • System exhibits flexibility and high resilience	• Availability of fallow land during the dry season; • Abundance and diversity of post-larvae and fish juveniles in tidal water; • Adoption of export-oriented growth policy, creating demand for market-based products • Traditional patron-client peasant societies being replaced by commercial aquaculture
Conservation phase	• Accumulation of ecological capital, such as biomass and nutrients, and social capital, such as skills, networks, trust and human relationships. • System exhibits stability and rigidity, as resources are bound up by tight organisation, thus, excluding domination by alternative species or social institutions	• High levels of financial investments by the government as well as large local farmers; • Development of ancillary services along the supply, creating employment and trade networks • Shrimp cultivation became the dominant livelihood activity, occupying private farmland, mangrove forests, public land and waterbodies

Release phase	• Release of accumulated capital and collapse of system structure; • Social capital and behaviour can break away from normalised routines and positions.	• Increased salinity leading to adverse impacts on subsistence based livelihood activities; Disease outbreaks in shrimp farms; • Reluctance to continue brackish water shrimp farming and social movements against outside entrepreneurs; • Occurrence of severe cyclones and tidal surges
Re-organisation phase	• Social learning and memory support experimentation and development of novel ideas, while crisis provide windows of opportunity; • Specific coalitions of interests emerge and compete for discursive dominance	• Skills acquired from brackish water shrimp cultivation used to experiment with white fish or freshwater prawn cultivation • Destruction by cyclone Aila providing opportunity for changes in farming systems • Difference in perceptions on brackish water shrimp cultivation; recognition of the ecological and economic potential for integrated freshwater prawn and paddy farming

The changes that occurred during the exploitation and conservation phases were similar for both villages, as well as the south-western coastal region in general. While primary data from FGDs and livelihood trajectory interviews reflected these broader changes, they were later validated with secondary data from the academic and grey literature. Triangulation of data enhanced the quality and accuracy of primary data; for example, it was often difficult for respondents to specify the names and dates of various policies and programs. The events during the release and reorganisation phases were comparatively recent and specific to each of the villages; hence, data analysis was based on primary data only.

During data analysis, codes were also assigned to texts that described the roles of different actors in navigating the above changes. These texts were then examined with a political ecology lens (refer to section 2.4), particularly to understand how power relationships, through which subordinate groups (that is, poorer households) were adversely incorporated within unequal socio-economic and political relations, influenced whose desirable states were reached. Further analysis revealed information related to certain key elements of social resilience, such as memory, learning, leadership and crisis, especially in case of Kamarkhola.

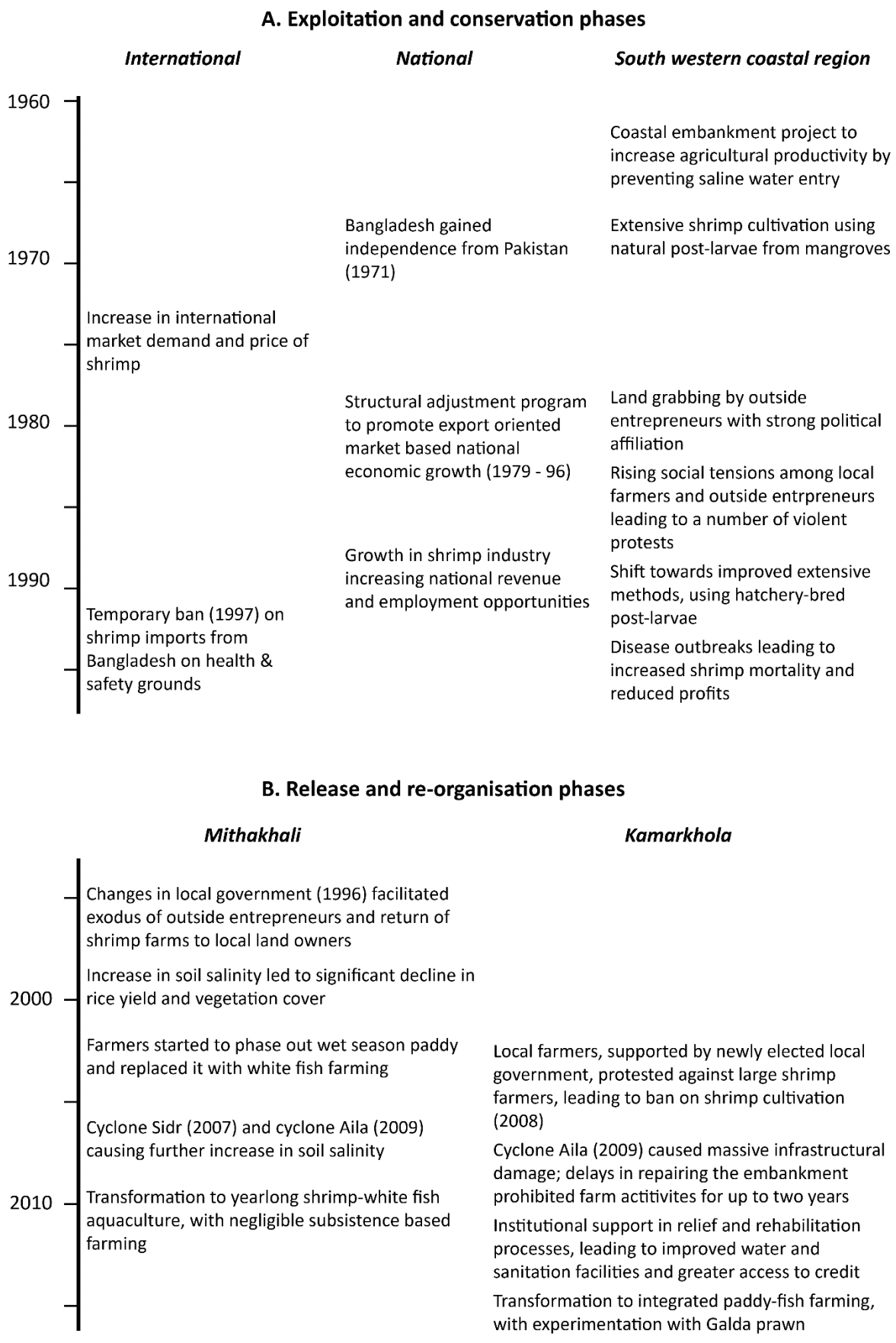


Figure 5.1 Timeline of events at different phases of the adaptive cycle

5.3 Results

Figure 5.2 illustrates the changes in predominant farming systems in the two study villages over the past four decades. The following sub-sections describe the underlying drivers of these socio-ecological changes both from a system and an actor-oriented perspective.

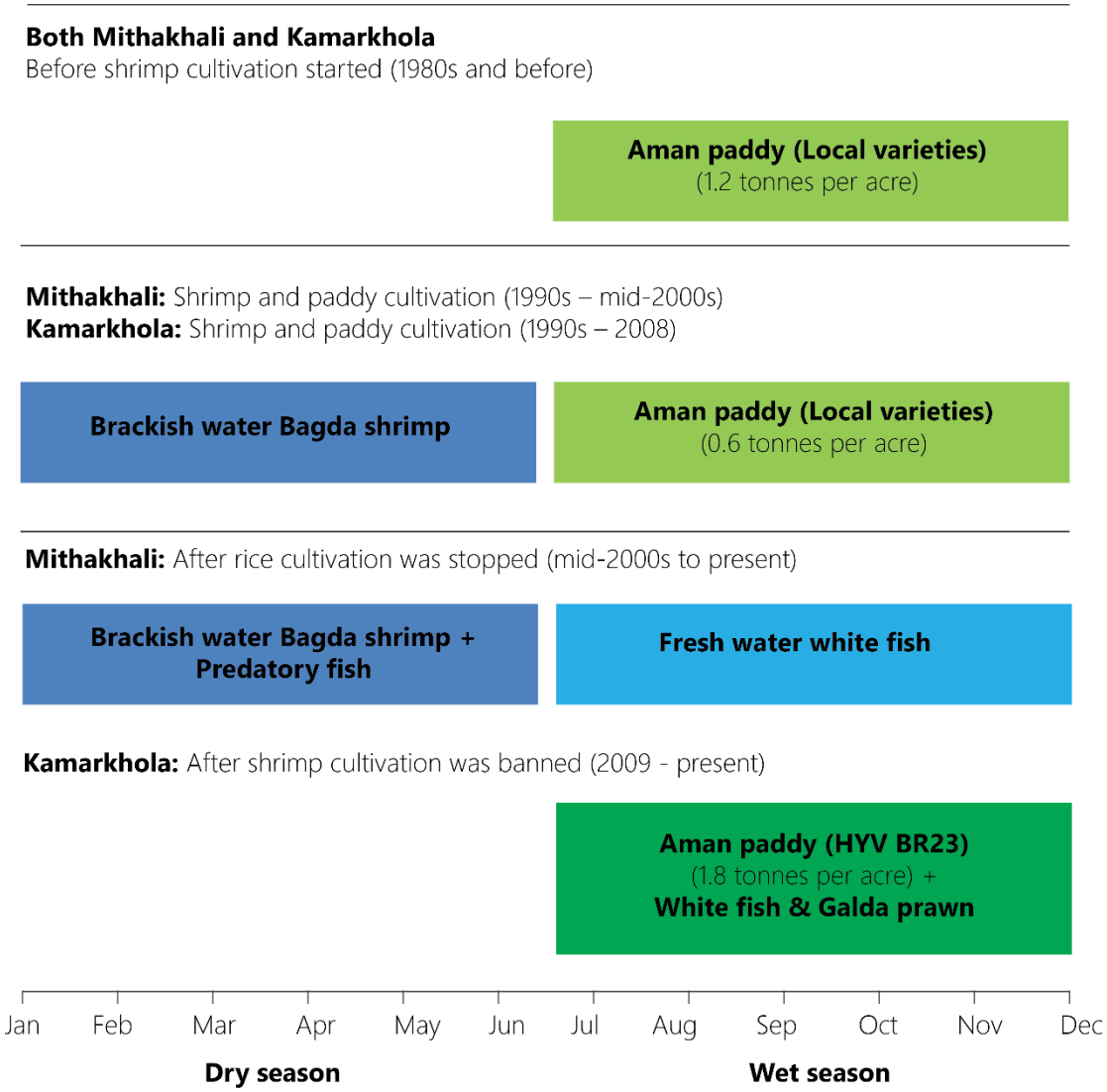


Figure 5.2 Seasonal calendar showing changes in predominant farming system in Mithakhali and Kamarkhola

5.3.1 Mithakhali and Kamarkhola: Exploitation phase (early 1960s – mid-1980s) and conservation phase (mid-1980s – mid-1990s)

During the **exploitation phase** (early 1960s – mid-1980s) changes in national growth policies, infrastructure development and implementation of donor funded projects led to the emergence and rapid proliferation of the shrimp industry. This phase is characterised by increased use of easily available natural resources and increased involvement of multiple stakeholders in the brackish water shrimp industry. During the 1960s and early 1970s, the government implemented the 'Coastal Embankment Project' under which hundreds of 'polders' were constructed in the coastal region of Bangladesh to increase wet season agricultural productivity by keeping out saline water (Islam and Kibria, 2006). From the late 1970s, increased international market demand and high prices for shrimp spurred an interest amongst farmers in shrimp aquaculture, causing agricultural lands to be turned into shrimp farms during the dry season. The sluice gates were kept open from February to April to allow saline water to enter farms, along with a wide variety of fish fry and natural shrimp post-larvae (Karim, 2006). Meanwhile, between 1979 and 1996, the World Bank's Structural Adjustment Programme aimed to promote the country's economic growth through creation of an export oriented market based economy (Battacharya *et al.*, 1999). Many infrastructure development programs along with improved technology dissemination and fiscal incentives were launched to expand the shrimp industry (Karim, 1995). Apart from the expansion in the number of shrimp farms, the industry experienced concurrent growth in associated services such as hatcheries, processing plants, ice plants and shrimp depots.

During the **conservation phase** (mid-1980s – mid-1990s), the shrimp industry continued to grow but at a relatively slower pace and many of the adverse socio-economic and agro-ecological impacts started to become apparent. Beside the government's role in promoting the sector, a large number of outside entrepreneurs including businessmen, politicians, army and civil officials started to invest in shrimp farming by appropriating public lands, clearing mangrove areas and grabbing local farmers' lands (Nuruzzaman *et al.*, 2001). While the profits were huge, the amount of land suitable for brackish water shrimp cultivation was in short supply; hence, the appropriation of *khas* (public) land became a source of power play in the region. Due to inter-department conflicts, absence of precise distribution policy and underhand dealings, most of the *khas* land, as well as *khas* wetlands and canals, were allocated to politically powerful persons (Chowdhury, 2001). Moreover, these outsiders also pressurised local farmers to lease out their lands for shrimp farming and in some cases, used hired musclemen to forcefully evict marginal rice farmers from their land (Islam, 2008).

> "During the 1980s, local farmers in this area did not have much knowledge about the prospects of shrimp farming. We used to block the canal openings from February to June to prevent entry of saline water into our fields. The land remained fallow during this dry season and the natural salts rose to the topsoil, making in white in appearance. Slowly powerful businessmen or outside entrepreneurs came to this area and started to inundate our land with saline water by opening the canals during the dry season. The incoming saline water contained large quantities of wild shrimp post-larvae, as well as a number of predatory fish juveniles. The businessmen made huge profits without any investment; finally, when they drained out the water in June, the local landowners could plant Aman paddy. Initially, the farmers did not complain much because their livelihoods were not being affected. But after a couple of years, when rice yield started to decline, farmers wanted compensation from the entrepreneurs, who then started providing a small amount of money as rent. As yields continued to decline, the rent continued to increase." – Keramot Ali (male), lower middle class farmer, Mithakhali.

During the 1990s, to increase production and cope with the decline in natural shrimp fry availability, farmers started to release hatchery bred post-larvae, which were comparatively less expensive but more susceptible to diseases than natural ones sold by fry collectors (Chowdhury, 2001). Besides Bagda shrimp, many farms also harvested good amounts of predatory fish, which entered the farms along with the tidal waters (Nuruzzaman, 2006). Large-scale conversion of agricultural land to shrimp farms, deliberate flooding of rice fields and canals with saline water and legal and illegal construction of gates and pipelines through embankments significantly increased soil and water salinity. Seepage of saline water into adjacent agricultural lands ultimately forced many small landowners to stop rice cultivation and shift to shrimp, or to lease out their lands to the larger shrimp farmers. Although the shrimp industry, as a whole, led to increased national income and greater employment opportunities through the establishment of associated activities (Pokrant, 2014), many studies (Manju, 1996, Nijera Kori, 1996, Rahman *et al.*, 1995) found increased income inequality and economic disempowerment of local people, as high incomes were enjoyed only by a few powerful entrepreneurs. Landless farmers and sharecroppers, who traditionally leased in land to grow crops, lost access to these productive resources and became unemployed.

5.3.2 Mithakhali: Release phase (mid-1990s – early 2000s) and re-organisation phase (mid-2000s – present)

The **release phase** was one of chaos and collapse. Overtime, local farmers started to realise that on the one hand they were deprived of the huge amount of profits that were generated from their own land by outside entrepreneurs, while on the other hand, they were suffering from the adverse effects of shrimp cultivation, including decline in paddy yield, loss of homestead gardens, restricted access for fishing in canals and livestock rearing. False

contractual agreements, non-payment of lease money, disputes over common public lands, increased insecurity of women through molestation by outsiders and adverse impacts on traditional subsistence sources led to increased social tensions (Ghafur *et al.*, 1999). Local people were involved in street protests and violent confrontations with outside shrimp farmers, leading to serious disruptions in law and order, violations of human rights, and even incidences of rape and murder (Manju, 1996, Nijera Kori, 1996). During the 1990s, almost all candidates of union council elections took advantage of people's sentiments and used an anti-shrimp position in their electoral campaigns (Chowdhury, 2001). In Mithakhali, the locally elected lawmaker passed a law in 1996 stating *"Jomi jar, gher tar"* (Only the true landowner has full rights over the shrimp farms on his land). Local farmers were able to regain control over their lands and subsequently divided the large commercial farms into smaller farms farmed by individual landowners as well as hired labours.

> "The lawmaker mobilised the local farmers and encouraged them to protest against the illegal activities of the outside entrepreneurs. When they came to flood the lands with saline water, we ourselves stood on the land, with sticks and axes. There were lots of violent conflicts between the local farmers and the musclemen hired by these outsiders. In the end, they had to leave permanently." – Keramot Ali (male), lower middle class farmer, Mithakhali.

Following the eviction of these outside entrepreneurs, local farmers in Mithakhali continued to farm brackish water shrimp along with predatory fish in the dry season, followed by paddy cultivation with small amounts of freshwater white fish in the wet season. However, by the time the landowners gained control over their land, the 'golden era' of shrimp cultivation was almost over. Since the outside entrepreneurs were not the landowners and focused only on short-term profits, they did not take good care of the land, causing the soil to lose its fertility over time. Meanwhile, in the mid-1990s, the white spot syndrome virus, believed to have originated from imported post-larvae, spread across shrimp farms and is still a major concern for farmers today. Following the eviction of these outside entrepreneurs, that is, during the late 1990s, local farmers farmed brackish water shrimp along with predatory fish in the dry season, followed by paddy cultivation with small amounts of freshwater white fish in the wet season. But as paddy yields continued to decline, it finally reached a point where the costs became higher than the revenue. At that point, people slowly started to phase out paddy cultivation and replace it with large scale white fish cultivation. However, this time, the local large landowners played an important role in this transition.

> "The outside entrepreneurs taught us shrimp cultivation and introduced the *'hari'* (land leasing system). When they were evicted, the local large landowners started taking their place. These rich people were always looking out for poor people who wanted to either lease out their land or sell it altogether. Poor people lack foresight; they were happy with the high rent or price they were offered. They are also naïve; they never saw this much cash in hand before. Hundreds of small farms were slowly assimilated into the larger ones, making the rich more powerful. The large landowners were reluctant to drain out water from their land after the end of the dry season. And unless the large land owners removed water from their farms, the small farmers could not plant rice in the wet season. One kg of Bagda shrimp sold for BDT 700-800, while 1 maund (37 kg) of rice sold for BDT 300; so any economically rational being would opt for aquaculture." – Iqbal Alam (male), poor farmer, Mithakhali.

The final blow came in 2007, when cyclone Sidr brought in highly saline tidal water for a day and degraded the soil to such an extent that crop cultivation became impossible. This was followed by cyclone Aila in 2009, which had relatively less effect on Mithakhali as it is located towards the inner part of Mongla sub-district, further away from the main rivers. The tidal surge which accompanied cyclone Aila inundated the village during high tide and the water receded back again on the same day during low tide. Hence, apart from the immediate loss of fisheries and increased soil salinity in subsequent years, there was no damage of infrastructure.

During the **re-organisation phase**, the livelihood system in Mithakhali was completely based on aquaculture. However, further land degradation and increased disease outbreaks had severely dwindled the incomes from shrimp cultivation. As estimated by the manager of a shrimp co-operative, shrimp mortality had increased from 5% to 80% over the last 15 years, and at the time of study, a farmer could earn about BDT 17,000 per acre (compared to BDT 138,000 per acre in the past) during the dry season, followed by another BDT 27,000 per acre from white fish farming during the wet season. However, given that the mean agricultural land ownership of poor and extreme poor households, who together comprised 68% of the total population, was only 1.42 and 0.04 acres respectively, the cash income for most people from shrimp and white fish cultivation was very limited. At the same time, due to soil salinity and private control of water canals, farmers were deprived of all other sources of subsistence, such as rice, vegetables, open-access fish and livestock. Lack of funds and specialised skills constrained these households from entering other high return non-farm activities. While small farmers faced food insecurity and rising debts, large farmers could still enjoy economies of scale and cope with losses by intensifying production (that is, releasing more post-larvae and supplementary feed).

Figure 5.3 shows that at the time of study, most of the farmers (90 out of 150 households) were against brackish water shrimp cultivation. While the large landowners were partially responsible for the transition to aquaculture during the early 2000s, at the time of study they were using their power to ensure further maintenance of this farming system. As shown in Figure 5.3, only a limited number of respondents (19 of 150 households) were in favour of shrimp cultivation, and the percentages were higher for the rich and upper middle classes.

> "The big landlords want shrimp cultivation to continue so that they can get money by sitting in Khulna city, Dhaka city or even abroad. In a given season, they can earn up to BDT 10 million (approx. GBP 80,000). During election time, they will be able to fund the local politicians, whereas someone like me won't be able to contribute a penny. So obviously, the politicians will support them. Those who are poor want the embankment to be built. If the embankment is there we can keep out the saline water and use freshwater stored in canals to grow rice as well as Galda prawns and white fish. We would also have the potential to grow other winter crops like sesame and pulses." - Gias Uddin (male), poor farmer, Mithakhali.

In contrast, an interview with a rich farmer revealed a different perspective on the issue. The rich farmer explained that although most people in the village were against shrimp cultivation, reverting back to the previous paddy based system was not feasible.

> "I understand how decades of shrimp cultivation has adversely affected the agro-ecology of this village. But we cannot stop it at once even if we wanted to. This is something many of the farmers don't realise. If we stop shrimp cultivation today, it would take at least 3-5 years for the soil to regain its strength and become fertile enough to support paddy growth. 30 years of land degradation cannot be altered in a day. So how will these people survive in the meantime? Who will support us?" – Amzad Hossain (male), rich farmer, Mithakhali.

In Mithakhali, farmers, who were neither for nor against shrimp cultivation (41 of 150 households), mainly comprised of those who had a good amount of land and for whom the balance between income and expenditure from shrimp was more or less same as that from paddy. But these people acknowledged that stopping shrimp cultivation would be beneficial for the community at large. This group also included some landless people, who had always depended on physical labour regardless of farming system, or people who were engaged in service or other non-farm sectors.

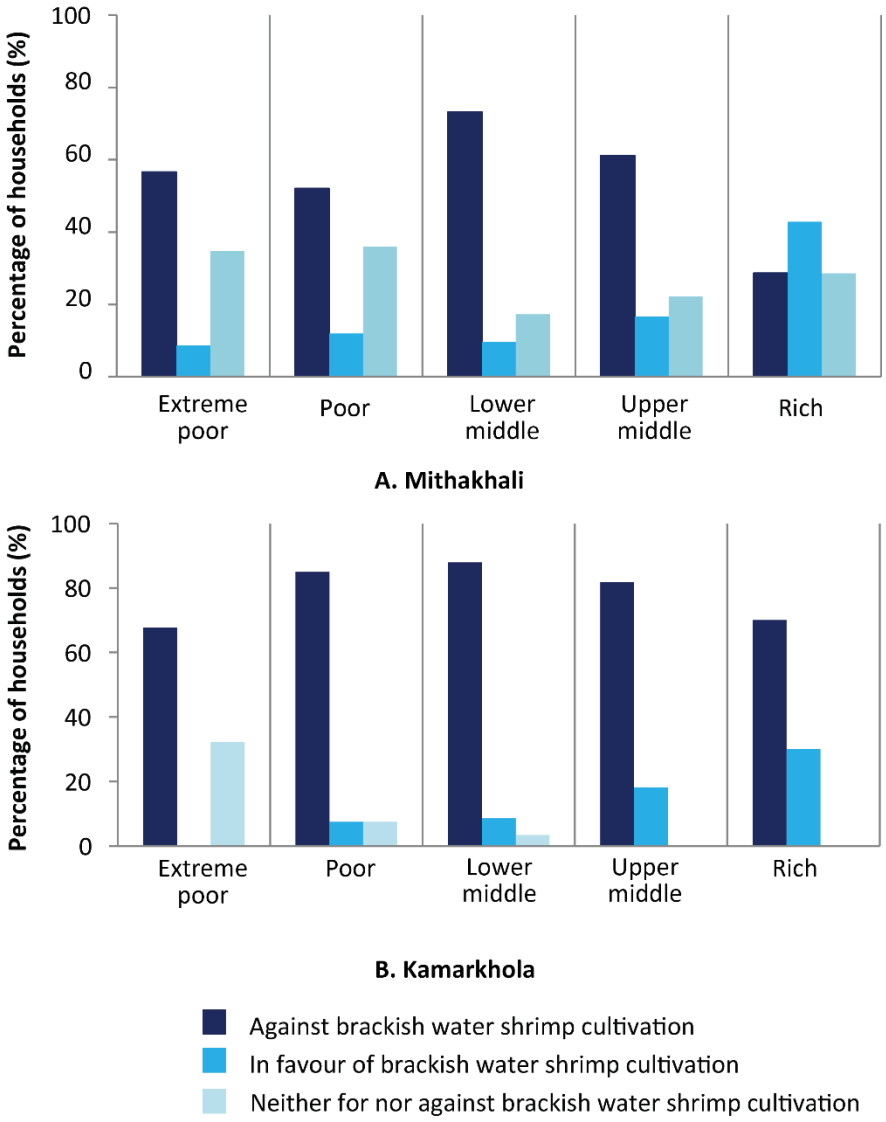


Figure 5.3 Perceptions of brackish water shrimp cultivation in Mithakhali and Kamarkhola

5.3.3 Kamarkhola: Release phase (late 1990s – 2008) and re-organisation phase (2009 – present)

During the mid-1990s, in Kamarkhola, shrimp cultivation was mainly carried out by outside entrepreneurs, who leased in land from local farmers in exchange of meagre rents. Success of these early entrepreneurs inspired local large landowners, who established their own independent farms or engaged in co-operative farming along with small farmers. Overtime, as the adverse effects of shrimp cultivation became more apparent, people were divided over whether to continue shrimp aquaculture. Large landowners and some medium sized ones who had gained good profits from shrimp, as well as some landless people who benefitted from working on shrimp farms, wanted to continue shrimp farming, while most others, especially small landowners and some large owners who faced losses from shrimp,

were against it. In late 2008, residents of Kamarkhola as well as other neighbouring villages united to chase away the outside entrepreneurs when they tried to open the sluice gates in the embankment. The newly elected local parliamentary member and a couple of anti-saline water environmental protection groups played key roles in mobilising farmers and helping them express their collective frustration against years of injustice. Finally, an order from the High Court permanently banned brackish water shrimp farming in Kamarkhola.

In mid-2009, Kamarkhola was severely affected by cyclone Aila, which caused massive infrastructural damages, displacing people to temporary settlements on the embankment and prohibiting agricultural activities for about one and a half years. Despite the short-term hardships, many people referred to the event as a blessing in disguise as it brought the area under limelight. Institutional support, in terms of relief and rehabilitation materials, enabled the people to survive during the farming system transition and led to overall infrastructural development, including better housing, water and sanitation facilities, cyclone shelters and embankment reinforcement. After agricultural activities resumed in 2011, most farmers obtained good yields from rice and some used their experience from shrimp farming to grow freshwater prawn and white fish as polyculture in ponds or as integrated culture on their agricultural lands. Thus, in contrast to Mithakhali, the socio-ecological system in Kamarkhola managed to reorganise and prevent the farming system from tipping over to a state that is undesirable for most farmers (122 of 150 households). Only a few households (13 of 150) were in favour of shrimp cultivation and as expected, the relative percentages were higher for the rich and upper middle classes. A small number of people (15 of 150 households), mostly from the landless extreme poor class, expressed ambivalent opinions of being neither for nor against shrimp farming.

5.4 Discussion

This chapter investigated the underlying drivers of socio-ecological changes in the two study villages, using both resilience and political ecology concepts. The conceptual convergence helped in understanding the complex interactions between multiple domains operating at various spatial scales and also in analysing the roles of power dynamics, good leadership and opportunities created by crisis in creating differential vulnerability contexts. By empirically exploring the combined application of concepts from ecological and social origins, this chapter demonstrates the need to adopt actor oriented approaches to better represent the social dynamics of SESs.

The adaptive cycle heuristic offered a useful analytic framework to structure the empirical evidence into four distinct phases and understand the multiple cross-scale interactions between several domains. Although the adaptive cycle may not be applicable to all complex systems (Cumming and Collier, 2005), it has been particularly useful in analysing changes in characteristics and behaviours of capture fisheries systems (Jacques, 2015, Prado *et al.*, 2015, Goulden *et al.*, 2013, Seixas and Berkes, 2003), with relatively limited application in culture fisheries systems (Beymer-Farris *et al.*, 2012, Garschagen, 2010). The evolution of the shrimp aquaculture system studied in this chapter closely adheres to the attributes of the different phases of the adaptive cycle model, in terms of the changes in potential and connectedness in the ecological and social sphere..

The exploitation phase was characterised by plentiful natural resources and rapid growth of the aquaculture industry. Availability of fallow lands during the dry season, good soil productivity and abundance of wild shrimp post-larvae enabled outside entrepreneurs to earn huge amounts of cash with minimal investments. New social hierarchies were forming, as the traditional patron-client relationships among peasants were replaced by market oriented cash crops. During the conservation phase, the growth rate slowed down as land scarcity impeded further extensification of shrimp aquaculture and productivity was increased by stocking hatchery bred post-larvae in addition to the wild ones present in the tidal waters that entered the farms. The system's potential and connectedness increased at the cost of decreasing resilience. Development of associated services, such as hatcheries, depots, and processing plants, expanded social networks along the supply chain and the shrimp-paddy rotational system was institutionalised throughout the coastal region. However, disease outbreaks in shrimp farms, declining paddy yields, and distributional injustices between outside entrepreneurs and local farmers triggered the release phase. The cohesive social structure became unstable and contradictory coalitions of interests started to emerge. While some farmers still favoured the cash crop economy, others preferred to revert back to the traditional subsistence based farming system, thus, forming new constellations of values in both the villages. The farming systems in both villages transformed to a new state; however, local governance processes and power dynamics among farmers of different wealth classes determined whose desirable state was reached. During the reorganisation phase, farmers drew upon their skills and knowledge to experiment with newer forms of livelihoods, such as pond-based polyculture of freshwater prawn-white fish (in Kamarkhola) and land-based farming of different marine and freshwater fish (in Mithakhali), ultimately leading to a new adaptive cycle.

While the resilience approach conceptualised the changes in system characteristics and behaviour, the political ecology perspective highlighted the roles of differential values, interests and power in steering the direction of change. It helped in explaining the root causes for the different responses of the two communities.. In Mithakhali, at the time of study, shrimp cultivation was carried out by large local landowners, not by outside entrepreneurs who were overthrown back in the late 1990s. This made it difficult for local people to protest against shrimp farming, as the large landowners, often affiliated with local political parties, had the rights to farm their own land as they pleased. However, in Kamarkhola, shrimp cultivation was mostly carried out by outside entrepreneurs, making it comparatively easier for the local farmers to evict these shrimp farmers in 2008, with the support of local political leaders and grassroots organisations. Moreover, in Mithakhali, outside entrepreneurs were evicted in the 1990s because local farmers wanted to cultivate shrimp on their own land and earn increased cash. At that time, the negative effects of shrimp cultivation on other livelihood sources were not yet apparent. But in Kamarkhola, when local farmers protested against outside entrepreneurs in 2008, they wanted to stop shrimp cultivation and revert to paddy, as they were aware of the adverse consequences of brackish water shrimp farming.

Moreover, in Kamarkhola, there was relatively greater balance in the wealth distribution between households compared to Mithakhali (refer to chapter 4). As the percentages of wealthier households and the average amount of land owned by them were comparatively lower, fewer households had vested interests in shrimp cultivation. Previous studies within the fisheries sector have also demonstrated how power relations influence the access, control and management of resources, and thus, play a key role in determining desirable states. For instance, a study on commercial prawn aquaculture in Tanzania by Beymer-Farris *et al.* (2012) found that the short-term wealth accumulation motives of private corporations and the state led to mangrove ecology degradation that jeopardised the livelihoods of local communities. In a separate study, Moshy *et al.* (2015) also found that authoritarian implementation of neo-liberal marine conservation policies on Mafia Island, Tanzania, without consideration of livelihood impacts among resource users, resulted in a desired ecological state at the cost of increased poverty in the social sphere. These findings illustrate that the integration of a political ecology approach in resilience studies facilitates a better understanding of how powerful actors can achieve their desirable state to the detriment of the majority of stakeholders.

In addition, the presence of certain key elements of social resilience, such as, social learning, social memory, leadership and crisis, enabled the transition of the farming system to a more desirable state. By the late 2000s, local farmers in Kamarkhola, including those who were initially enticed by the increased cash incomes from shrimp, learned that long-term sustainability of farm livelihoods depended on the health of the agro-ecosystem, a thing that Mithakhali farmers could not foresee in the late 1990s or early 2000s. Along with this social learning, people also possessed social memory on how conflicts and movements had been the means to resolve issues arising from shrimp cultivation. During the 1990s, there were various kinds of local resistance in Khulna to appropriation of public lands, coercive treatment of small-scale rice farmers reluctant to lease out their land and flooding of paddy fields with saline water. Hence, the culture of social movements and dealing with crisis actively through collective action was embedded within the social memory of local people. Like previous social movements, the protests in Kamarkhola were supported by members of local political parties or NGOs who played key roles in organising local community members and helping them express their collective frustration against years of injustice. In this case, the local parliamentary member, in association with a couple of anti-saline water environmental protection groups, played a crucial role in mobilising people and ultimately obtaining an order from the High Court that banned shrimp cultivation in the area.

The case of Kamarkhola exhibits that power dynamics can sometimes be altered in favour of the less powerful, if good governance and similar value positions can enable poorer groups to raise their voices. The importance of social memory and good governance in driving change was also acknowledged in previous studies. For instance, in their study, Beymer-Farris *et al.* (2012) found that villagers drew upon their social memory on local resistance against industrial prawn farming in Rufiji delta to protest against the establishment of the prawn farm on Mafia Island which was desirable for the private corporation, the national economy and prawn consumers but not for local residents. Similarly, Seixas and Berkes (2003), in their study of lagoon fisheries in Brazil, found that election of a new Colonial president created space for policy formation based on local ecological and scientific knowledge and led to strong enforcement of fishery rules that protected livelihoods of local communities.

While social learning, memory and leadership all contributed to social reorganisation and bringing about change, one single event that culminated the process was the 2009 cyclone Aila. In Kamarkhola, the destruction created by the cyclone opened up opportunities to start a new farming regime. As quoted by one of the respondents, *"Whatever Allah does, He does*

it for the best! Cyclone Aila was a blessing in disguise for the farmers of this area". While farmers in Mithakhali were concerned about the immediate difficulties of stopping shrimp cultivation, those in Kamarkhola could depend on cyclone aid during the transition period.

5.5 Conclusion

This chapter integrated insights from socio-ecological resilience and political ecology to understand the underlying drivers of socio-ecological change in the study areas. The chapter found that in the absence of good governance, power asymmetries arising from skewed wealth distribution can steer the socio-ecological system to a state that is desirable for only a small fraction of powerful actors, while social resilience achieved through memory, learning, leadership and crisis can lead to a greater good. These socio-ecological changes had differential impacts on households' livelihoods and well-being, which are investigated in the following chapter. The next chapter looks at the livelihood strategies of households of different poverty groups both before and after the changes in farming system and also analyses individual livelihood trajectories to identify the factors that enabled some farmers to experience an upward trajectory, while others were pushed downwards or remained steady. Moreover, the chapter examines the implications of these livelihood dynamics on the well-being of households at different poverty levels.

Chapter 6. Investigating livelihood dynamics and human well-being outcomes of households of different poverty levels

Abstract

Cross-scalar interactions between multiple agro-ecological, socio-political and economic conditions and processes have significantly modified the vulnerability contexts of rural communities in coastal Bangladesh. The previous chapter showed how actors with differential values, interests and power can steer the direction of socio-ecological change to one that is desirable for some but not desirable for others. This chapter investigates the differential capacities of households to adapt to these changes and their well-being outcomes. In doing so, the chapter quantitatively compares the livelihood strategies of households at different poverty levels at two time periods and then qualitatively analyses individuals' livelihood trajectories. Findings show that a household's livelihood adaptive capacity is determined by its own poverty level as well as the community's vulnerability context, which is, in turn, shaped by the activities of other households. A cash crop system that impeded all forms of subsistence based livelihood activities enabled richer households to accumulate further wealth at the cost of environmental degradation and decreased income and food security for the poorer ones; thus, further exacerbating inequalities in wealth and power. In contrast, a subsistence based farming system, supplemented by market oriented aquaculture, promoted more equitable and sustainable livelihoods for all. Agricultural land was the most important determinant of upward livelihood trajectories, as high levels of initial land ownership often enabled households to shift from low-return to high-return activities. Households differed in their notions of well-being, while material dimensions, such as income and food security, were important for all, some also valued subjective dimensions like better environmental quality and peace of mind and relational dimensions like trust and living well together. By explicitly engaging with the livelihood dynamics and well-being outcomes of different wealth classes, the chapter contributes to a better understanding of who wins and who loses as a result of socio-ecological change. It emphasises that future adaptation plans and actions need to acknowledge the heterogeneous needs and values of different stakeholders to ensure socially equitable and environmentally sustainable livelihoods.

6.1 Introduction

Rural livelihoods in coastal Bangladesh are vulnerable to the impacts of multiple stressors (Shameem *et al.*, 2014, Pouliotte *et al.*, 2009). The previous chapter showed that socio-ecological change brought about by natural shocks and stresses, such as salinity intrusion, tidal surges and cyclones, and changes in farming systems significantly modified the vulnerability contexts of the study villages. The purpose of this chapter is *"To investigate the livelihood dynamics and well-being outcomes of households of different poverty levels in the two study villages",* thus, addressing Objective 3 of this PhD research. The research questions under this objective are:

1. How did the socio-ecological changes in the two communities affect the livelihood strategies of households at different poverty levels?
2. What factors did households consider in designing their livelihood portfolios?
3. What determined the direction of household livelihood trajectories and why?
4. What were the implications of the socio-ecological changes and livelihood responses for the well-being of households of different poverty levels?

To address these questions, this chapter uses a livelihoods approach - a grounded and multi-dimensional perspective that explains the conditions and processes within which people construct their livelihoods, which, in turn, drive them towards enhanced well-being or undesirable trajectories (Olsson *et al.*, 2014). As discussed in chapter 2, the sustainable rural livelihoods approach and the associated sustainable livelihoods framework have been instrumental in promoting research on how people's ownership and access to assets determine their capacity to undertake different livelihood strategies within the opportunities and obstacles presented by the local vulnerability context (DFID, 1999, Scoones, 1998). However, this static view of livelihoods often results in descriptive analyses of livelihood capitals and groups strategies into different structural categories (McLean, 2015). Livelihoods are dynamic, meaning that the same people can pursue different strategies at different times due to changes in the context in which they operate (De Haan and Zoomers, 2005). Hence, researchers have emphasised the need to view livelihoods as a 'moving target' and use livelihood trajectories as a means of capturing the dynamics (McLean, 2015, Valbuena *et al.*, 2015, Van Dijk, 2011).

Livelihood trajectories not only try to capture the chronology of events in an individual's life, but also seek to dig deeper into people's beliefs, desires and constraints (De Haan and

Zoomers, 2005). By asking questions of why certain options were chosen while others were not considered, researchers can identify how social structure, power relations and institutions shaped particular trajectories (McLean, 2015). Livelihoods exhibit path dependency, meaning that past responses to change pre-determine and condition the set of options people have in devising their current and future strategies (Fazey *et al.*, 2015). Understanding the opportunities and barriers faced by people in their quest to make a living is essential in designing policies and programs to enhance people's livelihood adaptive capacity and reduce their future vulnerability (Fazey *et al.*, 2015).

The literature acknowledges that the livelihood adaptive capacities of individuals and households are differentiated by class, gender and ethnicity, thus, emphasising the need for context specific studies using social stratifiers (Adger *et al.*, 2007). Van Dijk (2011) argues that context is important as people's behaviour and outcomes are largely determined by social structures – the rules and norms of human interaction. Within a context the social position of an actor dictates his agency, that is, his ability to influence change by altering the terms of livelihood arrangements. Moreover, as structures are contingent on the actions of actors, they are changeable (Jessop, 2001). This is supported by the previous chapter, which showed how the past activities of wealthier and powerful farmers shaped the present vulnerability context. This chapter shows how the changes in vulnerability contexts, brought about by the changes in farming systems, affected the livelihoods of households of different poverty levels. The chapter first uses quantitative data from the household questionnaire surveys to provide a snapshot of the overall situation at two different time periods, that is, before and after the changes in farming systems, and then analyses livelihood trajectories to penetrate deeper into the ways in which different actors navigated their livelihood pathways between these two periods.

The links between livelihoods and poverty have been long established in the literature, as reflected by the studies reviewed in section 2.5.3. These studies have more or less reached similar conclusions that wealthier households with greater asset endowments can engage in high-return farm or non-farm activities that lead to further asset accumulation and reduced vulnerability, while poorer households with limited skills or investment capacity are forced to engage in low return activities that allow mere survival (e.g. Gautam and Andersen, 2016, Martin and Lorenzen, 2016, Oumer and de Neergaard, 2011, Van den Berg, 2010, Cramb *et al.*, 2004). What is often missing is the relational aspect of livelihoods, that is, how activities of one group affect another and who wins and who loses in the process. The literature on equity and justice in adaptation argues that adaptive decision making processes are

influenced by social power and unequal distribution of costs and benefits are likely to create winners and losers (Eriksen and Lind, 2009, Carr, 2008). Similarly, the resilience literature acknowledges that greater resilience at system level does not automatically lead to greater well-being for all actors within the system (Armitage *et al.*, 2012, Coulthard, 2012). To understand these issues, this chapter looks into the human well-being outcomes of the changes in livelihood strategies due to the socio-ecological changes. It employs the 'social conception of human well-being', which argues that while the 'material' dimension and 'subjective' dimensions are essential in understanding human well-being, a 'relational' aspect should also be taken into account (White, 2010, 2009) (refer to section 2.8 for details).

This chapter, thus, contributes to our understanding of the interactions between livelihoods and poverty, in the context of climate sensitive aquaculture dependent communities. The recent IPCC AR5, which is the first in the series of IPCC reports to dedicate a separate chapter to 'Livelihoods and Poverty', stated that although an abundance of studies have looked into the impacts of climate change on livelihoods, most of them offered a snapshot of a given situation without addressing the continuous struggles people face in making a living (Olsson *et al.*, 2014). The report calls for an explicit analysis of livelihood dynamics that would clearly reveal people's responses to multiple stressors along the axes of inequalities, power imbalances and class (Olsson *et al.*, 2014). Similarly, while the literature on shrimp aquaculture has repeatedly highlighted the increased inequities in wealth distribution and the disproportional livelihood challenges of poorer households (Abdullah *et al.*, 2016, Swapan and Gavin, 2011, Pouliotte *et al.*, 2009), studies have not addressed the differential livelihood dynamics of households explicitly disaggregated into different poverty groups. A closer inspection of these issues can reveal the heterogeneous needs of different households in enhancing their livelihoods options and outcomes.

6.2 Research methods

As mentioned in chapter 3, the study used a mixed methods approach involving participatory wealth ranking, focus group discussions, livelihood trajectory interviews and household questionnaire surveys to collect primary data from Kamarkhola and Mithakhali villages in south-western coastal Bangladesh. Chapter 4 disaggregated the survey households in each village into five poverty levels (rich, upper middle, lower middle, poor and extreme poor) by triangulating the results from participatory wealth ranking, fuzzy set analysis and principal component analysis. This categorisation was used in this chapter to

differentiate households' livelihood strategies and well-being outcomes in the two communities.

The household questionnaire surveys generated quantitative data on the livelihood strategies adopted by households of different wealth classes at two different time periods, that is, before and after the changes in farming systems. While it was relatively straightforward to collect information on the livelihood activities of all household members at the time of study, recalling similar information for the time period before the changes in farming systems proved to be challenging in certain cases. These challenges mainly related to two issues: firstly, the 'before' time period referred to a range of years (that is, 10 – 15 years ago) rather than a particular year; and secondly, in some cases, the household demographic structure changed between the two time periods, due to marriage, birth or death, with consequent changes in number of income generating members. Additional questions were often asked to address these issues and a representative scenario was constructed in such cases. Data analysis involved generation of descriptive statistics and bar graphs; due to insufficient numbers of sample households in certain wealth classes, especially the rich, statistical tests could not be carried out to test whether or not the differences in livelihood activities between the different wealth classes were statistically significant.

Qualitative data from the FGDs and livelihood trajectory interviews were translated from Bangla to English, transcribed and coded to generate information on households' livelihood patterns, decision making factors, and causes of experiencing upward, downward or steady trajectories. Most of the interviewees were males as they were the main bread earners and had greater knowledge on farming activities. However, a small number of females were also interviewed, particularly in cases where male members were absent at the time of interview. It should be noted that this study aimed to investigate the livelihood adaptation dynamics of households of different wealth classes; hence, intra-household differences and gender dimensions of adaptation were not studied specifically.

Quantitative and qualitative data from the household questionnaire survey were used to understand the effects of socio-ecological change on the well-being of households of different wealth classes. The household questionnaire included an open ended question (refer to question 9u. in Appendix B) that aimed to understand the respondents' perceptions on their overall changes in well-being due to the transitions in farming systems. In the field, the actual Bangla phrase used was *"Apni ki ager cheye 'bhalo' achhen na kharap",* where the word *'bhalo'* refers to 'good' and *'kharap'* means 'bad'. The use of adjectives such as socio-

economically, psychologically or culturally before the words 'good' and 'bad' was intentionally avoided to capture the broader meanings of these terms for different people. Well-being is a fuzzy concept (Coulthard *et al.*, 2011). Research in a wide range of developing countries shows that using such subjective line of inquiry usually results in a wide range of responses where relational factors such as having a peaceful community often emerge besides the usual objective factors such as income and assets (Coulthard *et al.*, 2011). This study also aimed to elicit these socially generated meanings from households of different wealth classes. Data from the household survey were also supplemented with qualitative data from the livelihood trajectory interviews that provided deeper insights into individuals' struggles and aspirations.

6.3 Results

6.3.1 Differential livelihood adaptation strategies to socio-ecological change

This section examines how households of different poverty levels in the two villages adapted their livelihoods to the socio-ecological changes, in the form of farming system transitions, thus, addressing the first research question under Objective 3. Table 6.1 shows the numbers of households in each wealth class, their mean agricultural land ownership and common livelihood strategies at individual and household level. Figures 6.1 and 6.2 present the percentages of households within each class involved in different livelihood activities both before and after the transition in farming system. It should be noted that these figures only illustrate if one or more members of a household were engaged in the given activity, irrespective of the scale and income from that activity.

Table 6.1 Common livelihood strategies of households of different wealth classes in the two study villages

Wealth class	Households surveyed	Average farm land (acres)	Individual livelihood strategies (Adult males only) (at the time of study)	Household livelihood strategies (at the time of study)	Household livelihood strategies (before transition in farming system)
Kamarkhola					
Rich	9 (6.0%)	15.54	Agriculture – 58% Agriculture and service – 11%	Reluctantly engaged in agriculture or dependent on land rent; planning to move towards semi-intensive shrimp farming	Specialisation in shrimp cultivation, with less focus on paddy
Upper middle	56 (37.3%)	5.97	Agriculture – 64%	Within farm strategic diversification – crops, Galda prawns and white fish	Specialisation in shrimp cultivation, with less focus on paddy
Lower middle	58 (38.7%)	2.20	Agriculture – 49% Service – 11%	Strategic diversification comprising of farm and non-farm activities	Dependent on shrimps; leased out land, had small independent farms, or part of co-operative farms
Poor	43 (28.7%)	0.58	Agriculture – 17% Agriculture & wage labour – 38% Wage labour 12%	Diversification for survival	Dependent on shrimps; leased out land, had small independent farms, or part of co-operative farms
Extreme poor	30 (20%)	0.13	Agriculture & wage labour – 14% Wage labour 48%	Depended on physical labour	Depended on physical labour
Mithakhali					
Rich	7 (4.7%)	22.53	Aquaculture & business – 29% Business – 24% Aquaculture – 12%	Specialisation in shrimp and fish cultivation, with associated business	Shrimp and paddy cultivation, with most income generated from shrimp
Upper middle	18 (12%)	7.36	Aquaculture – 63% Service – 16%	Specialisation in shrimp and fish cultivation, with some involved in service	Shrimp and paddy cultivation, with most income generated from shrimp
Lower middle	52 (34.7%)	3.78	Aquaculture – 47% Aquaculture & small business – 10% Small business – 10%	Dependent on shrimps and small businesses; lease out land, have small independent farms, or part of co-operative farms	Diversified livelihood comprised of crops, shrimps and white fisheries for subsistence
Poor	50 (33.3%)	1.42	Aquaculture – 37% Service – 10% Aquaculture & small business – 8%	Dependent on shrimps; lease out land, have small independent farms, or part of co-operative farms	Diversification across farm, off-farm and non-farm activities for survival
Extreme poor	23 (15.3%)	0.04	Wage labour – 40% Small business – 17% Van driver – 10%	Depended on physical labour and petty trades	Depended on physical labour and petty trades

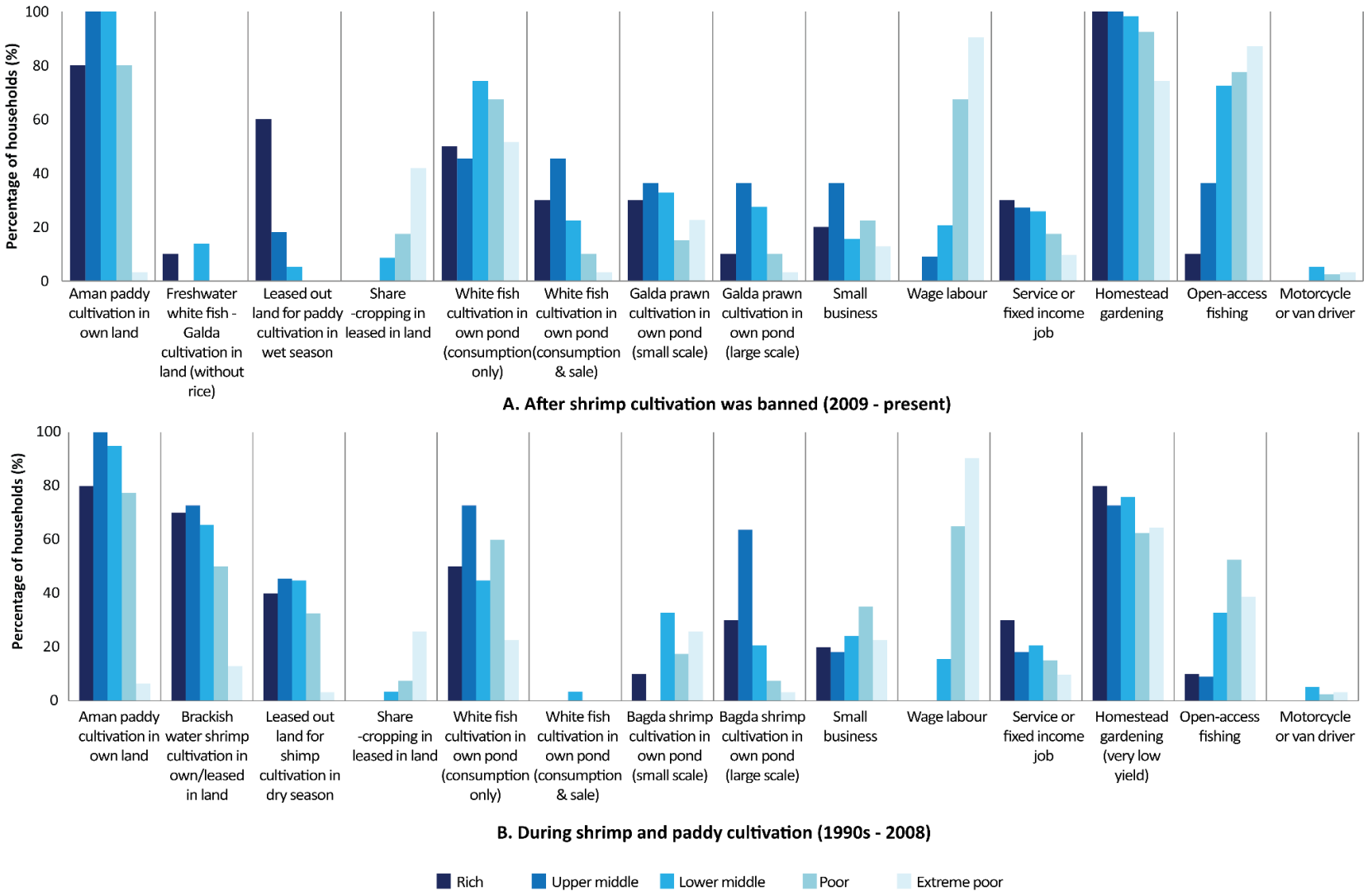


Figure 6.1 Livelihood strategies pursued by households of different poverty levels in Kamarkhola after (2009 – present) and before (1990s – 2008) changes in farming systems

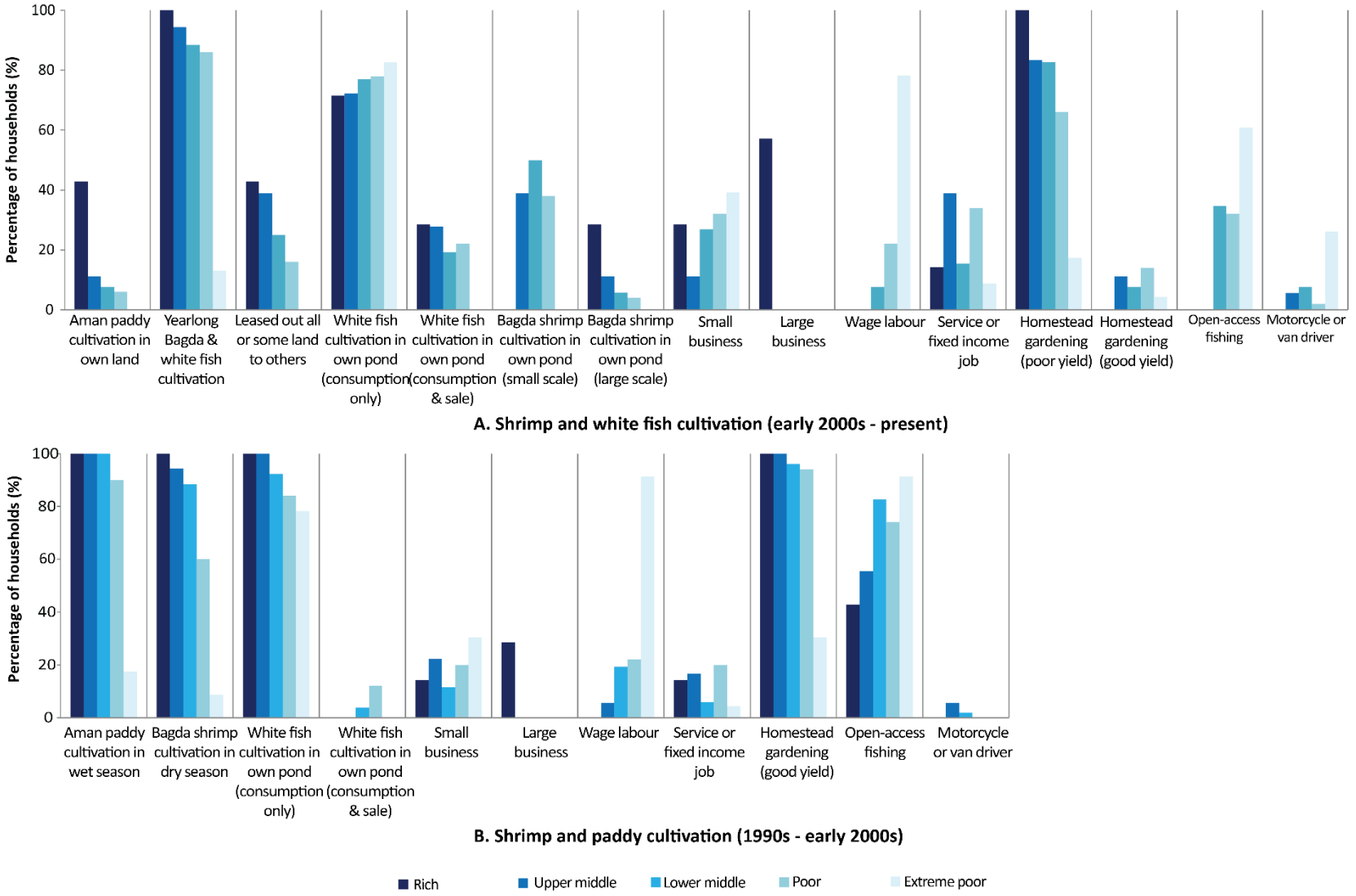


Figure 6.2 Livelihood strategies pursued by households of different poverty levels in Mithakhali after (early 2000s – present) and before (1990s – early 2000s) changes in farming systems

Rich households

Rich households, endowed with large amounts of agricultural land, usually wanted to specialise in one activity that had high economic returns. In Kamarkhola, during the shrimp-paddy rotational period, most rich households cultivated brackish water shrimp on their own land during the dry season (70%) and grew Aman paddy during the wet season (80%) with a low yield of 0.7 tonnes per acre. About 30% leased out all their land to others for shrimp cultivation, while 10% leased out some land (Figure 6.1). During shrimp cultivation, these large landowners usually acted as managers or entrepreneurs, taking decisions, supervising accounts, and monitoring hired labour at post-larvae release and shrimp harvesting times. The economies of scale from large amounts of land resulted in more income per unit land and any losses due to disease outbreaks in one of the post-larvae batches could be compensated for by releasing another batch. Thus, these households were able to enjoy higher profits with minimum time or labour involvement. After shrimp cultivation had been banned in Kamarkhola, some rich farmers (60%) leased out most of their land for paddy cultivation while others were reluctantly diversifying their livelihoods by cultivating freshwater prawns cum paddy and rearing livestock, like others. Paddy cultivation required greater investment of time and labour, with relatively lower incomes, making it less appealing for rich farmers to do on their own. Compared to other wealth groups, a larger proportion of rich households (30%) were engaged in the service sector and some activities like wage labouring, fishing in open-access canals and sharecropping were almost absent in this group (Figure 6.1). At the time of study, the two most common livelihood activities of adult male members in these households were agriculture (58%) and agriculture cum service (11%).

> "My father had 66 acres of land, which I inherited after he passed away. I completed my master's in 2004; if I stayed back in the city I could have earned about BDT 25,000 per month as a service holder. But I chose to return to this village because I believed that the shrimp business had greater prospects. I used to earn BDT 100,000 – 200,000 every month, just by selling the shrimps from my farm. I never worked in the field, but I visited my farm every day to ensure there was no theft. After the ban, I leased out most of my land to sharecroppers. It's not possible for me to grow paddy in such large amounts of land; I have never done it. I'm thinking of starting a semi-intensive shrimp farm if I can get some loans. I heard the government is giving industrial loans to boost this sector. I have seen a friend earn up to BDT 50 million in a year from semi-intensive farming." – Lelin (male), rich farmer, Kamarkhola.

In Mithakhali, at the time of study, all rich households were engaged in yearlong shrimp-white fish farming as their primary activity. As these households had large amounts of agricultural land (22 acres on average), some of them even leased out a portion of their land

to others and earned annual rents. The large land ownership meant that not all land was located in the same region; hence, variation existed in terms of soil fertility and topography. Thus, almost half of these households (43%) were also able to grow Aman paddy on small portions of their land – an opportunity which was not available to households of other classes. However, the yield of paddy was as low as 0.4 tonnes per acre. Large scale Bagda shrimp and white fish cultivation was also carried out by some (29%) in homestead ponds, while others only cultivated white fish for consumption. A large number of these households (86%) were also engaged in small or large business, mostly related to fish trade, which served as their secondary income source. At the time of study, about 63% of rich adult males were involved in aquaculture cum business, aquaculture only or business only. Before the transition in farming system, these households cultivated Bagda shrimp during the dry season followed by Aman paddy during the wet season. Pond-based white fish cultivation and homestead gardening were also undertaken for household consumption only. Compared to the time of study, when none were involved in catching fish from canals, about 43% of rich households caught open-access fish for consumption in the past (Figure 6.2).

Upper middle class households

In Kamarkhola, upper middle class farmers who had sufficient amounts of land (6 acres on average) or ponds (0.22 acres on average) usually pursued within farm diversification. In this case, diversification was often a matter of choice, where the households strategically deployed resources to different activities to obtain optimum returns. At the time of study, all households carried out paddy cultivation on their own land, with 18% of households leasing out some of their land under sharecropping arrangements. Given their relatively large ponds, many of these households cultivated white fish and Galda prawn at a commercial scale (45% and 36%, respectively). While all households also grew vegetables in their homestead gardens, fishing in open-access water bodies was less common in this group, compared to the lower three groups. During the shrimp-paddy rotational period, about 45% of upper middle class households leased out some of their land to others; however, while the poorer groups leased out land due to lack of profits from small parcels or inability to invest, these households leased out land as a form of exchange. On one hand, they leased out small parcels that were located amidst others' lands and on the other hand, they leased in land that was situated within their own large parcels. Most of them either had their own big shrimp farms (36%) or were part of a co-operative farm (36%). During this period, these households mainly used their ponds for Bagda shrimp cultivation, with small amounts of white fish for consumption only.

In Mithakhali, at the time of study, most of the upper middle class households (94%) were engaged in yearlong shrimp-white fish cultivation, while households that have their heads involved in service had leased out some or most of their land to others. The numbers of service workers were highest in this category, with 39% of households having at least one member involved in service and 19% of adult males involved in service and aquaculture or service only as their as their main occupation. Most households cultivated white fish in their ponds for consumption (72%); while some (28%) did so for sale as well. About 50% of households also grew Bagda shrimp on a small or large scale. Before the farming system transition, these households farmed Bagda shrimp during the dry season followed by Aman paddy in the wet season and also cultivated white fish in their ponds for subsistence. While, at the time of study, none of these households were involved in catching open-access fish, about 56% used to do so before the transition.

> "Till 1995, I cultivated Aman paddy in the 11 acres of land that I have inherited from my father. At that time, I used to obtain about 0.9 tonnes of rice every season; however, as the yield started to decline due to rising salinity, I started dry season shrimp cultivation like other landowners in the village. Shrimp cultivation was a very profitable livelihood option in the beginning; about 1000 post-larvae used to provide a harvest of 400 kg of shrimp after 3 months. However, when other landowners started to realise the benefits from white fish cultivation as well, they trapped water in their lands all throughout the year, which prohibited paddy cultivation by other farmers. Continuous waterlogging led to decline in soil fertility, which in turn, resulted in decrease in shrimp productivity. Now out of 1000 post-larvae only 200-300 survive till the harvesting time. For the last couple of years, I have been trying to cultivate some paddy; I leased in 2 acres of land and obtained a total yield of 0.7 tonnes, of which 0.35 tonnes were given to the land owner as per the contract. I also earn a fixed salary from my teaching job and overall my financial position is much better than most people in the village. However, those who rely solely on shrimp are not in a good financial position." – Rezaul Karim (male), upper middle class farmer, Mithakhali.

Lower middle class households

This category comprised of the largest percentage of households in both villages. The lower middle class households had moderate amounts of agricultural land and homestead ponds. In Kamarkhola, 45% owned 1-2 acres of land and 48% had between 2.3-4.6 acres. These households tried to make optimum use of these resources; at the time of study, all lower middle class households in Kamarkhola engaged in Aman paddy production on their own land, three-quarters of them grew white fish for consumption and about one-third even reared Galda prawns on a small scale. Those who had larger ponds also cultivated white fish and Galda prawns on a large scale for sale. Interestingly, 14% of these households were trying out land-based Galda prawns with white fish cultivation – a farming system that is uncommon in the area. At an individual level, about 49% of adult males were exclusively

involved in paddy cultivation on their own or on leased in land, 11% were service workers and 7% were involved in agriculture cum service. During the shrimp-paddy rotational system, about 45% of these households leased out some or all of their land to others, while others had their own small farm (31%) or were part of a big co-operative farm (19%). Like other categories, the percentage of households involved in homestead gardening and catching fish from canals was much lower during the shrimp-paddy rotational period. However, relatively more households were involved in small businesses, as buying and selling post-larvae or mature shrimp were important activities for many in this group.

> "I have 3.3 acres of land, in two equal parcels at different locations. In one of the parcels, I have started integrated rice and fisheries polyculture farming. During the wet season I cultivate Aman paddy along with freshwater Galda prawns and a variety of white fishes on the same land and also plant vegetables, such as brinjals, on the dykes. I feel that this system is much more sustainable and profitable, as Galda shrimp and white fishes are not susceptible to diseases like the saline water Bagda shrimps. I use the other land parcel for paddy cultivation only. Fish cultivation requires regular supervision; since that land is quite far away from my home, I cannot go there every day. In addition, I have a grocery cum food store at the local market. About four years ago, I borrowed BDT 50,000 from a NGO, which I repaid in ten instalments of BDT 5000 each along with BDT 1000 as interest. During the shrimp cultivation period, I was also involved in Bagda farming for about 10 – 12 years, like other farmers in the village. However, I faced significant losses due to virus outbreaks in my farm. I'm very happy that shrimp cultivation has been banned in this area. Now the environment is much better." – Yasin Gazi (male), lower middle class farmer, Kamarkhola.

In Mithakhali, at the time of study, most of the lower middle class households (88%) engaged in yearlong Bagda shrimp and white fish cultivation, while others leased out all their land and were solely involved in business or service. Among those who were engaged in aquaculture, 52% had their own small farms, 13% had their own large farms together with land leased in from others and 21% were part of co-operative farms. The majority of households cultivated white fish for consumption (77%) and Bagda shrimp at a small scale in their ponds (50%). At an individual level, most of the adult men were involved in aquaculture only (47%), while some were engaged in aquaculture with business (10%) or business only (10%). Before the transition in farming system, most households were involved in Bagda shrimp cultivation followed by Aman paddy (88%), while the rest left their land fallow during the dry season. During that time more households engaged in catching open-access fish (83%) and homestead gardening (96%), mainly for subsistence.

Poor households

Given the limited asset endowment of poor families, livelihood diversification at household level usually involved engaging in any available options, even if at a smaller scale. In Kamarkhola, at the time of study as well as during the period of shrimp cultivation, poor

households were typically involved in five to six different farm and off-farm activities. According to the household survey, poor families had about 0.58 acres of agricultural land on average, with 20% having no land and 47% having between 0.33 to 0.66 acres. About 80% of the poor cultivated Aman paddy on their land during the wet season with an average yield of 1.3 tonnes per acre and about 18% leased in about 0.38 acres on average on sharecropping contracts. Besides crop cultivation, a major proportion of these households (68%) had at least one adult male member working as a wage labour. For subsistence, most households grew vegetables in their homestead gardens (93%), cultivated white fish in their own ponds and also caught fish from open-access water bodies (78%). However, given the small amount of homestead land (about 0.11 acres on average) and ponds (0.04 acres on average), the yield was very low. A relatively smaller proportion of households had at least one member involved in service (18%) or small businesses (23%).

During the shrimp-paddy rotational system, about a third of these households leased out all or most of their land to others for shrimp cultivation during the dry season, while about half of them carried out their own cultivation as small independent farms (12.5%), as part of large co-operative farms (32.5%) or as large independent farms with land leased in from others (2.5%). Since shrimp cultivation was riskier and less profitable on smaller farms, poor households mostly chose to obtain rent from land or be part of a larger co-operative farm, rather than doing it independently. About 20% of households also worked as wage labours on shrimp farms or brought shrimps from farms and sold them at the market. Compared to the time of study, relatively fewer households were involved in homestead gardening or white fish farming because of increased soil salinity, or catching fish because most canals were blocked by private shrimp farmers. In terms of livelihood strategies at individual level, most adult male members were farmers and wage labours (36%), while some were only farmers (17%) and some were only wage labours (12%).

> "Poor people like us have to do a bit of everything to survive. I have leased in 0.66 acres of land from my aunt, for which I have to pay an annual rent of BDT 10,000. In February-March, I released 21,000 post-larvae in 11 batches at a cost of BDT 600 – 900 per 1,000 post-larvae. But viral attacks killed most of them; I lost my investment and now I don't know how I'll pay the rent or repay the loans. In June, I also invested BDT 16,000 to release 111 kg of white fish in my small pond (0.45 acres) for consumption as well as sale; they are my last hope. During December-January, I grow some vegetables in my homestead garden and from April-June, I harvest shrimps from others' farms. I receive about BDT 30 for a kg of brinjals and BDT 50 for every kg of shrimp I harvest. Only Allah knows what will happen to us." – Alamgir Hosssain (male), poor farmer, Mithakhali.

In Mithakhali, most poor households either had small independent shrimp farms or were engaged in co-operative farms (86%), while some had leased out their land. Before the

farming system transition, these households cultivated shrimp in the dry season (60%), followed by paddy in the wet season (90%). Compared to the shrimp-paddy system, at the time of study, more households were involved in the service sector (34% vs 20%) and had small businesses (32% vs 20%). Involvement in other activities, like pond-based white fish/shrimp farming and wage labouring, remained the same, while homestead gardening and catching open-access fish had declined.

Extreme poor households

Compared to the other groups, farm level diversification was limited among extreme poor households as they had no agricultural land of their own, very little space in their homestead area to grow vegetables and very small ponds to cultivate fish. In Kamarkhola, the main livelihood activity of this group was wage labouring (90%) followed by sharecropping on land leased in from others (42%) and petty businesses (23%). During the shrimp-paddy rotational system, the proportion of households involved in homestead gardening and catching fish from open-access water bodies was much less due to increased soil salinity and encroachment of canals by private farmers. Moreover, the percentage of households involved in sharecropping was also lower, as better-off households were unwilling to lease out their land and the yield from paddy was also very low. Only 13% of households carried out small-scale shrimp cultivation, mostly on leased in land, while most of them worked as wage labour preparing land for shrimp cultivation or harvesting shrimp from farms.

> "My husband (aged 50) is the only bread earner; since we never had any agricultural land, his only source of income is wage labouring. Depending on work availability, he works on others' farmland during sowing and harvesting season, cuts mud at government funded local construction work, and loads and unloads goods at the market. His daily income ranges from BDT 50 – 250; many days we have to survive on one small meal only. He cannot even migrate to other districts as we have two disabled members in our family – one is my middle child, who is mentally handicapped and the other is my mother-in-law who is physically paralysed. We cannot even grow vegetables at home as there is no space or rear livestock as we have no paddy husks to feed them. My economic situation has always been the same, but things are better now in certain aspects. Now that the canals are no longer under private control, I can catch fish for subsistence. I can also collect cow dung from the grazing lands for use as cooking fuel. Moreover, after cyclone Aila, a NGO built a nice house for us, which is much better than the one that had been destroyed." – Sufia Gazi (female), extreme poor housewife, Kamarkhola.

Like Kamarkhola, extreme poor households in Mithakhali also combined off-farm income as wage labour (78%) and non-farm income from petty businesses (39%) to make a living. The proportion of households involved in small businesses was highest for this class; business for these households usually involved buying shrimp from the farms and selling them for a marginal profit at the market, trading shrimp post-larvae or owning a small tea/ grocery

shop. In terms of involvement with shrimp cultivation, only 13% of households with agricultural land between 17 and 40 decimals had their own small shrimp farms, 21% were engaged in buying and selling shrimp, 9% were involved as managers, security guards or wage labours on farms and a majority of 56% were not involved in any way. Since pond ownership was very limited (with 74% having between 2-5 decimals and 17% having no ponds), these households mainly used their ponds for cultivating small amounts of white fish for subsistence. Livelihood strategies for these households were quite similar before farming system transition as well; however, greater percentages of households were involved in catching open-access fish (91% compared to 61%) and homestead gardening (30% compared to 17%). Slightly greater numbers of people were also involved as wage labours because many worked in the shipyard at Mongla port during that time.

Figure 6.3 Livelihoods in Kamarkhola – (Left to Right) A farmer growing potatoes and leafy vegetables in his homestead garden; A farmer walking through his green paddy fields after harvesting Galda prawn; A household rearing cattle for sale in times of need [Photos taken during fieldwork in 2014]

Figure 6.4 Livelihoods in Mithakhali – (Left to Right) Freshly harvested white fish for sale; Agricultural fields flooded with brackish water for shrimp farming; Poor farmers repairing their fishing nets used to harvest shrimp and white fish from others' farms [Photos taken during fieldwork in 2014]

6.3.2 Factors affecting livelihood decision making

The livelihood strategies adopted by households of different poverty levels under differential vulnerability contexts have been discussed in the previous section. This section presents an analysis of the various factors that persuaded households to choose these strategies thus, addressing the second research question under Objective 3. While the previous section highlighted that ownership of productive assets and the prevailing farming system played key roles in determining households' livelihood strategies, a number of other factors, such as reducing risks of natural hazards and diseases, smoothening consumption through seasonal variation in income, taking advantage of complementarities between different activities and coping with dwindling returns from primary activity, often motivated households to design their livelihood portfolios in distinct ways.

Risk reduction

Reduction of risks, both climate-induced as well as market-related, is usually considered as the most important 'push factor' for diversification (Barrett *et al.*, 2001, Hussein and Nelson, 1998). Households often use their subjective judgment to anticipate the probability of success of the various income generating activities they are engaged in. In order to reduce the risk of failure, households may trade-off a given portfolio of activities with greater probability of failure and a higher total income with one that has a lower chance of failure but also has a lower total income (Ellis, 2000). This 'self-insurance' is regarded as *ex ante* risk management, in which people create a portfolio of activities across sectors or space that have low correlation of incomes. Although several forms of diversification were observed in the study areas, households rarely mentioned *ex ante* risk reduction as their motivating factor. This was because the main risk factor in these areas was increasing salinity in the dry season, which was *not* an unanticipated event. People had lived in this salinity regime for decades and were aware of the seasonal nature of salinity intrusion. Another risk factor was cyclones accompanied by tidal surges; however, while cyclones were totally unexpected, households did not include them as a factor in diversifying farm activities because in case of cyclones, such as Aila in 2009, everything is washed away regardless of the type of crop, fisheries or livestock.

However, households mentioned avoidance of risks associated with shrimp viral attacks as a motivating factor for not being engaged in the farming process directly. For instance, Faridul Huq, an upper middle class farmer in Kamarkhola mentioned that, during shrimp cultivation period, he used to lease out his entire 6 acres of land to other large shrimp farmers, as he

never wanted to get involved with the risk associated with the shrimp business and hence, chose to rely on the fixed income from land rent. In contrast, in some cases, although diversification towards off-farm and non-farm activities certainly reduced risks, the primary motivation was not risk reduction. For example, in the case of the upper middle class farmer mentioned in section 6.3.1, his fixed salary from a teaching job helped to maintain his household income in years when viral attacks caused mass mortality of shrimp on his farm. For him, diversification indeed insured him against crop failure; however, his involvement in teaching was a result of his education (human capital), rather than a risk reduction strategy.

In Kamarkhola, diversification was used as an *ex post* coping strategy following cyclone Aila. In this case, livelihood diversification was an unplanned and involuntary response to disaster, which was mostly adopted by poor and extreme poor households. In the aftermath of the cyclone, when the whole village was inundated for months, poor people found a new livelihood source – fishing in open waters. Fishing in common water bodies was not possible during the shrimp cultivation period as canals were under the control of large shrimp farmers. However, during Aila, the tidal surge brought in lots of fish and destroyed all private farms and gates. Poor people living on the embankment caught fish every day, which generated an income in the absence of agricultural activities within the village.

Seasonality

As most households in rural areas are engaged in farm and off-farm agricultural activities, seasonality is an inherent characteristic of their livelihoods. Diversification can be an optimal strategy when some factors of production such as land or labour remain under-utilised due to seasonal or market variations (Paavola, 2008). For example, in the study areas, due to scarcity of freshwater, all agricultural land traditionally remained fallow during the dry season (January to June). Early shrimp farmers considered this as an opportunity to make use of the land by cultivating brackish water shrimp during this time.

Moreover, households had to meet their continuous consumption needs even when income flows diminished. While drawing on savings or selling stored crops was a widespread means of dealing with income instability, the seasonal fluctuation in income was an important motive for diversification. Temporary migration to other agricultural zones was an example of how diversification was used to smoothen consumption. For example, between September and November, male members of poor households in both villages went to nearby districts or sub-districts to engage in government sponsored construction activities, such as embankment rehabilitation, road building or canal dredging. After harvesting and

storing their own Aman paddy in December-January, these people migrated to inward districts, such as Gopalganj, where availability of freshwater enabled cultivation of dry season Boro crops and hence increased labour demand.

Subsistence vs. cash income

Households may also seek to diversify their livelihoods because different strategies can cater for different household needs. While farm production can meet the subsistence needs of the family, cash income is needed to purchase essential goods and services, such as clothes, soaps, fertilisers, and pay school fees and health treatment costs. For example, an old farmer in Kamarkhola mentioned that traditionally farmers used buffalos to plough their land and applied cow dung on their soil, but now they used hired diesel tractors and purchased chemical fertilisers/pesticides. The need for cash drove people to engage in off-farm and non-farm activities, and also sell much of their farm produce. Even within the farm, households diversified their products; for instance, households cultivated white fish for subsistence and Galda prawn for sale.

The opposite can be true as well. While non-farm income can generate cash, rural households often prefer to consume their own produce rather than that purchased from the market. During an interview in Kamarkhola, a housewife mentioned that despite her husband's steady income from his teaching job at the primary school, the family decided to buy a small parcel of land so that they could grow their own rice, which was supposedly of better quality than that sold in the market. Another woman mentioned that she replanted the coconut trees after cyclone Aila, because home-made coconut oil was an essential product for cooking and skin care for her family.

Economies of scope

Diversification within farm activities often resulted because of the 'complementary' nature between the different activities. Poor rural farmers with low levels of capital often found it easier to add more activities associated with the primary livelihood option, rather than investing in new or non-farm areas (Hussein and Nelson, 1998). Barrett *et al.* (2001) terms this as 'economies of scope' which allows greater per-unit incomes when the same inputs are distributed across multiple outputs instead of a single one. For example, in Kamarkhola village, now that farmers had shifted from brackish water shrimp to paddy cultivation, it was possible to rear livestock as the cow dung provided manure for the crops and the hay served as fodder for the animals. However, in Mithakhali, where shrimp cultivation was still dominant, it was not worthwhile to rear livestock as additional food would have to be

purchased from the market. Another example was the integration of paddy, freshwater Galda prawns and white fish in agricultural fields in Kamarkhola (refer to narration of the lower middle class farmer in section 6.3.1). Multiple outputs from the same unit of land generated much greater incomes and subsistence than focusing on paddy alone.

Economies of scope can also be achieved when one engages in a business directly related to farm products or starts farming products that are bought and sold as part of the business. For example, Tariqul Islam, a crab businessman cum farmer in Mithakhali, was initially a trader who bought crabs from other farmers and sold them to depots in Khulna. Crabs were not intentionally farmed in Mithakhali, rather they were a by-product of shrimp cultivation. However, when Tariqul realised the potential profits from crabs, he started his own crab farm on 1.33 acres of land, making him the first crab farmer in the area. Now he had also developed connections with crab juvenile collectors; hence, besides buying by-product crabs from others, he also started supplying crab juveniles to these farmers, so that they could intentionally grow crabs on their farms. The crabs from his own and others' farms, in turn, increased the sales of his business.

Diminishing returns from primary activity

Dwindling profits from brackish water shrimp cultivation, due to viral outbreaks and poor soil fertility, was a major concern for all households in Mithakhali village. However, unlike Kamarkhola, stopping shrimp cultivation completely and moving towards freshwater based farming activities was not possible unless the powerful and large shrimp businessmen were willing to do so. Hence, although most households were against shrimp farming, they were forced to do so as the high soil and water salinity precluded other alternatives in most cases. Yet, some farmers were trying to restart paddy cultivation and homestead vegetable gardening wherever some high lying land parcels were available. Some were even experimenting with freshwater Galda prawn, although it was not the norm in this village. More people were willing to establish small businesses such as fish stores, poultry farms or grocery stalls, as additional income sources.

Another means by which shrimp farmers were trying to cope with the decreasing shrimp yields was by intensifying the cultivation process. During the 1980s, shrimp farmers practiced the traditional no-stocking extensive method, in which only the natural shrimp post-larvae that entered the farms during high tides were grown and harvested on maturity. Farmers sometimes supplemented these with natural post-larvae gathered by fry collectors from the mangrove forest. However, to cope with the decreasing availability of natural fry

and to increase yield, farmers started to release hatchery-bred post-larvae in the mid-1990s, which were relatively less expensive than the natural ones sold by fry collectors but more susceptible to diseases. Continuous inundation by saline water had degraded the soil quality to such an extent that it could no longer support the phytoplankton that the shrimp fed on. At the time of study, farmers reported increasing the frequency and amount of post-larvae released on the farms to compensate for lost yield. Many also started to add supplementary feed and chemical fertilisers to improve soil quality.

6.3.3 Livelihood trajectory analysis

The comparison of households' livelihood strategies at two different time periods and the analysis of the diverse factors influencing these decisions, in the previous sections, have produced an overall picture of the impacts and adaptation responses of different poverty groups under changing vulnerability contexts. This section analyses individual livelihood trajectories to obtain a deeper understanding of the sequence of livelihood strategies and outcomes and the various factors that shaped upward or downward mobility, thus, addressing the third research question under Objective 3.

Upward trajectories

Analysis of the livelihood trajectories of farmers of different poverty levels revealed that increased ownership of agricultural land, profits from shrimp/fish trading and diversified income sources were the most important determinants of increases in wealth status. However, these factors did not operate in isolation and were intrinsically linked to one another. Households with sufficient amounts of farmland were able to earn significant profits from shrimp cultivation during the 1980s and 1990s, when shrimp yields were high due to good soil quality and an absence of disease outbreaks. These households were able to use these profits to purchase additional land at a time when land prices were much lower. The household survey data showed that of the 150 sampled households in Mithakhali, 45 households (30%) had purchased land in the last three decades, although the quantity varied significantly from 0.66 to 38 acres, with a median of 1.32 acres. If disaggregated by wealth status, 5 of the 7 rich households (71%), 8 of the 18 upper middle class households (44%), 19 of the 52 lower middle class households (37%) and 12 of the 50 poor households (24%) had purchased agricultural land. Thus, many of the better-off households were in their current socio-economic situation because of land accumulation in the past.

Land ownership not only led to increased income from farm activities, but also allowed households to invest in high return non-farm activities, such as retail shops or fish depots,

that required significant start-up costs. Moreover, diversification could be achieved by deploying different parcels of land for different uses, allowing households to earn fixed annual rents besides the fluctuating incomes from shrimp. Cash from multiple sources provided funds for investment and cushioned these households from shocks and stresses.

> "I inherited about 5 acres of land from my father. Since the late 1980s, I used to cultivate Bagda shrimp and paddy in my land. The paddy was mainly for household consumption. I used the cash from Bagda shrimp for purchasing more land. Gradually, I increased my land ownership over the years and today I have around 30 acres. At that time the price of land was very low. One acre of land cost about BDT 15,000, whereas now the market price is BDT 600,000. At that time, only a few people were engaged in shrimp cultivation; others used to depend on rice farming only and were quite poor. My 30 acres of land is separated in 4-5 parcels. I have three shrimp farms of 10 acres, 6 acres and 3 acres, which I manage on my own. The rest of the land is either leased out to others or used for farming under cooperative system. Although profits from aquaculture are now decreasing, I do not have much problem because I have my own farms. I do not have to pay rent to others and I use my savings for investment. I do not take any loans from NGOs or others. I have my own fixed deposits in bank and if I need money, I take loan against those deposits. Financially I'm much better off than before. I also have a shop in the village market. Previously, I used to buy wholesale goods from Khulna and sell them here. Now I have rented out my shop." Humayun Rashid (male), upper middle class farmer, Mithakhali.

There were also examples of people who solely used their incomes from shrimp or fish trading to purchase large amounts of land that pulled the whole family out of poverty and ensured financial security for the next generations.

> "I have 65 acres of land, which I have now divided among my six children, as I'm too old to work now. I didn't get anything from my father, I purchased all these land using the money I earned from fish trading during the 1970s and 1980s. At that time, only a handful of people cultivated shrimp using natural post-larvae from the mangroves, while many people caught mature shrimp and white fish from the rivers. I used to buy those fish and sell them at my own depot in Rampal (nearby sub-district). In mid 1990s, when I had enough land, I started my own farm and used the money to educate my children. Four of them are now service job holders in Mongla and Khulna (nearby town and city) and have income security in times of dwindling shrimp yield." - Amin Sheikh (male), a rich farmer, Mithakhali. In contrast, the percentage of households that had bought land and the amount of land purchased were significantly less in Kamarkhola. In the past three decades, only 17% of the survey households had purchased between 0.08 – 1 acre of agricultural land, with a median value of 0.66 acres. Of the 25 households that had purchased land, 13 belonged to the lower middle class and 9 belonged to the upper middle or rich class. The market demand for land was comparatively much lower in Kamarkhola because it is a relatively remote area with poor physical access to regional market hubs.

Downward trajectories

Division of land among siblings, sale of land for consumption or investment purposes, decline in aquaculture yield and business failure were identified as main determinants of a

decline in wealth status. Other factors such as debt servicing and natural hazards were mentioned by a couple of respondents. The household survey data showed that in the last two decades, 40% of households in Mithakhali had lost a median of 4 acres and an average of 4.8 acres of land due to division of inherited property. Similar statistics are observed for Kamarkhola as well.

There were a number of cases where the respondents identified their parents' or own consumptive behaviour and/or laziness as causes for selling land that led to increased poverty in the long-term.

> "My father had 60 acres of land and at that time our family was in a good financial position. About 25- 30 people, mostly extended relatives and resident labours, lived in our house at that time. My father later sold most of the land and spent the money for household consumption. It was not in my father's nature to save money and plan for the future; my father sold assets from time to time and enjoyed life. I was not hard working either; I spent most of my early adulthood as a football player. I got jobs at times, but my father didn't allow me to work under others. After the death of my father in 1965, I inherited about 3 acres of land." – Komor Uddin Gazi (male), lower middle class farmer, Kamarkhola.

Some people also sold land to generate funds for investing in non-farm activities. However, business failure ultimately pushed these households deeper into poverty.

> "In 1985, I started brackish water shrimp cultivation in 10 acres of land under a co-operative system. At that time, I faced huge losses because like other people in this area, I had no experience about shrimp farming. To cope with the losses, I sold 3 acres of land between 1988 and 1990 at a price of BDT 15,000 per acre. Then I decided to shift from farm based livelihood to business, which would provide a more stable income. I sold another 3 acres and went to Jessore to start a flat rice (chira) mill, along with a partner. However, I could not gain any profits from this business; when I went there I took BDT 15,000 with me for investment and when I returned after three years I was empty handed. Now I cultivate shrimp in the remaining 4 acres, but the yield is very low." – Rafiqul Islam (male), lower middle class farmer, Mithakhali.

Poor yields from shrimp cultivation, rising soil salinity and division of land among siblings were often cited as the common factors of downward mobility.

> "After the death of my father I was solely responsible for looking after the 50 acres of land he left behind, as my brothers were too young at that time. In 1999, I started brackish water shrimp cultivation like other farmers in the village. The high market price of shrimp and the prospect of earning additional profit in the dry season lured me into this business. Although he owned a lot of land, he leased in additional land and formed a big farm of 200 acres. In the first year, I invested about BDT 1,200,000; I myself took a loan of BDT 300,000 from Krishi Bank, while the rest was provided by a business partner. Most of this money was used to provide rents for land that I leased in from others. In the beginning, the profits were equal to the investments; but from the second year I started to face huge losses due to virus attacks. Despite initial losses, I was hopeful that I would earn profits in the following year. After a couple of years, I started to provide additional feed to the Bagda shrimps. I also consulted

some experts from the Fisheries Department, but they could not specifically identify any problems. In the 8 years that I was involved in shrimp farming, I never earned any profits. Although my business partner was willing to continue, I was adamant and forcefully stopped the shrimp farming in 2008. I think it's my poor fate, while others say that the soil quality of the land was poor. Till today, I could not repay my loan and the bank filed a case against me. In 2005, I divided my father's land among my siblings and now I'm left with 10 acres. The 2009 cyclone Aila caused another financial shock, as I lost my house and could not plant crops for two years. I left the village and went to live in my father-in-law's house at Chalna. As the farmlands stayed inundated for two years, the soil salinity increased significantly. "Ekebare bish hoye gese mati" (The soil became toxic). Now I get around 7 tons of rice each year, which is comparatively lower than other farmers in the area." – Mostofa Gazi (male), lower middle class farmer, Kamarkola.

Similarly in Mithakhali, changes in farming system from subsistence crops to cash crops and successive business failures often led to a vicious cycle of poverty and indebtedness.

"I never had my own land, but till the early 1990s I worked as a sharecropper. At that time, an acre of land yielded about 1.2 tonnes of paddy; after giving half of the yield to the landowner, I used to keep 60% of the remaining paddy for household consumption and sell the other 40%. We had 4-5 cattle, a dozen hens and lots of vegetable plants in our homestead area. There was little cash but we were much better-off. When shrimp cultivation started, landowners were no longer willing to lease out land for sharecropping. So I used my little savings as well as some loans from relatives to start a small tea stall in the village market. The business was not running well and so I stopped it. For the next 4-5 years, I worked as a wage labour in and around the village. Then in the late 1990s, my wife obtained a loan of BDT 5,000 from a NGO, for which we had to pay an interest of BDT 125 per week. I started grocery business with that money; however, that business was also a failure. I took another loan of BDT 8,000 from a different NGO to repay the first one. About 6 years ago, I started a poultry business in partnership with a relative. There was a fair in the village once and I earned BDT 7,000 in a week. But few months later, all my chickens died of disease and I became totally helpless. We restarted the business with new loans and as of today I have a debt of BDT 23,000." – Rokon Gunda (male), extreme poor farmer, Mithakhali.

Steady trajectories

While diversification of income sources was identified as a determinant of upward mobility for some people, for others it was simply a means to cope with diminishing returns from their primary livelihood strategy; hence, for these latter households, diversification helped in maintaining their wealth status rather than leading to asset accumulation.

"I tried a number of different livelihood strategies in my lifetime, but overall my wealth status has remained unchanged in the last three decades. Around 1988, after I dropped out of secondary school, I used to work as a day labour and earn around BDT 800 per month. Of the 3 acres of land owned by my father, 1 acre was leased out for BDT 2100 per year and the other 2 acres were used for shrimp cultivation. About 3000 post-larvae used to be released in the 2 acres of farmland, which yielded four harvests of 70 kg each. Besides running our own shrimp farm, I was also involved in shrimp business. I used to buy shrimp directly from the farmers and sell them in the market at a price of BDT 190 per kg (for head-less type) and BDT 270 per kg (for head-on type). The cumulative income from my own shrimp farm, the

leased out land and the shrimp business was sufficient to run a family of 4-5 members at that time. I saved some money from these sources and purchased about 1 acre land in 2004 for BDT 70,000. But in 2002, I got married and started my own family, which increased my household expenses. My father's lands were divided among my brothers. Moreover, the shrimp cultivation and business is not going well for the last 4-5 years. Now I release 4000-5000 post-larvae per acre and get only about 5 kg per harvest. Since water cannot be exchanged in small farms, fish die due to changes in pH and oxygen concentration. To cope with the declining productivity, I started a small poultry farm in my homestead area, where I rear up to 250 chickens. I borrow the baby chicks, rear them and then sell the mature hens for a profit and repay the original chick owner. I earn up to BDT 5000 from this poultry business. In future, I plan to focus on white fish cultivation. Rather than relying on the traditional system, I intend to take loan and invest in establishing a proper fish farm where biological parameters will be monitored." - Jahangir Hossain (male), lower middle class farmer, Mithakhali

Although sale of land was associated with decreasing economic status, for some non-poor households, such strategies did not bring about changes in wealth status, as the money was used for other productive purposes that ensured financial security in the long run.

> "Both my maternal and paternal grandfathers were zamindars[4] and they had huge amounts of lands. Over time these assets were divided among their children and my father sold most of his portion to educate me and my siblings. Now we do not have much land and most of us are service holders, so we have a steady income from non-farm sources. So, our socio-economic situation is more or less same." – Tariqul Islam (male), upper middle class farmer, Mithakhali

The extreme poor and poor households in fact comprise the vast majority of people whose wealth status remained unchanged. ,

> "We have always been poor. We do not have any assets other than this small patch of land where we live. My husband, who works as a wage labour as well as a van driver, has been the only bread earner of the family. Some days he would earn about BDT 100-300, while on others he had no work. My elder son was never interested in education and dropped out after primary school. Now my husband cannot work as much as before due to age; but my son works as a wage labour now. We were never involved in other activities, as we never had any savings to start a new project. We don't want to take loans because we know we can't repay it; moreover, they won't give loans to asset less people like us." - Shikha Mondol, extreme poor housewife, Kamarkhola.

[4] In the Indian subcontinent, during the colonial period, zamindars were aristocrats, typically hereditary, who occupied enormous tracts of land and held control over the peasants, from whom they collected taxes for the British monarchy.

6.3.4 Implications for well-being outcomes

The socio-ecological changes and the associated changes in livelihood strategies had differential well-being outcomes. This section applies the social conception of well-being to analyse the material, social and relational dimensions of well-being, thus, addressing the fourth research question under Objective 3. Figure 6.5 shows the percentages of households reporting 'better-off than before', 'same as before', and 'worse-off than before' within each wealth class, as an aggregate of the different dimensions of well-being. The underlying reasons for these well-being outcomes are discussed below.

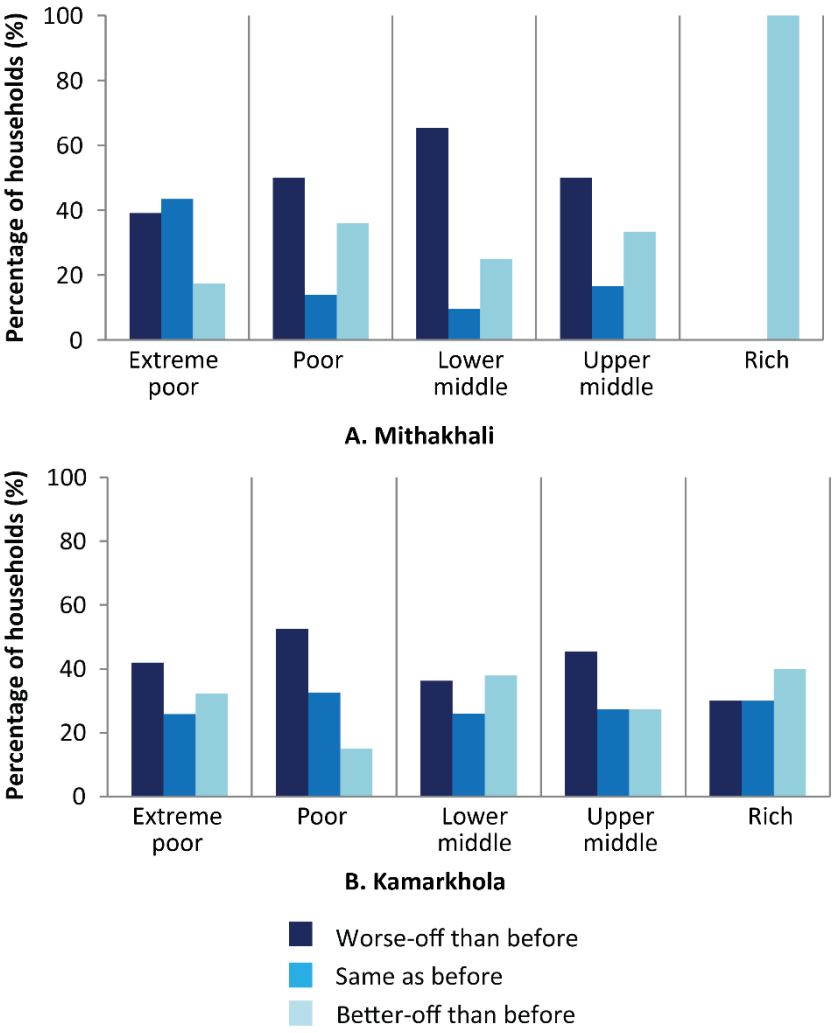


Figure 6.5 Changes in well-being of households in Mithakhali and Kamarkhola after respective transitions in farming system

Material dimension

The material dimensions of well-being received comparatively greater attention than the other dimensions, as income, food security and living standards, were the most basic needs for survival. In Mithakhali, all the rich households stated that their well-being had improved,

particularly due to accumulation of land in the past three decades, which allowed them to carry out shrimp and white fish cultivation on a large scale and also invest in high return non-farm activities. Similarly, households from other wealth classes mentioned good profits from shrimp or income from multiple sources as the main reasons for increased well-being. Other idiosyncratic factors included decrease in number of dependants and increase in the number of income earners as children had grown up and started to work.

> "The shrimp business has enabled my family, as well as many others, to escape from the poverty-stricken minimalistic rural lives. My father dropped out of primary school and worked as a medium-scale rice farmer during his 20s and 30s. Later shrimp farming allowed him to earn lots of money, which he spent to educate his children. Now my brother and I have good jobs in Khulna city, where we live with our families. We come to the village from time to time to supervise the managers who look after our shrimp farms". – Mahfuz Hasan (male), upper middle class farmer, Mithakhali

In Mithakhali, material well-being remained unchanged for a large percentage of the extreme poor households. As these people were never directly involved in farming and always depended on physical labour, changes in farming system did not affect them significantly. However, opinions on work availability varied, as discussed below. Among the upper middle, lower middle and poor classes, relatively smaller percentages of households mentioned similar levels of well-being in the two time periods, mostly because the balance between incomes and expenditures remained unchanged.

Compared to Kamarkhola, more households in Mithakhali stated that they were worse-off than before and the percentages were slightly higher for the middle income and poor households. On the one hand, these households were unable to grow rice or fish for subsistence, and on the other hand, their incomes from shrimp were decreasing day by day due to diseases and soil degradation. The common complaint was that soil salinity had increased so much that neither rice nor shrimp were growing well. A few people also mentioned that declining profits among farmers had led to decreases in land rents and profits from shrimp related businesses. Moreover, as most items were purchased from the market, household expenditures had increased. Some wage labourers were also facing decreases in work availability, firstly, due to lack of agricultural activities, and secondly, due to decline in jobs in the nearby port. While previously they could find work within the village, after the farming system transition they had to migrate to nearby sub-districts with two or three paddy crops a year. Since the supply of labour was greater than demand, many labourers had to work for lower wages. A few people also mentioned that the increased use of bamboo cages (locally called *'charos'*) for harvesting shrimp had lowered the need for labour in large shrimp farms.

In Kamarkhola, for almost all wealth classes other than the rich, more households considered themselves to be worse-off than before, particularly in the material dimension. This seems quite contradictory, given the fact that the majority of the people in this area were strongly against shrimp cultivation which had led to the ban in the first place. This was mainly due to three reasons. Firstly, although the ban on shrimp farming allowed rice cultivation along with white fish and livestock rearing, they had not completely settled in to this new form of life. At the time of the study, it had been only three years since farming activities had resumed after cyclone Aila and many households had not yet successfully started freshwater Galda prawn farming or livestock rearing on an economically beneficial scale. Secondly, of the 63 households who were worse-off than before, 36 acknowledged that although the environmental quality was better, the cash income from rice was much lower than the income from shrimp. Thirdly, households which were reliant on shrimp related businesses were earning lower profits as their trade was now solely reliant on other villages in the region. Some households also cited other general and idiosyncratic factors such as lack of work availability, general increases in prices of goods and services, illness or death of family members and decreases in land ownership.

> "During shrimp cultivation, millions of taka worth of goods would be carried along these rivers day and night. People had cash in their pockets, and they could purchase the goods they needed. Now it's difficult to get over that addiction to cash. I secretly farm shrimp in a small parcel of land outside the embankment. But there is no satisfaction in cultivating shrimps stealthily in such small amounts of land." - Oliar Gazi (male), rich farmer, Kamarkhola.

Among households that had a similar state of well-being as before, the most common reason was that the balance between income and expenditure was the same. For the rich, upper middle and lower middle class households, the large cash earnings from shrimp cultivation were replaced by smaller incomes from different sources. Some of them were also engaged in fixed income jobs causing their financial situation to remain unchanged. The poor, who were mainly small scale farmers and/or wage labourers, did not experience economic changes because the relatively small incomes from shrimp cultivation or land rent were similar to that earned from rice cultivation. Similar to Mithakhali, the change in farming system had no significant effect on some of the extreme poor households, as they had never been directly involved in farming and solely relied on their physical labour.

The households in all wealth classes who felt they were better-off than before mentioned the ability to grow rice, fish, vegetables and livestock for subsistence and/or sale as the primary reasons for their increased well-being. Some of these people were also facing

dwindling incomes from shrimp cultivation but were now benefitting from freshwater Galda prawn which are less susceptible to diseases. Another group of households were better-off than before because they had multiple livelihood activities, such as agriculture, business and/or service, which together generated a good income. A small number of poor and extreme poor farmers, who were previously dependent on wage labouring only, had now started sharecropping which provided rice for subsistence. Individual factors, such as an increase in number of working members, increase in salary or increase in land ownership had also improved the socio-economic situation for some households.

Relational dimension

While the material dimension referred to 'what people have', the relational dimension reflected 'what people can do with what they have', thus, emphasising people's freedom to act in ways that correspond to their own interests and values. In Mithakhali, majority of the farmers reported a loss of relational well-being, as large landowners used their power to shift from a shrimp-paddy rotational system to yearlong aquaculture based livelihoods. This suffocated the agency of smallholding farmers by trapping them in an undesirable farming system. People's words, tone of voice and facial expressions often reflected a sense of despair, injustice and frustration. The lack of autonomy in choosing livelihood strategies, the need to adhere to existing rules of farming, and the fears about long-term livelihood outcomes, were evident in some narrations.

> "Even if I want I can never stop shrimp cultivation on my own. As long as other farmers adjacent to my land are doing so, I have to do it as well. Recently, due to the oil spillage in Sheila River near the Sundarbans, the government is thinking of creating an alternative route by dredging our nearby Passur River. But no matter how much they dredge, each high tide will bring tonnes of sediment and raise the river bed once again. The only solution is to stop shrimp farming and cut all the dykes along the farms so that the silt and clay can be deposited on the land during high tide. You have to allow water exchange to occur in its natural way. If shrimp cultivation is stopped, the soil will start regaining its fertility in a year."
> - Abdul Kuddus (male), lower middle class farmer, Mithakhali.

There was a general lack of faith in institutions, such as, the national and local government and non-government organisations, and trust among community members and different actors in the aquaculture supply chain. Farmers faced losses from both ends; on the one hand, increased disease outbreaks were reducing shrimp yields, while on the other hand, farmers sometimes failed to receive a good market price for these produce.

> "I used to collect drums of shrimp from the farms and sell them at the depots in Khulna. Now I have stopped this business due to age; moreover, now the shrimp yields have decreased and many more people are involved in this business, so there is no profit. All the farm owners used to trust me with their shrimp, because they knew that I would repay them in

> time. The people at the Khulna depots used to tell me that they never found a bad fish in the drums I supplied. Even today, when I go there they hug me out of affection and respect. But nowadays, the middlemen are pushing gels and water into the shrimp to increase their weight and get more profits. But in the long run the European countries are identifying these adulterations and are now showing reluctance to buy our shrimp." – Mizan Khan (male), lower middle class farmer, Mithakhali.

In contrast, some considered the change in farming step a necessary transformation that enabled farmers to cope with the changing needs of society. Three decades ago, the population size was smaller and competition for natural resources was limited. People could spend their entire lifetimes within the confines of their village, with food sufficiency being the only concern. However, a better life in the new millennium necessitates cash for pursuing education, accessing proper health care, and purchasing consumptive goods, like TV and mobile phones. Thus, relational well-being improved, as cash from shrimp farming provided a freedom of choice.

In Kamarkhola, although material well-being remained unchanged or even worsened for some people, relational well-being improved significantly as people had the freedom to act in ways that were meaningful to them. People had confidence on the local government leader, who helped them take collective action against the outside entrepreneurs. Although a large number of households relied on micro-credit for investment in crops and fisheries, they perceived NGOs as profit making organisations that ripped the poor in the name of development. Well-being also involved 'living well together' as a community, rather than pursuing one's own selfish motives.

> "Those who say that they were better-off during the shrimp cultivation period are *"Lobon doshshu! Era noro poshu"* (Salt pirates! They are like predatory animals!). Shrimp farming only benefitted 5 out of 100 people, while the poor and landless suffered from poverty. If they asked for some fish, they'd be beaten up by the farm owner. But now if a hungry person comes to my door asking for rice, he does not return empty handed." - Mobarrak Hossain (male), lower middle class farmer, Kamarkhola.

Subjective well-being

Subjective well-being referred to 'what people think or feel about what they have or do'. In rural Bangladesh, rice farming traditionally formed an integral aspect of cultural identity. There was pride and satisfaction in being recognised as a successful rice farmer. Large landowners often served as informal village leaders and supported smallholding farmers in times of need. In Mithakhali, the inability of grow rice and the general shift in the social structure, led to a loss of subjective well-being.

> "We have been rice farmer for generations; we neither understand nor can do anything other than rice. After the harvest, my yard would be filled with piles of paddy and workers would be busy milling them. The paddy heaps were so high that our children would climb them to see the entire village. My homestead yard used to be filled with large buffalos that were used for ploughing the land. Now I have a couple of malnourished cows." - Faisal Kabir (male), upper middle class farmer.

The opposite was true was most farmers in Kamarkhola; the transformation in farming system led to a better environmental quality and greater peace of mind. Vegetation cover and soil quality improved over time. Although some farmers reported losses in prawn yield due to disease outbreaks, freshwater prawn cultivation was relatively less risky.

> "During shrimp cultivation, the roads used to be so muddy all the time that if you walked along your shirt would be spilled with mud. The air was very toxic, it felt as if we were inhaling chemicals. Now it feels great to have so many fruit trees around our house. Our children have something to eat. When a guest like you comes along we have something to offer." – Adnan Gazi (male), upper middle class farmer, Kamarkhola.

6.4 Discussion

This chapter investigated the livelihood dynamics and well-being outcomes of households of different poverty levels under the differential vulnerability contexts of the two study communities. The empirical evidence presented in this chapter emphasises the complex dynamic nature of livelihood adaptation and its implications for well-being. Firstly, households' livelihood strategies and outcomes are strongly related to their wealth status, with agricultural land ownership being the most important determinant. Secondly, the interactions between the different adaptation activities can lead to trade-offs, whereby successful adaptation by one household or wealth group can cause a subsequent reduction in another household or group's adaptive capacity in the community. Thirdly, Livelihood adaptation is a not a one-off response to a particular shock; it is a process occurring through linear time, where key decision making points influence the direction of change and responses based on evaluation of past outcomes and future goals. Fourthly, livelihoods are not only the means of survival or improving living standards; people's abilities to pursue activities that conform to their values and interests give meaning to their lives. The following paragraphs discuss these conceptual contributions in light of the research questions outlined in section 6.1 and the empirical evidence presented in section 6.3.

As mentioned above, livelihood vulnerability largely depended on the households' ownership of assets as well the activities of other households that shaped the dominant farming system, i.e. 'rules of the game'. In Mithakhali, where shrimp-white fish aquaculture

was the primary livelihood activity, smallholding farmers, especially in the lower middle and poor categories, experienced the highest level of vulnerability as they could neither earn enough cash from shrimp nor conduct subsistence based livelihood activities. Previous studies in coastal Bangladesh also found that increased salinity brought about by shrimp cultivation led to decline or loss of paddy, prohibited livestock rearing due to lack of fodder, reduced availability of dung for cooking fuel, and limited access to common pool resources (Abdullah *et al.*, 2016, Belton, 2016, Faruque *et al.*, 2016, Pouliotte *et al.*, 2009). Among the landless extreme poor, who always depended on petty trades and wage labouring activities, some reported no change in income as they were never directly involved in farming, while others reported decreased work availability and lack of sharecropping options as causes of increased livelihood vulnerability. Previous studies have shown that the farm jobs created by the shrimp sector are mostly temporary or part-time with low wages and without employment contracts (Abdullah *et al.*, 2016). These jobs mainly involve repairing farm embankments, stocking and harvesting shrimp, guarding and maintaining large farms operated by absentee landowners, and clearing aquatic weeds (Belton, 2016, Pouliotte *et al.*, 2009). In contrast, the rich and some upper middle class households, in fact, benefitted from the cash crop based economy as exhibited by the cases of individuals who experienced upward mobility. This further exacerbated existing income inequalities and reinforced power imbalances, as also found by Abdullah *et al.* (2016).

In Kamarkhola, the livelihood vulnerability of all household classes, other than the rich, decreased as they could make optimum use of their resources to pursue a diversified livelihood portfolio. While the rich did not become more vulnerable per se, their cash income decreased significantly in absence of a cash crop farming system. However, they had enough savings or resources to move towards other high-return activities in the long-term. Similarly, a comparative study of three villages in coastal Bangladesh by Faruque *et al.* (2016) revealed that rice, prawn and white fish cultivation led to positive livelihood outcomes for all social groups in low and medium salinity villages by fostering both subsistence and market oriented livelihoods. In the high salinity village, most of the profits from shrimp farming were enjoyed by a few households, while others suffered from food insecurity (Faruque *et al.*, 2016). Further evidence by Belton (2016) shows that integrated paddy-prawn-fish farming significantly increases labour demand, creating work opportunities for females as well as males. In contrast, the commodification of peasant livelihoods through shrimp farming creates surplus labour, leading to lower wages for females and increased migration by males (Belton, 2016).

Ownership of agricultural land was the key determinant of upward or downward livelihood trajectories. Land, either obtained through inheritance or purchased using shrimp profits, led to income stability and enabled households to educate their children or invest in high-return non-farm activities, making them subsequently less dependent on risky shrimp cultivation. Similar evidence was found by Abdullah *et al.* (2016) in coastal Bangladesh, where compared to middle or lower income households, higher income households were able to obtain greater absolute and relative profits from shrimp cultivation as their initial high land ownership enabled them to acquire more land over time. The authors further state that factors such as age or education of household head, ownership of livestock or durable assets showed no significant relationship with income, thus, highlighting agricultural land ownership as the single most important determinant of income (Abdullah *et al.*, 2016). These observations relate to Carter and Barrett (2006)'s conceptualisation that once a household crosses a certain threshold of asset ownership, it can shift from a low return livelihood trajectory to a high return one. While some households also mentioned income from diversified sources resulting in increased wealth, it should be noted that such diversification was possible because the household had enough land, pond or human capital to start with. Declines in land ownership, through division of parent's property or sale of land for consumptive purposes, was identified as the main reason for downward mobility, unless successful transitions were made to other non-farm activities. Moreover, it was observed that business failures or significant losses from shrimp cultivation, coupled with high debts, pushed households into poverty. As mentioned by Carter and Barrett (2006), low initial level of assets presented a threshold problem and prohibited wealth accumulation, thus, confining households in a poverty trap.

It is also noteworthy that all the examples in the 'upward trajectory' section were from Mithakhali and hence, were related to profits from shrimp cultivation. While in Kamarkhola there were examples of households whose material well-being had improved, significant increases in wealth were only observed in Mithakhali due to the existence of a cash crop based farming system. While ownership of agricultural land was the main determinant of increasing wealth, such wealth accumulation would not have been possible in the presence of a subsistence based farming system. While large amounts of land could yield significant amounts of paddy, the lower market price of paddy compared to shrimp or white fish did not allow large savings or profits. Moreover, as highlighted by the cases, a shrimp based system promoted the scope of a number of non-farm activities as well.

Downward mobility in livelihood trajectories was often the result of a number of negative circumstances operating simultaneously or in sequence. Anirudh Krishna (Krishna, 2010, 2006, Krishna *et al.*, 2006a, Krishna *et al.*, 2006b, Krishna *et al.*, 2004), who studied poverty dynamics of 10,000 households across five countries, notes that although a household can endure one shock, repeated shocks over a long period of time can cripple the household, making it extremely difficult to climb up the poverty ladder. As exhibited by the last three cases in the 'downward trajectory' section, a number of successive adverse events like poor shrimp yields, indebtedness, sale/division of land, business failures and/or natural hazards disabled the households' capacity to recover and led to a long-term decline in asset ownership. These cases also indicated that dwindling incomes from primary activity left households in a state of despair, often causing them to take up risky strategies in which they had little experience.

The livelihood trajectories of many non-poor and chronically poor people remained steady. This group comprised of two types of households – ones which made significant changes to their livelihood strategies over time and ones which did not. Although the former group brought about changes in their primary and alternative income sources, such changes in livelihood strategies did not bring out any significant changes in economic status. Rather these changes were adopted to smoothen consumption, cope with economic shocks or forgo one form of asset to build another. In the case of the latter group, lack of land, funds for investment and specialised skills constrained these households from entering high return farm or non-farm activities. Their dependence on physical labour only generated very low incomes, barely able to meet subsistence needs. This also prevented them from enhancing the skills of their children through education, thus, increasing the likelihood of remaining trapped in poverty for generations. Moreover, old age often incapacitated the household head from carrying on wage labouring, often leading to further hardship or dependence on children.

Finally, the chapter found that well-being was not restricted to economic opportunities only, but was also culturally and socially embedded. Rice cultivation was not 'just a job' but a 'way of life'; there was a great sense of pride in this occupational identity. White (2010) points out that the reference to 'rice' is far from incidental; sufficiency in rice is an important aspect of well-being for most people in rural Bangladesh. Similar findings have been made in the fisheries literature where small-scale fishermen associate a strong sense of social identity and devotion to the fishing way of life (Coulthard, 2012, Coulthard *et al.*, 2011). A good life also entails a life 'lived well together', where well-being does not only involve

individual benefits; rather it includes values that are grounded in a broader shared understanding of how the world is and should be (White, 2010). Thus, a social conception of well-being was used here to assess the implications of the local vulnerability context on people's well-being. It highlighted that the notion of desirable states was not always dominated by economic gains, rather socially and culturally defined meanings played an integral role.

Overall, these findings indicate that the need to tailor methodological approaches to understanding livelihoods and well-being. Purely quantitative approaches, such as assessing adaptive capacity as a weighted average of different livelihood assets, or using aggregate indicators like GDP, education, and child mortality as proxies of human well-being, are often reductionist, apolitical and superficial representation of reality. This is not to negate the importance of structured quantitative methods, but to point out the necessity of flexible qualitative and mixed methods approaches that can capture intangible aspects like power, agency, values and preferences. The use of unstructured livelihood trajectory interviews, as demonstrated in this chapter, proved to be particularly useful in eliciting the hopes, fears, and struggles of individuals, whose stories were different, yet instrumental in constructing the reality. They added flesh and blood to the skeletal structure provided by the quantitative comparison of livelihood strategies at two time periods. This is similar to a pathway lens that focuses on how and why change and responses have occurred, the various ways in which different groups perceived, responded and navigated change, and the roles of contextual issues, including power relations, in shaping human agency (Fazey *et al.*, 2015). The mixed methods approach for well-being assessment illustrated overall changes in well-being as perceived by the respondents themselves, and also disentangled the three dimensions. While the three-dimensional categorisation provided structural and analytical clarity, such boundaries are often artificial. Given the limitations of time and resources, this study adopted a quick approach for well-being assessment by adding on questions to the household survey and livelihood trajectory interviews. A comprehensive analysis of well-being, involving participatory group exercises for identifying, ranking and describing key indicators, would have generated better empirical evidence (Abunge *et al.*, 2013, Britton and Coulthard, 2013). This will be an interesting area for further work.

6.5 Conclusion

The previous chapter analysed the underlying drivers of socio-ecological change in the two study sites and identified two broad sources of vulnerability, that is, natural shocks and stresses, such as salinity intrusion and cyclones, and anthropogenic challenges arising from brackish water shrimp cultivation. This chapter examined how this socio-ecological change shaped the livelihood strategies and well-being outcomes of households of different wealth classes. It found that a cash crop based system that caused environmental degradation and limited subsistence based livelihood options, allowed richer households to accumulate more wealth and poorer households to suffer from greater food insecurity, thus, exacerbating existing inequalities and reducing subjective and relational well-being. In contrast, a subsistence based system supplemented by some market-oriented produce led to more sustainable and equitable livelihoods that promoted subjective and relational well-being for most households, although there were differences in changes in material well-being. Analysis of individual livelihood trajectories found that changes in land ownership played the central role in determining upward or downward mobility of wealth status. Moreover, livelihoods are path dependent, meaning that the outcomes of previous strategies influence the options available for the future. In sum, this chapter highlighted the importance of both the vulnerability context at community level and wealth status at household level as key determinants of livelihood adaptation capacities. However, adaptive capacities are also influenced by a number of other opportunities, barriers and limits, which may reinforce one another and pose heterogeneous impacts on different livelihood activities. The following chapter looks into these opportunities, barriers and limits, with particular focus on their interaction and how they can be overcome.

Chapter 7. Differentiating opportunities, barriers and limits for livelihood adaptation

Abstract

Households' capacities to adapt their livelihoods to socio-ecological change are largely determined by their ownership and access to resources, as highlighted by the findings of the previous chapter. However, an isolated focus on the household attributes that enhance adaptive capacity ignores the various opportunities and barriers posed by the activities of other households within the community as well as the broader social, political and environmental contexts. While the literature on adaptation barriers is expanding, the heterogeneity of impacts of barriers on households of different wealth classes, and the opportunities that can create enabling conditions to overcome them, are still understudied. This chapter, thus, explores the adaptation opportunities, barriers and limits faced by households of different wealth classes in the two study communities, with respect to the livelihood activties identified in the previous chapter. This chapter has three findings – firstly, the same conditions that facilitate adaptation by one social group can restrict the adaptive capacity of another; secondly, various forms of opportunities and barriers interact in complex ways such that one factor aggravates or enhances another; and thirdly, while some ecological limits cannot be avoided, others, such as knowledge, institutional or economic barriers, can be reduced through changes in farming practices, proper training and knowledge dissemination among farmers, access to credit for initial investments, and capacity building of local institutions. To ensure more equitable and environmentally sustainable livelihoods in future, policies and programs should aim to expand households' adaptation space by accounting for the heterogeneous needs of different social groups.

7.1 Introduction

The rapid growth of the aquaculture industry and increased occurrence of climatic shocks and stresses have brought about significant socio-ecological changes in rural communities of coastal Bangladesh (Faruque *et al.*, 2016, Shameem *et al.*, 2014). The previous chapter showed that households of different wealth classes had different capacities to adapt their livelihoods to these changes and hence, experienced varied well-being outcomes. The adaptation literature, which often uses the household as the unit of analysis, similarly

acknowledges that resource endowments and entitlements are the most important determinants of a household's adaptive capacity (Elrick-Barr *et al.*, 2014). For example, Sabates-Wheeler *et al.* (2008) argues that the ability to diversify livelihoods and its outcomes are not wealth neutral; poor households with low asset endowments find it difficult to diversify in advantageous markets that could lead to upwards paths of wealth accumulation. However, an exclusive focus on the household attributes that enhance adaptive capacity, leads to an isolated and static view of the household that ignores how other actors within the system influence households' ability to adapt (Elrick-Barr *et al.*, 2014). Moreover, it is essential to consider the broader social and institutional processes that create capacity, the roles of cross-scalar socio-ecological interactions in shaping actions, and the political landscape that determine whether adaptive actions lead to positive outcomes (Elrick-Barr *et al.*, 2014).

Thus, households of different wealth classes not only face differential opportunities and barriers due to their own resource base, but their abilities to design their desired livelihood portfolios are influenced by the activities of other households in the community as well as the social, political and environmental contexts in which the households operate. The conceptual framework of this study (Figure 2.1), which has been developed from the literature review (refer to chapter 2), hypothesizes that households' livelihood adaptation strategies and outcomes are determined by the community's vulnerability context, the household's own poverty level, as well as other opportunities, barriers and limits operating at various spatial scales. As discussed in the literature review in section 2.8.2, the growing body of case studies and theoretical work on adaptation has generated a wide range of barriers, many of which are not specific to climate adaptation but refer to impediments to overall economic development and human well-being (Shackleton *et al.*, 2015, Eisenack *et al.*, 2014). Some of the commonly reported barriers are bio-physical or natural (Sallu *et al.*, 2010), socio-cultural (Curry *et al.*, 2015, Jones and Boyd, 2011), financial or economic (Bryan *et al.*, 2009, Deressa *et al.*, 2009), technological (Islam *et al.*, 2014), institutional (Quinn *et al.*, 2011) and psychological (Grothmann and Patt, 2005). Moreover, studies have reported the co-occurrence of multiple barriers, where barriers from different categories interact or reinforce each other (Antwi-Agyei *et al.*, 2015, Islam *et al.*, 2014).

The literature review also revealed some research gaps. There is little empirical literature to understand the heterogeneity of impacts of barriers on different social groups and to identify the drivers that prevent certain groups from successfully adapting to climate change while supporting others within the same context (Mersha and Van Laerhoven, 2016,

Shackleton *et al.*, 2015). While it is necessary to understand why certain groups are more vulnerable than others, it is also important to recognise how successful adaptation by privileged members of society affects the adaptive capacity of the disadvantaged ones (Shackleton *et al.*, 2015). Similarly, the role of conflicts, vested interests and power relations in constraining the adaptation options of poorer groups are under-researched (Armah *et al.*, 2015, Shackleton *et al.*, 2015). There is a gap in identifying the causal explanations for the occurrence of barriers and the opportunities that can create enabling conditions to overcome them (Eisenack *et al.*, 2014, Klein *et al.*, 2014). Eisenack *et al.* (2014) argues that understanding the interdependencies between barriers, through comparative research designs, is central to explaining their occurrence, persistence and resolution. The literature also shows a geographical imbalance in terms of the regional distribution of studies, whereby rural communities in Sub-Saharan African countries have received comparatively greater focus (see reviews by Antwi-Agyei *et al.*, 2015, Shackleton *et al.*, 2015), compared to those in coastal Asia (Orchard *et al.*, 2016, Williams *et al.*, 2015, Islam *et al.*, 2014). As opportunities and barriers manifest themselves as context specific (Armah *et al.*, 2015, Klein *et al.*, 2014, Biesbroek *et al.*, 2013), studies with a regional focus are essential.

This brings us to the fourth objective of this PhD research, which aims to address the research gaps outlined above. As mentioned in chapter 1, objective 4 is *"To explore the livelihood adaptation opportunities, barriers and limits faced by households of different poverty levels in the two study communities"*. The research questions under this objective are:

1. What opportunities, barriers and limits did households of different poverty levels face in adapting their livelihoods?
2. Did adaptation by one group affect the adaptive capacity of another?
3. How did the different opportunities, barriers and limits interact? How can certain barriers be overcome or reduced?

Based on the literature review, this chapter conceptualises adaptation opportunities as factors that *"enhance the ability of actor(s) to secure their existing objectives"* (Klein *et al.*, 2014: 8), barriers as factors that *"restrict the variety and effectiveness of options for an actor(s) to secure their existing objectives"* (Klein *et al.*, 2014: 8) and limits as *"the point at which an actor's objectives cannot be secured from intolerable risks through adaptation actions"* (Klein *et al.*, 2014: 8). While barriers can be overcome, avoided or reduced with concerted effort, creative management, changed ways of thinking, political will, and

reprioritization of resources, land uses and institutions (Moser and Ekstrom, 2010), limits are unsurmountable with incremental adaptations and require transformational adaptations based on redefinition of actors' objectives. Barriers are relative to the specified adaptive actions being considered, to the actors that may implement them and to the specific context in which they may be undertaken (Eisenack and Stecker, 2012). That is, conditions that might seem problematic to one actor can be viewed as beneficial by another (Eisenack *et al.*, 2014). This chapter, thus, views opportunities and limits as two extreme ends of a continuum with different degrees of barriers in between (refer to Table 7.1). With respect to the livelihood activities identified in chapter 6, this chapter assessess the differential opportunities, barriers and limits and groups them into eight categories, namely, ecological, economic, socio-political, knowledge, institutional, infrastructural, markets, and gender. It then analyses the interactions between the different opportunities and barriers in order to understand the causal explanations for the occurrence of barriers and highlight how adaptation by one group affects the adaptive capacity of another. Finally, the chapter discusses how certain barriers can be overcome or reduced, using comparative analysis of the two cases. This chapter, thus, contributes to the growing literature on adaptation opportunities and barriers by addressing the research gaps mentioned above.

7.2 Research methods

The study used a mixed methods approach involving participatory wealth ranking, focus group discussions, livelihood trajectory interviews and household questionnaire surveys to collect primary data from Kamarkhola and Mithakhali villages in coastal Bangladesh (refer to chapter 3 for details). Chapter 4 disaggregated the survey households in each village into five poverty levels (rich, upper middle, lower middle, poor and extreme poor) and chapter 6 discussed the various livelihood strategies adopted by these different wealth classes. This chapter uses qualitative data from focus group discussions and livelihood trajectory interviews to explore the differentiation opportunities, barriers and limits faced by households of different wealth classes with respect to the livelihood strategies identified. Data analysis involved transcribing and translating field notes and audio recordings, coding the qualitative data to identify opportunities, barriers and limits both before and after the changes in farming systems in the two villages, and then grouping them into eight categories based on findings from the literature.

7.3 Results

Table 7.1 summarises the differential opportunities, barriers and limits experienced by households of the five wealth classes in relation to a number of livelihood activities. This section structures these opportunities, barriers and limits into eight categories, namely, ecological, economic, socio-political, knowledge, institutional, infrastructural, markets and gender, supplemented with detailed examples of livelihood trajectories in Table 7.2.

Table 7.1 Opportunities, barriers and limits to livelihood adaptation faced by households of different poverty groups in the two study villages

Site	Sl.	Livelihood adaptation options	Rich	Upper middle	Lower middle	Poor	Extreme poor
Kamarkhola	1	Semi-intensive shrimp cultivation					
	2	Freshwater prawn in pond					
	3	Temporary labour migration					
	4	Prawn-carp-paddy farming in land					
	5	Livestock rearing					
	6	Homestead gardening					
	7	Rain-fed Aman paddy cultivation					
	8	Service jobs within/outside village					
	9	Sharecropping					
	10	Fishing in open-access canals					
	11	Winter/ dry season crops					
	12	Small-scale business					
	13	Van or motorcycle driving					
	14	Brackish water shrimp cultivation					
Mithakhali	15	Semi-intensive shrimp cultivation					
	16	Leasing out land					
	17	Shrimp-carp farming in land					
	18	Temporary labour migration					
	19	Van or motorcycle driving					
	20	Service jobs within/outside village					
	21	Small-scale business					
	22	Fishing in open-access canals					
	23	Aman paddy cultivation					
	24	Livestock rearing					
	25	Homestead gardening					
	26	Sharecropping					

Legend

	Opportunity
	Barrier (Low)
	Barrier (High)
	Limit
	Unwilling to undertake due to wealth status

7.3.1 Ecological

Availability of freshwater and soil salinity determined the types of crops that could be grown in the study sites. Only rain-fed Aman paddy could be grown during the monsoon while winter and summer crops could not be cultivated due to lack of freshwater for irrigation (Sl. 11, Table 7.1). However, farmers in both villages mentioned increased pest attacks, greater heat stress, late onset of monsoon and high amount of rainfall in shorter periods of time as causes of reduced paddy yields. From February to April, the land became so parched that white deposits of salt appeared on the surface, fragmenting the topsoil. In Mithakhali, decades of shrimp cultivation had degraded soil quality to such an extent that farmers had to stop paddy completely (Sl. 24, Table 7.1) and replace it with white fish farming. Moreover, the tidal surge that accompanied cyclones Sidr and Aila in 2007 and 2009 led to a high increase in soil salinity in the following years. Frequent cyclones meant that the soil could not recuperate from the previous event before being exposed again, leading to cumulative effects. Shrimp disease outbreaks, which occurred almost every year, also posed an ecological barrier for all household categories. Moreover, hotter summers often led to increased heat stress for shrimp; while the better-off households would invest in digging deeper ponds and improving soil fertility through fertilisers, the poorer households lacked money for such adaptation (Sl. 17, Table 7.1).

In Kamarkhola, following the ban on shrimp, soil quality increased substantially over the next five years. However, continuous inundation of land for months after Aila affected individual land parcels differently. While some farmers benefitted from silt deposition, others have suffered from layers of sand deposited by tidal waters (Case 1, Table 7.2). An upper middle class farmer in Kamarkhola explained that due to deposition of slit and clay, the paddy yield was as high as 2.2 tonnes per acre during the first couple of years after Aila. However, such high yields were no longer possible as scarcity of fuelwood drove women to collect the cow dung deposited by grazing livestock during the dry season, thus, depriving the soil of fertilisers. Respondents in Kamarkhola mentioned that continuous flow of tidal water in the post-cyclone period led to the formation of a freshwater canal in a nearby village allowing farmers in that area to plant winter crops to some extent (Case 2, Table 7.2). Respondents in Kamarkhola mentioned that if the government took any initiative to dredge their canal and connect it to that freshwater canal, farmers in Kamarkhola would also be able to store freshwater and use it for Rabi (winter) crops.

7.3.2 Economic

Livelihood adaptation options were largely determined by households' ownership of land and cash for investment, which have been discussed in chapter 6. In Mithakhali, rich households, endowed with large amounts of agricultural land, specialised in year-long shrimp and white fish cultivation. The economies of scale brought about by large land ownership led to more income per unit land and any losses due to disease outbreaks could be compensated by releasing another batch of post-larvae. Moreover, these households also engaged in high-return shrimp related businesses, which in turn brought more cash for farm investment. In Kamarkhola, where shrimp had been banned, many rich farmers leased out most of their land for paddy cultivation while others were reluctantly diversifying their livelihoods by cultivating freshwater prawns cum paddy, as non-cash crops required more time and labour but generated less income. In both sites, the upper middle class households specialised in one activity as their main income source, but also tried to generate optimum returns from their resources by carrying out large scale white fish, shrimp or prawn farming in their ponds and homestead gardening when possible. These wealthier households could generate more income from a given activity than the poorer households. For example, richer households could buy the best quality Galda post-larvae at higher cost (BDT 5000 per 1000 post-larvae). These post-larvae which hatched from the first batch of eggs usually produced male prawns which grew larger in size compared to females. Poorer households had to wait for the prices to drop, which also resulted in poor quality post-larvae.

The lower middle class households did not have enough land to specialise in one activity; besides diversifying their farm outputs, they also engaged in non-farm activities such as service or small businesses. Diversification was also seen among poor households who tried to grab any available opportunity for survival and usually combined their small-scale crop or shrimp cultivation with wage labouring. In Mithakhali, the poor and lower middle class were the worst affected by the farming system transition because they could neither earn enough cash from small-scale shrimp cultivation or land rent nor could they grow crops for subsistence. Similarly, in Kamarkhola, while middle income households had resources to invest in new livelihood activities, poor people suffered from land, pond and cash deprivation which prevented them from starting prawn or fish farming on a commercial scale. Lower middle and poor households in both sites mentioned lack of cash for excavating ponds as one of the biggest impediments for cultivating fish or shrimp on a larger scale. Finally, in both sites, the extreme poor households who mainly depended on physical labour

to make ends meet, often cited lack of cash as barriers to purchasing own van or rearing livestock.

While overall ownership of agricultural land predominantly determined households' wealth class and their capacity to adapt livelihoods, the location and spatial distribution of land also played an important role in trying alternative activities (Case 3, Table 7.2). Location of land closer to home increased households' ability to manage water and reduced risk of theft or damage to crops, as exemplified by the narration of the lower middle class farmer in section 6.3.1. The farmer mentioned that while the land beside his residence could be used for paddy-prawn-vegetables integrated farming, a similar land situated further away was only used for paddy due to lack of manpower for daily supervision. Similarly, as mentioned in section 6.3.1 and also shown in Table 7.1, in Mithakhali, some rich farmers were able to grow Aman paddy as they had some land at higher elevation. Case 2 in Table 7.2 also shows how location of a small land parcel outside the embankment allowed the upper middle class farmer in Kamarkhola to still cultivate brackish water shrimp, although it was banned in the area.

Liquidity crisis posed a serious barrier on the ability of poorer farmers to invest in farm inputs or non-farm activities. In Kamarkhola, where NGO activities had significantly increased after cyclone Aila, availability of credit served as an opportunity for farmers to start new activities following the ban on shrimp. During 2013-14, 65% of the 150 surveyed households in Kamarkhola had taken loans from NGOs (39%), banks (19%) or relatives (6%) for a number of purposes such as for investment in crop production (14%), investment in fish cultivation (9%), education of children (12%), starting new businesses (5%) and others. The percentage of households taking out loans in 2013-14 was significantly lower in Mithakhali, where only 18% households had taken loans mainly for investment in fisheries (11%) and businesses (3%). Respondents in Mithakhali mentioned that although they had access to credit, they were reluctant to borrow as the interest rates were high and they feared becoming indebted due to shrimp disease outbreaks. Besides monetary loans, acquiring raw materials on credit is important in rural economies, as exemplified by Case 4 in Table 7.2.

7.3.3 Socio-political

The power imbalances in society, resulting from unequal resource ownership and a widening poverty gap, suffocated the agency of poorer households to undertake their desired livelihood strategies while enhancing the ability of the richer ones to pursue their preferred

trajectories. This was particularly the case in Mithakhali, where dominance of the rich and upper-middle class farmers had contributed to the shift in wet season land use from paddy to white fish farming (refer to section 5.3.2 for details). As large farmers were mostly interested in cash, they were reluctant to drain out saline water at the end of the dry season, thus, preventing small farmers from planting paddy. Respondents alleged that as richer people were able to fund local politicians during elections, the political leaders also supported them. Moreover, small landowners were usually dependent on larger ones for water exchange. A poor farmer in Mithakhali alleged that during heavy rains large farmers intentionally did not drain their lands, so that water from large farms flowed to the smaller ones causing the shrimp from the smaller farms to escape into the larger ones. Large farmers also blocked canals and brought them under private control, which significantly dwindled natural fish population and prohibited poor people from catching them for subsistence (Sl. 23, Table 7.1).

In contrast, in Kamarkhola, collective action and social conflicts, supported by local political leader and grassroots organisations, had led to the banning of shrimp farming. While this had restricted the ability of richer households to earn greater incomes though shrimp cultivation, it had opened up diverse livelihood opportunities for poorer groups who could now invest in paddy cultivation, prawn and white fish farming, livestock rearing and homestead gardening. Despite the ban, a couple of large farmers were using their political contacts to illegally cultivate shrimp on some of their land (Sl. 14, Table 7.1). However, the yield was lower, because previously the whole area could be flushed at one time, but now water had to be released slowly from underground aquifers and holes in the embankment.

7.3.4 Knowledge

In both Kamarkhola and Mithakhali, farmers seemed to have a knowledge deficit on appropriate farm or pond management techniques, in terms of optimum salinity and temperatures, stocking densities, management of soil quality and application of supplementary feed. Traditionally, farmers followed the ‘no-stocking’ extensive system, where wild post-larvae brought in with tidal waters fed on natural phytoplankton. However, following the shift to hatchery-bred post-larvae raised in artificial environments, shrimp mortality increased significantly. Most farmers tried to cope with losses by releasing another post-larvae batch, leaving the results to fate. Farmers had very little knowledge on the causes of disease outbreaks, often referring to imported post-larvae or poor handling as probable reasons. Even those who applied supplementary feed or fertilisers to improve soil quality did so on a trial and error basis, without any proper guidelines.

In Kamarkhola, farmers trying to shift towards prawn cultivation failed to obtain good yields due to lack of experience (Case 3, Table 7.2; Sl. 2, Table 7.1). A lower middle class farmer mentioned that although he borrowed BDT 160,000 to excavate his pond and start prawn-white fish polyculture, he didn't earn any profits in the first season because of limited knowledge on the ratio of prawn to fish to be released, optimum water temperature, salinity and depth and harvesting times. In the second season, he consulted his social contacts in another prawn farming area, where farmers earned as much as BDT 300,000 per season. He commented that depending on his success, other farmers in Kamarkhola were willing to start their own farms. On the other hand, a rich farmer in Kamarkhola, who had a college degree in agriculture and good affiliation with the local fisheries department, had obtained good yields by cultivating both Galda prawn and Bagda shrimp in hypo-saline water in his homestead pond. He commented that land-based extensive shrimp farming was no longer profitable, as shrimp died due to heat stress or changes in water acidity. Pond-based farming allowed monitoring of water parameters, frequent water exchange through pumps and application of feed in amounts that did not pollute the water. However, poorer farmers neither had the capital for investment in pond excavation nor the knowledge to do so. Similarly, rich and upper middle class farmers in Mithakhali were planning to start semi-intensive shrimp cultivation (Sl. 15, Table 7.1). Although they had heard of others being successful in semi-intensive farming, they lacked proper knowledge on establishing the farms and the procedures for seeking government loans.

7.3.5 Institutional

Institutional support mainly involved relief and rehabilitation after natural shocks, livelihood or infrastructure development activities, and provision of credit. In Kamarkhola, respondents unanimously agreed that support from the government, donor organisations and NGOs was the single most important factor in enabling them to cope with the devastating impacts of the 2009 cyclone Aila. In Kamarkhola, during the first couple of years after cyclone Aila, most households, regardless of wealth category, exclusively depended on support from the government and NGOs for survival and rehabilitation. Of the 150 survey households, 55% mentioned that they received food aid from various organisations in the immediate aftermath of the cyclone. Within the first year following the cyclone, almost all households (92%) received BDT 20,000 in cash from the government for re-constructing houses and those who did not receive cash, had their houses built by NGOs (16%). In post-cyclone period, that is, from 2012 till date, a number of NGOs have been helping the extreme poor people in Kamarkhola to diversify their livelihoods. For example, the Food and Agricultural

Organisation (FAO) distributed Khaki Campbell ducks, which could lay up to 200 eggs during their laying period with each egg having a market price of BDT 8. FAO also gave fruit trees, vegetable seedlings and juvenile fishes to enhance livelihood options of poor households after the cyclone Aila. However, the scale of these activities were very limited (Case 2, Table 7.2).

On the other hand, a number of middle class and rich households complained that these organisations were biased towards the extreme poor, making them dependent.

> "When they come to provide any aid, they just focus on one group of people *"Hotodoridro!"* (extreme poor). Consequently, these poor people have become aid dependent, greedy and are becoming better-off without any effort. You won't believe that an extreme poor person, who could never even eat two meals a day, now asks me whether I'm willing to sell my land to him. The poor and landless people didn't lose much because of the cyclone as they had nothing to lose in the first place. It's people like me who lost their livestock and poultry, their houses, their fisheries and whatever assets they owned. My absolute loss was greater; hence, it was difficult for me to regain my previous socio-economic status after the cyclone". – Bilal Ahmed (male), upper middle class farmer, Kamarkhola.

Similarly, Lelin, a rich farmer in Kamarkhola, said,

> "I lost my whole garden of fruit trees due to the cyclone. But few months after the event, NGOs came and distributed seedlings to extreme poor people, who do not even have land to plant them. Didn't I even deserve a few seedlings?"

Since 2012, in Kamarkhola, 31% households received training in disaster preparedness and 52% households benefitted from improved water supply and sanitation facilities. Prior to this cyclone, there were no cyclone shelters in this village, forcing the displaced people to take refuge on the embankments instead. However, at the time of study, the government with support from donor organisations, had constructed a school cum cyclone shelter for future events. Although the government and NGOs played an important role in disaster preparedness or post-cyclone rehabilitation, their support in terms of livelihood training and information dissemination was limited. Throughout the 1990s, as part of the national policy to promote shrimp aquaculture, the government launched a number of projects involving development of water infrastructure, establishment of demonstration plots to train shrimp farmers or formation of local committees to manage sluice gates. However, such efforts were missing when farmers were trying to shift towards freshwater prawn or crab fattening, for example. The local fisheries or agricultural department seemed incapable of addressing farmers' queries about shrimp diseases or soil quality.

Compared to Kamarkhola, which came under the limelight after the cyclone, institutional engagement was limited in Mithakhali. According to the household survey, only 4%

households received training in disaster preparedness, 2% benefitted from improved water supply or sanitation facilities and 4% got training in livelihood generating activities. In the aftermath of the 2007 cyclone Sidr, 35% households received BDT 1,000 from the government, 10% got assistance in rebuilding houses, and 20% received food support.

7.3.6 Infrastructural

Development of infrastructure, such as roads, embankments and electricity grids, play a key role in expanding the livelihood options available. Case 5 in Table 7.2 shows how the construction of a road allowed an extreme poor person to take up van driving as a livelihood option (Sl. 19, Table 7.1). Similarly, big shrimp farmers in Mithakhali could have their own storage depots as the village had an electricity connection. However, in Kamarkhola, there was no power supply; hence, there were no shrimp hatcheries or fish depots within the area. All farmers had to store their fish in ice and carry them to nearby Chalna union for sale. The absence of a power supply prohibited the development of shops and businesses as well. Moreover, the roads were not paved or brick laden, making it impossible for vehicles to be driven during the monsoon. The option of driving vans for a living was limited in this area (Sl. 13, Table 7.1). As mentioned in section 7.3.5 above, as there were no cyclone shelters in Kamarkhola during the 2009 cyclone Aila, people of all wealth classes, except the rich, had to take refuge on the embankment for months. However, increased infrastructural development in the area, in terms of constructing durable housing with raised plinths, constructing a cyclone shelter, provision of good toilets and ongoing embankment repair work, means that households will have greater capacity to cope with future events.

7.3.7 Markets

Proximity and easy access to local business hubs facilitates the growth of non-farm activities. Mithakhali village is very close to Mongla business town and sea port and has good transportation facilities. Thus, 24% of the adult males in Mithakhali were exclusively involved in business and 23% were farmers cum businessmen (Sl. 21, Table 7.1). In contrast, in Kamarkhola, only 5% of adult males were engaged in business and 12% in agriculture cum business (Sl. 12, Table 7.1). Most of the businesses in Mithakhali were related to the shrimp and fish supply chain. Moreover, given the cash based economy and the peri-urban characteristics of Mithakhali, households purchased most of their daily necessities, leading to establishment of many grocery shops in the area.

Presence of good land and labour markets allow individuals to rent out their land and indulge in other higher return activities (Barrett *et al.*, 2001). In Mithakhali, both the selling

price and rents for land had increased in the last two decades due to high demand for land for extensive shrimp cultivation (Sl. 16, Table 7.1). In Mithakhali, at the time of the study, rents were BDT 15,000 per acre as land was leased for the entire year for shrimp/fish cultivation. Thus, some land owners with a good education leased out all their land and were working in the service or business sector where they had comparative advantage. Many poorer farmers with small land parcels also leased out land to large farmers and were themselves engaged in wage labouring. Labour markets were well established in both sites and people could migrate to nearby rice farming areas and shipyards to work as day labours (Case 5, Table 7.2; Sl. 3 and 18, Table 7.1).

The capacity to diversify livelihoods and explore new options often depended on national and international market demand. The livelihood trajectories in the study sites revealed examples of how some households were trying to explore newer products to take advantage of different markets. In Kamarkhola, a teenager studying in secondary school mentioned that he earned about BDT 20,000 in the previous year by selling pigeons that he rears at home. Although he initially started rearing birds as a childhood hobby, the increased demand for pigeons as pets and delicacies in urban areas provided him an opportunity to turn his hobby into a livelihood option. Similarly, in Mithakhali, a small number of shrimp farmers have also stared to grow crabs due to their increased demand in big hotels in the capital city as well as in European markets. However, price of export goods can fluctuate as well, due to changes in demand or problems within the supply chain. A shrimp farmer in Mithakhali mentioned that compared to October 2014 when the market price for Bagda shrimp was BDT 800 – 1000 per kg, in December 2014, the price fell to BDT 300 only.

7.3.8 Gender

Within households of different wealth classes, men and women often experienced heterogeneous adaptation opportunities and barriers. In both villages, almost all the women referred to themselves as housewives; however, their engagement in subsistence based livelihood activities within the household largely depended on the predominant farming system in the village. In Mithakhali, increased soil salinity precluded homestead gardening and livestock rearing – tasks that were traditionally conducted by women. The shift to aquaculture also prohibited women's engagement in post-harvest activities like sun-drying, milling and parboiling paddy. Comparatively, in Kamarkhola, the integrated paddy-prawn-fish farming had potential to increase work opportunities for women; but such changes were still at the nascent stage. In both villages, women in poor and extreme poor classes sometimes engaged in wage labouring activities within the village to cope with poverty;

however, women's wages ranged from BDT 150-250 while men were paid BDT 250-350 a day. Increase in seasonal migration of men, particularly, in the poor and extreme poor classes, left women solely responsible for taking care of children and the elderly for weeks and months.

In both villages, there were significant improvements in women's education due to overall national efforts in reducing gender gaps in schooling. Household survey data in Kamarkhola and Mithakhali showed that the percentages of adults with education up to Secondary School Certificate (SSC) level or above increased with decreasing age group, while the percentages of illiterate people have gradually declined (Figure 7.1). Chi square tests on gender disaggregated data revealed that while males of the older generation (age>40) were more educated than their female counterparts, there was no statistically significant difference between male and female educational attainment in the 19-25 age group. Increased education enabled younger women to work in the service sector, mainly with schools and NGOs; however, the numbers were very limited.

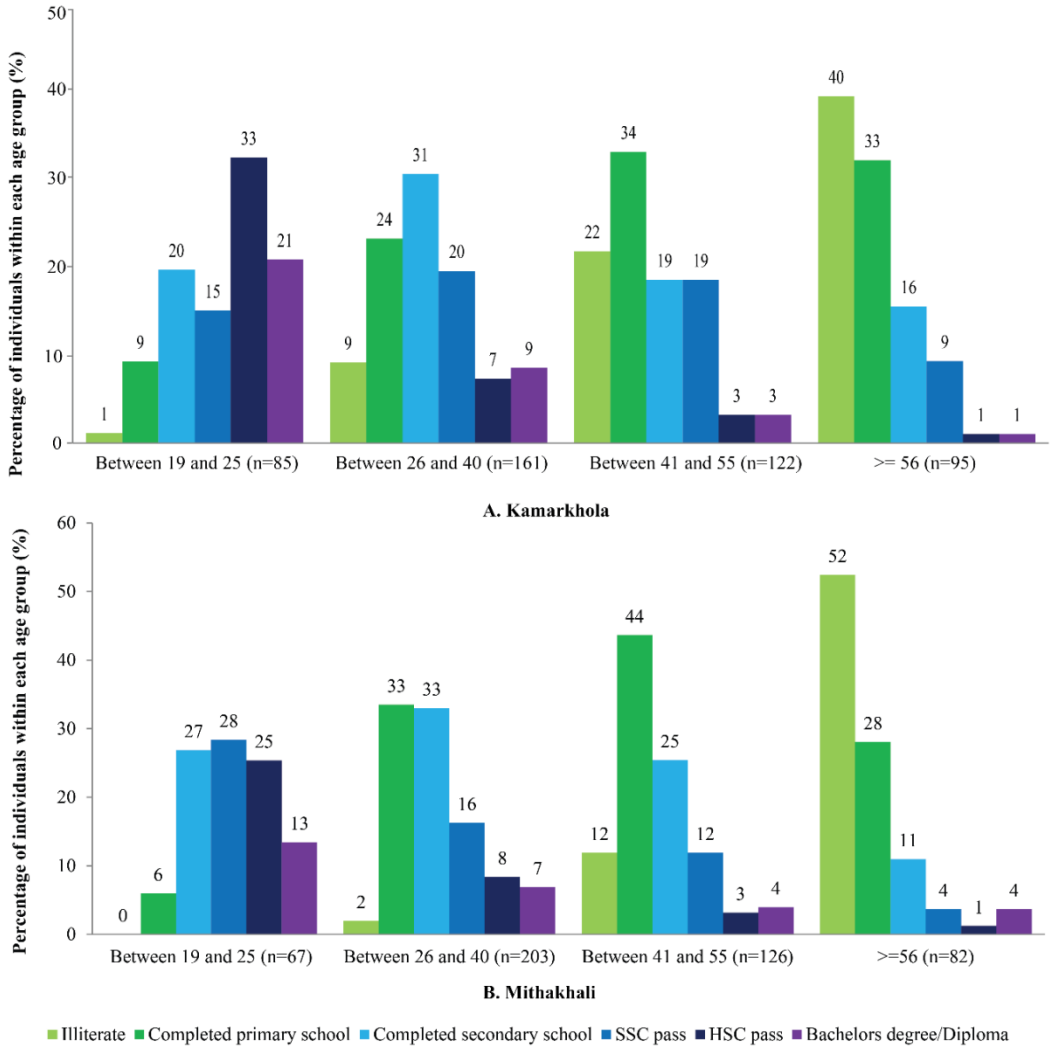


Figure 7.1 Education level of both males and females by age group in Kamarkhola and Mithakhali

Table 7.2 Livelihood trajectories of households of different socio-economic categories in the two study villages

Livelihood trajectories (T1 and T2 refer to the time periods before and after the farming system transitions in each site)	**Opportunities, barriers and limits**
Case 1: Rich household, Kamarkhola	***Opportunities***
T1. I inherited 300 acres of land. Before 2009, I earned huge profits from shrimp and also got good yields of paddy. The soil salinity did not affect the subsequent rice production because I could wash the land properly with freshwater from canals as well as the rains. I used to plant paddy in about two-thirds of land, while the land in lower areas were kept under freshwater and used for cultivating white fish. Even if 20% shrimp survived, their price was high enough to cover all investment costs. Unlike villagers' complaints that soil salinity destroyed the vegetation, I had abundant fruit trees and vegetables in my homestead garden. The pond beside my house had lots of freshwater fish, each weighing at least 7-8 kg. **T2.** During cyclone Aila, I lost about ten million Taka worth of fisheries. As the land remained inundated for 2 years, at least one foot of sand has been deposited on the top layer. Now we are only dependent on a single paddy crop. However, the extent of pest attacks has severely increased and yield has decreased due to sand deposition. I have to spend BDT 12,000 per acre for labour costs, fertilizers, pesticides, seeds and transportation, compared to BDT 4000 before. Since we cannot let in saline water, we are trying to grow some Bagda shrimp in freshwater along with rice. But as Bagda require at least 7-8 ppt salinity to survive during their growing stage, their mortality rate is higher and growth is slower. The alternative is Galda prawn; however, as people in this area do not have experience in freshwater prawn, Galda farms are limited. Bagda cultivation is less labour intensive and require less management compared to Galda. Having no other alternative, I'm thinking of starting semi-intensive Bagda cultivation.	**T1 & T2.** Large amount of agricultural and homestead land; cash for investment ***Barriers*** **T1.** Shrimp mortality due to disease outbreaks **T2.** Lack of experience in Galda prawn farming; cyclone; sand deposition in land; pest attacks ***Limits*** **T2.** Ban of shrimp cultivation
Case 2: Upper middle class household, Kamarkhola	***Opportunities***
T1. I own 6.5 acres of land, which were previously used for shrimp cultivation followed by paddy. If saline water is allowed to enter, the soil fertility decreases and the surrounding vegetation are destroyed as well. Between 2005 and 2008, I lost up to BDT 70,000 in shrimp because of viral outbreaks and soil degradation. The yield of paddy was also as low as 0.6 tonnes per acre. I'm happy that shrimp farming has been banned. **T2.** Currently, I grow paddy along with freshwater Galda prawns and white fish along in the same land. Since last 3-4 years, freshwater Bagda post-larvae are also available in Chalna hatchery and so I have released some Bagda shrimp as well. In addition, I have 1.6 acres of land (purchased in 1994) outside the embankment, where I'm allowed to farm brackish water shrimp. This land also helped me maintain my subsistence needs in the post Aila period when all other land were inundated for two years. There is a freshwater canal beside my land, which retains water even during the dry season, as it has got separated from the river and is as deep as 30-40 feet in some places. This allows me to grow	**T2.** Ban on shrimp cultivation; increased soil quality; availability of freshwater Bagda post-larvae; availability of freshwater in adjacent canal during dry season; support from NGO; location of land outside embankment. ***Barriers*** **T1.** Village under shrimp cultivation, hence high salinity; Shrimp mortality due to diseases and soil degradation **T2.** Cyclone; lack of experience in Boro paddy

sunflower in the dry season, with investment fund of BDT 9,000 per acre from BRAC. One acre yields about 444 kg of sunflower seeds, which can produce 144 kg of oil. I sell this oil for BDT 120 per kg. Sunflower cultivation is not that profitable because additional labour needs to be hired. Hence, I'm thinking of planting some Boro paddy this year; as no one in this area has ever planted dry season paddy before I do not have much idea about the yield or profits.	
Case 3: Lower middle class household, Kamarkhola	***Opportunities***
T1. We did not inherit any land from our father. Currently, my two brother and I own about 6 acres of farmland, all which have been purchased over the past 10-15 years using money we earned from a motorcycle renting shop and a small grocery store we had in the village market. We also took some loans from NGOs to purchase these land. During shrimp cultivation period, we were forced to lease out our land to large landowners in exchange of annual rents of Tk. 3000 per acre. As our land was located in different places, each of the parcels was not large enough to run our own independent shrimp farm during the dry season. In the wet season, we cultivated Aman crops and obtained only 0.8 tonnes per acre due to high soil salinity and low soil nutrients. The saline water prevailed in the soil for up to nine months from December to August. As the shrimp farmers prolonged the length of shrimp farming, the paddy planting dates had to be postponed; hence, the crops could not benefit properly from the monsoon rains. **T2.** Our shops were closed down for a year after cyclone Aila. My brothers migrated to work in Khulna city, and they refused to return to this cyclone prone area. Hence, I had to sell the shops as I had no one to look after them. Now I have a Galda prawn farm in 1.5 acre of land of which 0.5 acre is used for planting Aman paddy. Previously, I worked for some time in a Galda farm in another district, which enabled me to gain some experience. In February, I secretly brought in some saline water in my farm and released some Bagda shrimp post-larvae. Compared to the previous salinity levels of 7-8 ppt which was favourable for Bagda cultivation, the salinity level is now higher (about 11-12 ppt), especially after Aila. In April, I purchased and released 5000 Galda prawn post-larvae as well. Due to the high salinity in the water, most of the Bagda and Galda shrimp ultimately died. I think that instead of releasing them in the saline water, if I would have released them later in freshwater, the yield would have been much better. The advantages of Galda farming are that they can grow in freshwater, they are less susceptible to diseases and they require much less amount of land. On the other hand, the disadvantages are the high costs of shrimp post-larvae, the requirement of additional fish feed and costs of digging the ponds and land preparation. I feel that this freshwater farming system of rice cum Galda shrimp is much better than the previous saline water Bagda farming system. However, personally I am not been better-off after Aila, as I still could not benefit much from Galda prawn farming.	**T1.** Income from non-farm activities; purchase of land **T2.** Can farm in own land; integrated freshwater Galda and paddy farming possible. ***Barriers*** **T1.** Poor yield of paddy due to salinity and postponed planting dates; Fragmented land parcels. **T2.** Cyclone; still new to Galda prawn farming; sale of shops; increased salinity in dry season.
Case 4: Poor household, Mithakhali	***Opportunities***
T1. I have one acre of agricultural land. When there was rice, everyone had more or less enough food for subsistence. We never had to buy vegetables as we could grow many different types of plants like mustard, potato, pumpkin, chilli, spinach and banana in	**T1.** Good soil quality allowed within farm diversification

our homestead garden. We could also catch open-access fish from the canals. Moreover, I had about 15-20 goats and 5-6 buffalos. **T2.** Now I am engaged in shrimp farming under a co-operative system. Previously our investment to revenue ratio was 1:28, whereas now it is 1:5. This year, we faced losses in fact and did not even get our investment back. I also have about 0.08 acres of pond, where I grow a few Bagda shrimp for sale as well as some white fish for consumption. This year, I released about 1000 post-larvae, but could not harvest a single shrimp. I also released about 4 kg white fish juveniles at a cost of BDT 150 per kg. The white fish yield is barely enough for subsistence. I'm now indebted to the post-larvae supplier and have to wait till the next season to repay the loan. Now, even with the application of fertilisers it is difficult to grow vegetables in our garden. I cannot rear livestock due to lack of fodder. Now that all canals are blocked and under private ownership, we cannot catch fish as well. In one word, after rice cultivation stopped we are left with nothing. When there was rice, we had the option of sharecropping; so poor people like us who did not have enough land could cultivate others' land for a living. I wish I could dig a trench alongside the periphery of my land where I can farm Galda prawns and white fish. At the same time I can grow rice in middle. But this is never possible unless the powerful people stop shrimp cultivation. Moreover, I do not have the cash to invest in Galda farming.	***Barriers*** **T2.** Limited farmland; increased salinity and soil degradation due to shrimp cultivation; lack of investment capital ***Limits*** **T2.** Cannot grow paddy due to increased salinity
Case 5: Extreme poor household, Mithakhali **T1.** I do not have any agricultural land. Before shrimp cultivation started, I used to work as a wage labour in others' farms and at the Mongla port. Since this area was dependent on one crop only, the income from agricultural labour was not good enough. Although I had enough rice to eat three meals a day at that time, I'm better-off now because I have cash to purchase other necessary items. **T2.** Currently, I also work as a wage labour, but on a diverse range of activities. From February – July, I mainly work in shrimp farms; my work includes preparing land before farming starts, releasing post-larvae and harvesting shrimps, exchanging water through sluice gates every fortnightly and performing ad hoc work in the farm owner's house. I earn BDT 5000 per month, of which the farm owner deducts BDT 2000 for my food expenses. From November – January, I migrate to nearby sub-districts, where they have three paddy crops a year. For every 10 maunds of paddy I harvest, I receive one maund (37 kg). For the rest of the year, I work as a van-puller earning about BDT 150 – 200 per day. I do not have my own van, but rent it every day at a cost of BDT 30. Due to the development of road networks within the village, I can drive van for the last 7-8 years.	***Opportunities*** **T2.** Construction of roads; demand for agricultural labour in nearby areas ***Barriers*** **T1 & T2.** Lack of own farm land, only asset is physical labour

7.4 Discussion

This chapter explored the livelihood adaptation opportunities, barriers and limits experienced by households of different poverty levels in two communities with differential socio-ecological changes. The results show that economic, ecological and socio-political factors served as the most important opportunities, barriers and limits for adaptation. These factors determined the capacity of households to shape socio-ecological change in desirable ways, which, in turn, affected the main livelihood options available to different households. Institutional support, infrastructural developments, market access, gender, and knowledge on farming practices posed additional opportunities, barriers and limits in effectively executing the available livelihood options. Analysis of empirical evidence presented in section 7.3 leads to three main findings, which are discussed below.

Firstly, the different opportunities, barriers and limits had heterogeneous impacts on households of different wealth classes, such that the same conditions can facilitate adaptation by one group while restricting the adaptive capacity of another. Adger *et al.* (2009) argues that what constitutes an opportunity or a barrier depends on individuals' goals and values, which are often subjective and socially constructed. For privileged members of the society, adaptation is usually about progress, while for the marginalised ones, it might entail protecting assets and ensuring short-term food security (Adger *et al.*, 2009). For example, in Mithakhali, the transition towards a shrimp-white fish system served as an opportunity for wealthier households, who favoured market oriented cash crop cultivation that enabled further wealth accumulation. On the other hand, poorer households, who valued the peace and identity associated with subsistence based livelihoods, suffered from the inability to diversify their farm outputs or earn enough cash from small-scale aquaculture. Previous studies by Pouliotte *et al.* (2009), Swapan and Gavin (2011) and Abdullah *et al.* (2016) also found that shrimp cultivation exacerbated local income distributions and created new social hierarchies. Williams *et al.* (2015) and Khan and Grünbühel (2012) also highlighted the role of socio-political power in shrimp farming communities in Bangladesh, where employees of the Water and Power Development Authority (WAPDA) usually prioritised the needs of large landholders in managing entry and drainage of saline water through sluice gates.

In contrast, in Kamarkhola, the ban on shrimp aquaculture restricted the ability of large landowners to earn quick cash, forcing them to reluctantly lease out land for sharecropping. This opened up opportunities for poorer households to grow paddy on leased in land,

providing food security. Moreover, the ban enabled households of all classes to diversify their farm outputs and improve overall environmental quality. These cases show how the activities of one group can affect the adaptive capacity of another. They support the literature on social barriers to adaptation, which rightly underscores that societal transformation and adaptive capacity of different social groups is determined by systems of power deeply entrenched in social structures (Jones and Boyd, 2011). As mentioned by Adger *et al.* (2009), adaptation barriers are endogenous and originate from inside the society, and therefore, can only be understood in context.

Secondly, the various forms of opportunities and barriers are not mutually exclusive; rather they interact in complex ways such that a given factor can reinforce or dampen another factor directly or indirectly via its effects on related livelihood activities. For instance, ecological barriers in Mithakhali, such as shrimp disease outbreaks and soil salinity, led to economic barriers, especially for poorer households who could not re-invest in new post-larvae or repay creditors, ultimately leading to food insecurity. The opposite was true for Kamarkhola, where recovering soil quality allowed lower income households to invest in low risk diversified farm outputs. Many people, in fact, considered cyclone Aila to be a blessing, as it had served as an opportunity to wipe out any remaining shrimp farms and resume more traditional forms of livelihood. Similarly, economic factors, such as land ownership or income, often resulted in personal barriers or opportunities, in terms of investment in education. For instance, wealthier farmers in Mithakhali could invest in their children's higher education, enabling them to move to non-farm activities, like businesses or service jobs – a transformational adaptation that was not possible for the low income groups. On the other hand, poorer households often failed to provide higher education to children or were forced to remove them from school to be employed as wage labours to generate income.

Institutional barriers, in the form of livelihood information dissemination, had translated to knowledge barriers for Kamarkhola farmers who were trying to start freshwater prawn farming and for richer farmers in both sites who were willing to shift towards semi-intensive shrimp aquaculture. In contrast, institutional opportunities, such as leadership and mobilisation by grassroots organisations, allowed Kamarkhola farmers to take collective action against shrimp farmers and revert to a paddy-based livelihood system. Likewise, infrastructural barriers, such as poor road communication and power supply in Kamarkhola, led to market barriers as farmers had difficulty in storing or transporting their products to nearby market hubs. Previous studies by Antwi-Agyei *et al.* (2015) and Islam *et al.* (2014)

similarly underscored these complex ways in which multiple barriers combine to impede adaptation, as elaborated in section 2.7.2 of the literature review chapter.

Thirdly, the above findings lead to an understanding of potential ways in which some of the barriers can be overcome. While some ecological limits, such as seasonal salinity and tropical cyclones, cannot be avoided, others such as knowledge, institutional or economic barriers can be reduced through changes in farming practices, proper training and knowledge dissemination among farmers, access to credit for initial investments, and capacity building of local institutions.

In Kamarkhola, the ongoing shift towards a rice-prawn-fish integrated system is both ecologically and economically viable; however, successful transition requires training and information support, which needs to be provided by local government institutions and NGOs. This, in turn, requires increased communication with scientists and researchers, to build the capacity of agricultural and fisheries departments. Similar findings have been made by Hasanuzzaman *et al.* (2011), Chandra *et al.* (2010) and Ali *et al.* (2009), based on in-depth research on aquaculture practices in south-western coastal Bangladesh. Availability of low-interest credit is also essential, but most often farmers in this study were reluctant to take loans unless they were confident that they would be able to produce enough yield to repay the loans. This is in accord with Gehlich-Shillabeer (2008), who argued that borrowing from a variety of sources to overcome cash shortages, coupled with lower capacity to reimburse loans, had led to higher indebtedness and potential poverty traps. Thus, provision of micro-credit, in absence of knowledge support, may not lead to better livelihood outcomes.

The farming system trajectory undertaken by farmers in Mithakhali seems to be maladaptive in the context of increasing salinity and environmental degradation. The agro-ecosystem has almost reached a limit; according to local farmers the farmlands might lose all productive capacity unless some major transformations allow the soil to recuperate. However, this does not mean that sustainable shrimp and fish aquaculture is not possible; it requires numerous technological improvements, adequate knowledge transfer through institutional changes and appropriate monitoring of compliance with social and environmental requirements (Paul and Vogl, 2011). The importance of shrimp export in promoting national growth is well recognised and the government has enacted a number of laws and policies with respect to allocation of areas, conservation of natural biodiversity, shrimp production and handling procedures and safeguarding the rights of local people (Paul and Vogl, 2011). However, huge gaps exist in enforcement due to weaknesses in institutions and their capabilities, creating

scope for the powerful to pursue their vested interests (Paul and Vogl, 2011, Alam *et al.*, 2005).

These findings enhance our academic knowledge on what constitutes an opportunity, barrier or a limit and for whom, and highlights key issues for policy making in the context of coastal Bangladesh. The complex dynamics of these opportunities, barriers and limits suggests that while lists may provide structural and analytical clarity, the tendency to follow such categorisation may obscure the root causes of some of these opportunities, barriers and limits. The empirical evidence suggests that while low-lying coastal areas are prone to a range of shocks and stresses, the region's natural capital allows a range of ecologically and economically viable livelihood options, provided that conflicts between multiple resource users do not lead to environmental degradation and restrict the adaptation options for poorer households. Good leadership, proper implementation of policy guidelines, infrastructural development, better institutional support and knowledge dissemination can enable households with comparatively lower entitlements to generate optimum incomes in ways that do not jeopardise their future livelihoods.

7.5 Conclusion

This chapter analysed the differential opportunities, barriers and limits faced by households of different wealth classes in adapting their livelihoods to socio-ecological changes. In doing so, the chapter used qualitative data from focus group discussions and livelihood trajectory interviews to identify eight categories of opportunities, barriers and limits that determine the availability and outcome of different livelihood activities. Five livelihood trajectory interviews, one from each household class, were presented to examine the realities of opportunities, barriers and limits both before and after the transitions in farming systems in each village. The discussion section elaborated on the interactions between different types of barriers and identified potential ways in which some of them can be addressed. The following chapter, which is the last chapter of this PhD thesis, synthesizes the empirical findings from the four results chapters (chapter 4-7) and outlines the academic contributions. It provides a holistic discussion in relation to the overall thesis aim and the academic literature and briefly describes the research implications and priorities for future work.

Chapter 8. Discussion and conclusion

8.1 Introduction

Low lying coastal areas in many parts of Asia have undergone significant socio-ecological changes in the past few decades, particularly due to the commodification of peasant livelihoods through export-oriented aquaculture (Abdullah *et al.*, 2016, Orchard *et al.*, 2016). Empirical evidence from two communities in coastal Bangladesh show that wealthy and politically powerful farmers can transform the predominant farming system in ways that support their short-term interests at the cost of long-term environmental degradation. Resource constraints often limit the livelihood options of poorer households; however, negative externalities associated with the activities of wealthier households can further constrict their adaptation space and exacerbate existing inequalities in wealth and well-being. In contrast, social resilience achieved through learning, memory and good leadership can enable small farmers to overcome the power structures and alter the system configuration to one that is desirable for the majority of stakeholders. The findings suggest that a planned and transparently navigated transformation, supported by good governance and wider participation in decision making, can better address the heterogeneous needs of different social actors and prevent the system from embarking on a maladaptive trajectory.

The purpose of this chapter is to provide a broader discussion of how these findings can enhance our academic understanding of livelihood adaptation to socio-ecological change and what they mean for the coastal regions of Bangladesh and beyond. In doing so, the chapter first revisits the conceptual framework of this study and compares its conceptualisation of the social and ecological systems dynamics with other SES frameworks in the literature. It then discusses how the study findings support and contribute to the recent literature on the drivers, adaptation responses and distributional effects of socio-ecological change. Finally, the chapter concludes this thesis by discussing the implications of this work and future research directions.

8.2 Revisiting the conceptual framework

In the past decade, there has been a general shift from a static isolated view of a particular unit of analysis to a dynamic perspective of a coupled SES, characterised by multiple spatial and temporal scales, their interactions and feedback loops (Hinkel *et al.*, 2014, Binder *et al.*, 2013). Unpacking the complexities of SESs requires integrative interdisciplinary approaches

that bridge across several knowledge domains (McGinnis and Ostrom, 2014, Binder *et al.*, 2013). This has led to the development of a number of SES frameworks (e.g. Reed *et al.*, 2013b, Fraser *et al.*, 2011, Ostrom, 2009, Turner *et al.*, 2003, Scoones, 1998), which differ significantly in terms of their disciplinary origins, their diversity of research questions and purpose, and the way they conceptualise social and ecological systems (Binder *et al.*, 2013). A framework is *"composed of potentially relevant classes of variables and their general relationships to construct a meta-theoretical language for diagnostic or prescriptive study of phenomena"* (Epstein *et al.*, 2013: 434). Frameworks play a central role in SES research by outlining the interactions between the different components and providing a common language for scholars from different disciplines (Hinkel *et al.*, 2014). The conceptual framework of this study, presented in chapter 2 (Figure 2.1), contributes to the increased calls for adoption of an interdisciplinary approach to unpack the complexities of SESs, by combining a number of key concepts related to human dimensions of environmental change, namely, poverty, livelihoods, vulnerability, adaptation, resilience, political ecology and human well-being. This section discusses the key attributes of the conceptual framework used in this study, in terms of its conceptualisation of social and ecological systems and their dynamics and compares it with other similar frameworks in the literature, thus, highlighting its strengths and limitations.

The conceptual framework of this study included three hierarchical spatial scales, namely, global, national or regional, community and household, whereby, socio-ecological change at community level is conceptualised as the outcome of the cross-scalar interactions between multiple conditions and processes. The study put relatively greater emphasis on the influence of macro level changes on the micro level, for instance, how policy amendments and infrastructural developments at national and regional scales brought about changes in local farming systems. It also showed how changes in communities' vulnerability contexts affected households' livelihood adaptation responses, which, in turn, lead to further changes in context – thus, implicitly acknowledging the inter-scale feedbacks. However, the bottom-up feedback links were not explicitly shown in the framework, as the study mainly focused on the top-down linkages.

The conceptual framework of this study is quite similar to Turner *et al.* (2003)'s vulnerability framework which analyses the vulnerability of a specific 'place' that is subject to multiple stressors originating from higher spatial scales outside the 'place'. Unlike this study, Turner *et al.* (2003)'s framework shows feedbacks across scales, in terms of how human and environmental influences outside the place affect the impact and adaptation responses

within the place and vice versa. However, the authors did not prescribe any particular theoretical lens to study the drivers and consequences of change. This study used resilience and political ecology perspectives to analyse the root causes of socio-ecological change and applied a livelihood and well-being approach to study the consequences. The use of these conceptual lenses allowed this study to delve into the long-term conditions and processes that resulted in the current vulnerability context of the two communities, and capture the differential livelihood dynamics and outcomes. In doing so, this framework allowed the study to overcome some of the drawbacks of the sustainable livelihoods framework (SLF) (DFID, 1999, Scoones, 1998), which takes an ahistoric approach to understanding the vulnerability context and provides a static view of livelihoods at a given time (refer to review in section 2.5.2).

This study referred to changes in government policies, implementation of donor funded projects and improper implementation of policies at local levels as some of the key drivers of socio-ecological change (section 5.3.1). It also discussed the roles of institutional support in mobilising farmers against outside shrimp entrepreneurs and in providing relief and rehabilitation in the post-cyclone period. They were implicitly embedded within the socio-political domain of the adaptive cycle (Figure 5.1) and the boxes named 'socio-ecological change' and 'livelihood adaptation opportunities, barriers and limits' within the framework. However, the study did not undertake an explicit analysis of the cross-scalar interactions between multiple levels of governance structures and the formal and informal institutions that influence behaviour and relations between different actors. Issues of governance and institutions are not sufficiently addressed in some other SES frameworks as well. For instance, the SLF bundles governance and institutions under 'transforming structures and processes', while Reed *et al.* (2013b) tacitly refers to institutions as one of the conduits for diffusing social learning. Compared to these frameworks, Fraser *et al.* (2011)'s three dimensional vulnerability framework puts greater emphasis on institutional capacity, illustrating it as one of the three components of measuring vulnerability dynamics, the other two being agro-ecosystem resilience and socio-economic affluence. Governance structures and institutions play an integral role in shaping socio-ecological change and determining the capacity of social actors to respond to change. Inclusion of these factors within this study's framework could greatly enhance the understanding of social dynamics, as well as its impacts on the ecological components of the system.

The conceptual framework and the research questions of this study treated social dynamics in greater depth compared to ecological ones. Like the SLF and Turner *et al.* (2003)'s

framework, the study's framework adopted an anthropocentric perspective, where the ecological system is viewed as the provider of goods and services for human needs. The study implicitly engaged with the ecological system components in terms of changes in water salinity, soil degradation, disease outbreaks and overall decline in agro-ecosystem resilience. However, detailed analysis of the changes in ecosystem services, in terms of provisioning and regulating services, was not undertaken as this was beyond the scope of this research. In terms of interactions between the social and the ecological system, the study qualitatively explored the two-way influences, for example, by describing the impacts of shrimp cultivation (social system) on soil/ water quality and paddy/vegetable yields (ecological system), which in turn affected the well-being of social actors by restricting their livelihood options. A detailed account of the changes in stocks and flows of natural capital (e.g. Reed *et al.* (2013b)'s framework), especially in terms of quantitative assessments, can provide a better understanding of the ecological components and explore the links between ecosystem services and well-being, as demonstrated in some recent studies (e.g. Hossain *et al.*, 2016a, Daw *et al.*, 2015).

8.3 Consolidating findings to address the study aim

Application of the conceptual framework discussed above, provided a holistic in-depth understanding of the causes of long-term socio-ecological changes in coastal Bangladesh and the differential capacities of households to effectively adapt their livelihoods to these changes. Research on socio-ecological change has gained increased momentum in recent years, with particular emphasis on the processes that drive change, the differential responses of various social groups, and the distributional equity of costs and benefits of change (Nayak *et al.*, 2016, Moshy *et al.*, 2015, Orchard, 2014, Beymer-Farris *et al.*, 2012). Unlike previous studies, which often viewed change and adaptation as a one-off linear process brought about by specific interventions or events, the literature now addresses change and adaptation as dynamic, ongoing processes, where past changes and responses can direct future change by reinforcing or dampening the pathways and cross-scalar feedbacks that triggered the change in the first place (Fazey *et al.*, 2015, Wise *et al.*, 2014).

Resilience has emerged as an important concept in evaluating change in coupled social-ecological systems, as it provides a dynamic approach to system analysis and management by emphasising non-linearity and multi-scalar feedback mechanisms (Ingalls and Stedman, 2016). Resilience thinking is concerned with the capacity of a system to absorb disturbances and maintain its existing structures and functions, as well as shifting to a new regime when the current state become undesirable (Folke, 2006, Walker *et al.*, 2006). In other words, it

focuses on accommodating change through 'incremental adaptations', which create knowledge and skills through experimentation and evaluation of outcomes; these social learnings and memory later form the basis of 'transformational adaptation' when the system becomes untenable (Pelling, 2011, Folke *et al.*, 2010). While the coping and adaptation aspects of resilience have been studied extensively and applied in international development initiatives seeking to 'build resilience' to natural shocks and stresses, the transformational dimension has received far less attention (Brown, 2015). Transformational adaption is emerging as a new field of inquiry that can better inform developmental policy and programs, especially at a time of increasing threats from climate change (Brown, 2015, Park *et al.*, 2012, Rickards and Howden, 2012, Pelling and Manuel-Navarrete, 2011).

The empirical evidence of this research shows that, in the pursuit of building resilience to socio-ecological change, both the study communities underwent transformational adaptation as maintenance of the *status quo* through incremental adaptation was no longer feasible (Chapter 5, Objective 2). For instance, in Mithakhali, when paddy yields started to decline due to shrimp cultivation, farmers invested more in inputs such as fertilisers, pesticides and seeds; however, when these incremental adaptations were no longer effective, they resorted to transformational adaptation, that is, phasing out paddy altogether. In contrast, in Kamarkhola, the transformation was more abrupt and intentional. The ineffectiveness of incremental adaptations in maintaining paddy yields and coping with shrimp diseases caused small farmers to mobilise against large shrimp farmers, which led to a ban on shrimp cultivation. Using the findings from these two diverse cases, the following paragraphs discuss the drivers and processes of socio-ecological change, the differential adaptation responses, and the distributional effects of these changes and responses, thus, addressing the study aim.

8.3.1 Drivers and processes of socio-ecological change

The findings of this study show that socio-ecological change brought about by transformational adaptation can result from unintended consequences of action, as well as from deliberate decision-making (cf. O'Brien, 2012). Transformation is not a random isolated event; it is shaped by social actors with different values, interests and power (Moore *et al.*, 2014). In some cases, actors can govern the transition to a pre-determined state at a particular time (e.g. Kamarkhola), while in other cases, actors indirectly steer the trajectory of the transformation process towards their own goals (e.g. Mithakhali) (Moore *et al.*, 2014, Westley *et al.*, 2013). The role of social actors in navigating change raises issues of social inequalities and power imbalances, which are receiving increased attention in the

literature (Boonstra, 2016, Ingalls and Stedman, 2016, Nayak *et al.*, 2016). The system-oriented focus of resilience thinking leads to an insufficient engagement with issues of power; thus, emphasising the need for integrating insights from political ecology (Brown, 2014, Fabinyi *et al.*, 2014, Turner, 2013). Political ecology views asymmetric power relations as a core driver of environmental change, the costs and benefits of which are unequally distributed, thus, reproducing the power imbalances that caused it (Ingalls and Stedman, 2016).

There are various perspectives on the power and politics of regime-shift; an agent-centred view conceives power as 'coercion', whereby an individual or group manipulates the behaviour of others directly using muscle power or political backing, or as 'constraint' whereby powerful actors with a concealed agenda pursue their objectives in ways that restrict the abilities of others (Nayak *et al.*, 2016). Both forms of power have been observed in this study (Chapter 5, Objective 2). During the exploitation and conservation phases of shrimp cultivation, agricultural lands were forcefully grabbed by outside entrepreneurs, who also used their political ties to take control over public canals and water management infrastructure. During the release and re-organisation phase, large farmers in Mithakhali managed to gradually replace wet season paddy with white fish farming, by constraining the ability of poor farmers to drain their land at the end of the dry season. Powerful actors also tend to resist change of the dominant system and safeguard their interests (Moore *et al.*, 2014). This was observed in Mithakhali, where small farmers alleged that large landholders used their political ties to postpone construction of an embankment that would have abolished shrimp farming in the area.

In the case of deliberative transformation (e.g. Kamarkhola), the literature acknowledges several phases, namely, triggers or pre-transformation, preparing for change, navigating the change and institutionalising the change (Moore *et al.*, 2014, Olsson *et al.*, 2004). In Kamarkhola, the deterioration of soil quality, dwindling paddy yields, increased water salinity and poor income from shrimp due to disease outbreaks served as triggers for transformation. This led to 'sense making', where farmers from different wealth classes started to realise the long-term adverse impacts of the shrimp-paddy rotational system and developed a common story and purpose. In order to operationalise this collective purpose, farmers drew on their social memory of previous protests and conflicts in the region and resorted to social movements as an effective means of navigating the transition. At this stage, leadership plays an important role by linking and mobilising actors and breaking the system inertia (Folke *et al.*, 2005). The role of leadership, in the form of newly elected local

political members, was observed both in Kamarkhola and Mithakhali. In Kamarkhola, the new leader supported the social movement against shrimp cultivation in 2008, while in Mithakhali the elected law-maker enabled local farmers to retrieve their land from outside entrepreneurs in 1996. Transformation also makes use of crises as windows of opportunity, and recombining sources of experience and knowledge to navigate social–ecological transitions (Folke *et al.*, 2010). In Kamarkhola, the 2009 cyclone Aila destroyed all shrimp farms and allowed farmers to experiment with newer livelihoods, like freshwater prawn farming, by drawing on their previous experience with shrimp farming and knowledge on prawn farming practices from farmers in nearby areas. Similarly, in Mithakhali, although transformation was gradually taking place since the early 2000s, the final blow came in 2007, when the increased salinity brought about by cyclone Sidr put an end to paddy cultivation.

8.3.2 Differential adaptation responses to socio-ecological change

The capacity to adapt to socio-ecological change is largely determined by households' ownership and access to resources, which are often differentiated by wealth class. Various case studies have provided extensive evidence on the relationship between poverty and livelihood adaptation, especially in terms of diversifying within the farm and toward non-farm activities (Martin and Lorenzen, 2016, Olsson *et al.*, 2014, Oumer and de Neergaard, 2011, Ellis, 2000, Reardon *et al.*, 1992). In this study, households within each of the two study communities were disaggregated into five wealth classes, namely, rich, upper middle, lower middle, poor and extreme poor, through a comparative analysis of the results of three different methods of multi-dimensional poverty (Chapter 4, Objective 1). The findings revealed ownership of agricultural land as the most important determinant of wealth class; land ownership increased exponentially from the lowest to the highest wealth class, with rich households possessing almost three times as much land as the upper middle class in both sites. These observations are also substantiated by recent studies in south-western coastal region of Bangladesh (Abdullah *et al.*, 2016, Afroz *et al.*, 2016), as well as in other coastal areas in Asia (Martin and Lorenzen, 2016, Williams *et al.*, 2015).

An investigation of the links between poverty and livelihood strategies (Chapter 6, Objective 3) revealed that while rich and upper middle class households, with large land endowments, typically preferred to specialise in a couple of high-return farm and non-farm activities, the lower middle class sought to diversify their farm activities often with engagement in small business or fixed income jobs. The poor also tried to diversify, but the limited scale of each activity prohibited them from obtaining positive results. The poor and

extreme poor, with negligible land and a lack of specialised skills, mainly depended on wage labouring activities and petty trades. However, such static analyses often provide an incomplete picture and may lead to interventions that seek to increase wealth through economic growth. To provide a holistic picture, this study compared the livelihood strategies of households of different wealth classes at two time periods, analysed individual livelihood trajectories (Chapter 6, Objective 3) and identified differential adaptation opportunities, barriers and limits (Chapter 7, Objective 4). Engagement with these livelihood dynamics revealed that while livelihood adaptive capacity depends on a household's resource endowments and entitlements, that is, its own poverty level, it is also affected by the community's vulnerability context and the adaptation activities of other households. For instance, in Mithakhali, the transition from a shrimp-paddy rotational system to a yearlong shrimp-white fish aquaculture system disproportionately increased the livelihood vulnerability of the poorer groups, who could not use their own land to grow paddy due to the negative externalities posed by shrimp cultivation by large landowners.

The term 'differential livelihood adaptation', as used in this study, closely relates to the concepts of 'divergent adaptation' (Snorek *et al.*, 2014), 'response space' (Osbahr *et al.*, 2010) and 'adaptation pathway' (Wise *et al.*, 2014, Haasnoot *et al.*, 2013) – all of which conceptualise adaptation as a localised, complex and dynamic process, framed by the social, political, and institutional dynamics as well as power, knowledge, and values/interests across multiple scales. Adaptation to socio-ecological change occurs within a 'response space', whereby individuals'/communities' abilities to pursue successful livelihood adaptation pathways are constrained by the adaptive actions of other individuals/communities, as well as their antecedent decisions that lock them in particular trajectories (Snorek *et al.*, 2014, Wise *et al.*, 2014, Haasnoot *et al.*, 2013, Osbahr *et al.*, 2010).

These concepts can be used to better illustrate the findings of this study. Figure 8.1, which is inspired by Wise *et al.* (2014), shows the livelihood trajectories of two households who have different starting points owing to their different poverty levels (although the study involved five wealth classes, only two are shown for simplicity). These households operate within a shared response space, characterised by adaptive and maladaptive spaces - the boundaries between which are changing over time, due to biophysical changes, changes in social and institutional context, as well as the actions of other decision makers who may perceive different adaptation pathways. The trajectories comprise a series of livelihood strategies, punctuated by decision making points whereby households decide on their next

strategies based on their past experience and future goals. Household 1 enjoyed an upward trajectory, resulting from positive outcomes of past strategies. For instance, one of the cases in section 6.3.3, showed how a farmer used his land to earn huge profits from shrimp cultivation during the 1990s, which allowed him to purchase more land at a time when prices were lower. This further enabled him to invest in high-return non-farm activities and allocate different land parcels to different forms of farming arrangements. Thus, the household's livelihood adaptation space widened over time. On the other hand, household 2, with limited initial land ownership, experienced a downward adaptive trajectory and is likely to slip into the maladaptive space in future (refer to section 6.3.3 for examples of cases); its adaptation space narrowed down due to decline in its own resources and also due to the responses of household 1 that further shaped the context. The households, thus, exhibit divergent adaptation, whereby successful adaptation by one household/wealth class led to reduced adaptive capacity of another household/wealth class within a shared socio-ecological system.

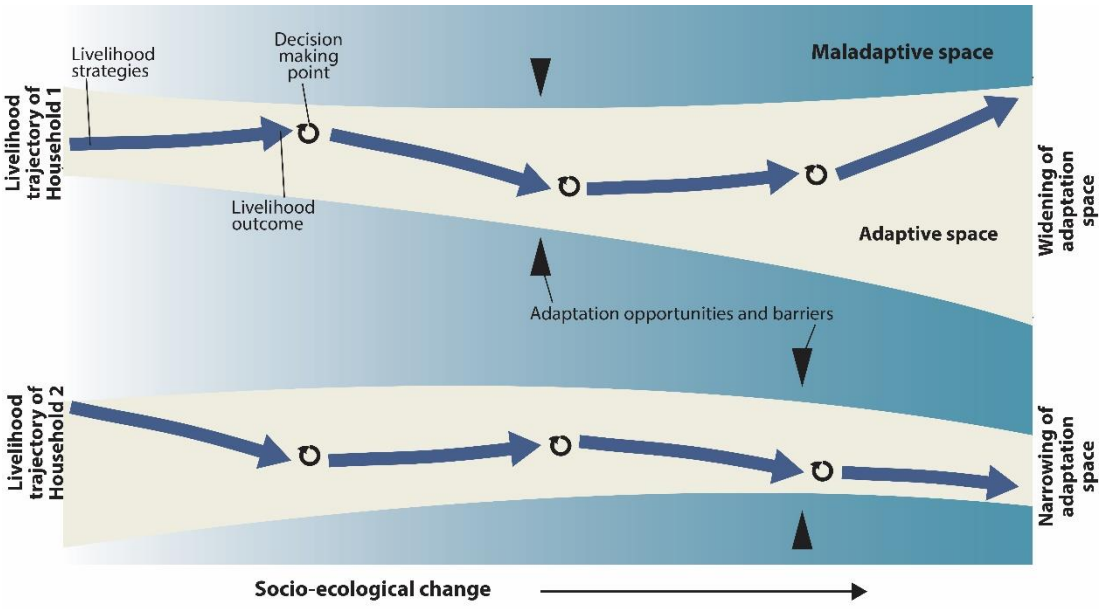


Figure 8.1 Differential livelihood adaptation to socio-ecological change (Author's own illustration, inspired by Wise et al. 2004)

Besides these economic and socio-political factors, the households' adaptation spaces are also modified by other opportunities, barriers and limits, which are often related to the specific adaptive actions being considered, to the actors that may implement them and to the specific context in which they may be undertaken (Chapter 7, Objective 4) (Eisenack and Stecker, 2012). Thus, increased soil and water salinity is viewed as a barrier to household 2 which wants to cultivate paddy and rear livestock for subsistence; however, it

serves as an opportunity for household 1 which is interested in cash income from aquaculture. Similarly, while a cyclone can adversely affect both households, the absolute and relative losses may be different. Household 1, which may suffer from huge financial losses due to escape of shrimp, can recover using savings or income from other sources. But household 2 may end up living on the embankment as its house was not strong enough to withstand the cyclone. It should be noted that households 1 and 2 are used as illustrative examples to explain the intertwined livelihood dynamics; in reality, many other trajectories are possible and households starting at different points may ultimately end up with similar outcomes.

8.3.3 Distributional effects of socio-ecological change and adaptation responses

The definition of resilience states that transformational adaptation may be needed when the current state becomes 'undesirable'. This raises questions about 'what is desirable and for whom' and 'who wins and loses as result of change'. For ecological systems, there are no contentions regarding the desirable outcome, as the persistence or sustainability of the system is the ultimate goal (Folke, 2006, Walker *et al.*, 2006). However, in social systems, human actors have varied perceptions and interests, resulting in different notions of desirable states (Folke, 2006, Walker *et al.*, 2006). These issues can be addressed by exploring what 'well-being' means for different people. Human well-being is gaining increased traction in recent years, particularly within the literature on resilience and ecosystem services (Daw *et al.*, 2015, Armitage *et al.*, 2012, Coulthard, 2012, Daw *et al.*, 2011). Since different groups of social actors derive benefits from different bundles of ecosystem services, environmental management and policies often involve trade-offs and create winners and losers (Daw *et al.*, 2015). Perfect equity in distribution of costs and benefits may not be possible; however, care must be taken to ensure that adaptive actions do not intensify inequalities and power differentials (Schoon *et al.*, 2015). Aggregate analysis of certain adaptive actions may point towards greater conservation and economic profits at community or national level; however, these actions may jeopardise the food security, employment and well-being of marginalised groups (Daw *et al.*, 2011).

Thus, this study used a well-being approach to disaggregate the differential values and needs of different wealth classes. The study found that on one hand, while brackish water shrimp aquaculture enhanced national economic growth and created employment for millions of people across the supply chain, it disproportionately undermined the well-being of poorer groups, who valued their identity as rice farmers. On the other hand, freshwater prawn, fish and paddy cultivation allowed both subsistence and market oriented

livelihoods, while maintaining the health of the agro-ecosystem. This is substantiated by a recent study in southwestern Bangladesh, where Belton (2016) found that the material gains from shrimp farming were offset by worsening subjective well-being caused by the loss of self-sufficiency in rice, frustration at injustices related to land expropriation and despair about the future. In contrast, integrated or rotational prawn-fish-paddy cultivation positively contributed to societal well-being by enabling both cash income and food security (material dimension), creating more equitable distribution of resources and increasing agency of women (relational dimension) and by retaining cultural identity as rice farmers (subjective dimension) (Belton, 2016).

Similar to the findings of this study, Abdullah *et al.* (2016) found that the ability to gain profits from shrimp farming mainly depended on the capacity to own, lease and control land. Hence, large landowners with political connections and financial resources necessary for investment turned out to be winners, while poor and landless farmers were pushed into further poverty (Abdullah *et al.*, 2016). These inequalities have grave implications for future adaptation to climate change. In the context of coastal Bangladesh, Hossain *et al.* (2016a) found that ecosystem regulating services, such as water quality maintenance and hazard protection, had deteriorated significantly in the past three decades with increased positive feedbacks. Faruque *et al.* (2016) notes that continuation of brackish water shrimp farming is likely to push the salinity front further inwards, aggravating local livelihoods in the future. Thus, to ensure resilient livelihoods and equitable distribution of well-being, processes of incremental or transformational adaptation should account for the needs of different stakeholders.

8.4 Academic contributions

Socio-ecological systems, such as the aquaculture industry studied in this research, are complex adaptive systems, whereby actors with different values and interests interact with each other and their natural environment. Actors learn from their past experiences and use their accumulated knowledge to respond to challenges. The system is not governed by deterministic laws – as the system evolves, the rules of the games change. A deeper understanding of these complex social and ecological dynamics is essential for ensuring equitable and environmentally sustainable livelihoods in the future. Unpacking these complex chains of interactions, spanning from local to global scales, require interdisciplinary approaches of scientific investigation; however, differences in epistemological origins and methodologies associated with different concepts often create

cognitive challenges of capturing the breadth without sacrificing the depth (Stojanovic *et al.*, 2016).

While the SES approach is theoretically interdisciplinary, methodological approaches are often steered towards quantifiable indicators, like stocks and flows of natural capital, crop yield, or material assets. Social components, like power relations, subjective well-being, and human agency, are sometimes ignored as they fail to fit the system model. For instance, in studying the interrelationships between ecosystem services and well-being in coastal Bangladesh, Hossain *et al.* (2016a, b) used indicators such as, percentage of population below poverty line, gross domestic product, and production cost as measures of material well-being, education level as a proxy for freedom of choice and improved water and sanitation facilities, housing conditions and birth by skill health trainer as measures of quality of life. While the authors studied the same SES as that of this paper, analysis of aggregate indicators at regional level reflected increasing trends in both provisioning services and material well-being, and weak relationships with regulating services. These results truly represent the reality at the regional level; however, such aggregate measures can lead to policies that seek to increase overall economic growth to promote human development. The adverse socio-economic and agro-ecological impacts resulting from the unregulated growth of the shrimp industry in coastal Bangladesh is the living example of the dangers of such reductionist research approaches and policy formulation. Examples of such scenarios can be found in most developing countries, whose policies were framed by international donor organisations in the post-war era. As argued by Scoones (2009), this reflects the hegemony of professional economists with specialist technical disciplines that shoved away alternative social science discourses.

While this study also used a SES approach, the conceptual and methodological approaches aimed to capture the inherent complexities, with a heavier focus on the socio-political components. Besides providing a holistic, in-depth understanding of the underlying drivers, differential livelihood adaptation responses, and the distributional effects of socio-ecological change, it also addressed the knowledge gaps and criticisms related to the individual concepts. The following paragraphs discuss the conceptual and methodological contributions this thesis to the academic knowledge on human-nature interactions.

This study contributes to the small, yet growing body of empirical studies that demonstrate how the combined use of socio-ecological resilience and political ecology approaches can enhance our exploration of the underlying causes of vulnerability from both a system- and an actor-oriented perspective. A number of recent theoretical papers have called for this

conceptual convergence, as a means of engaging with power dynamics and thus, better theorising the 'social' dimension' within socio-ecological resilience (Ingalls and Stedman, 2016, Brown, 2015, Fabinyi *et al.*, 2014, Turner, 2013, Cote and Nightingale, 2012, Davoudi, 2012). By engaging with the heterogeneous values, interests and social power of different wealth classes, and the roles of policies, governance and leadership in steering socio-ecological change, this study unpacked the complex dynamics within the social sphere. The integration of resilience and political ecology also facilitated an exploration of the multi-scalar, long-term processes of change, thus, overcoming the narrow ahistoric single scale focus adopted in the vulnerability literature (Tucker *et al.*, 2015, Miller *et al.*, 2010). The study showed that the vulnerability context at community level is comprised of multiple stressors, such as climatic shocks and stresses and anthropogenic challenges arising from land-use changes; thus, emphasising that isolated studies based on a particular event can veil the complexity of the situation. This is in accord with the emergence of multiple stressors as a relatively new field within global environmental change research (Räsänen *et al.*, 2016). Unlike the past when studies exclusively focused on the impacts of climate change, the last decade has seen a surge in the number of empirical studies highlighting the presence of multiple stressors, arising from both climatic and non-climate factors (e.g. Bennett *et al.*, 2015, Tucker *et al.*, 2015, McDowell and Hess, 2012, Quinn *et al.*, 2011).

The recent IPCC AR5 emphasised the need to explore the links between 'multiple stressors', 'multi-dimensional poverty', and 'livelihood dynamics', which is a novelty in the series of IPCC reports (Olsson *et al.*, 2014). Multi-dimensional poverty has received increased attention in recent years, particularly through the work of the Oxford Poverty and Human Development Initiative (OPHI) (Alkire *et al.*, 2015, Alkire and Santos, 2014, Alkire and Santos, 2010), and differentiation of wealth classes using multi-dimensional methods often forms the basis of research on livelihoods, vulnerability and adaptive capacity (e.g. Martin and Lorenzen, 2016). This study extensively dealt with methodological issues in multi-dimensional poverty assessment through the comparative analysis of results from participatory wealth ranking, fuzzy set analysis and principal component analysis. Livelihood dynamics were studied by comparing the livelihood strategies of households of different wealth classes at two time periods, and by analysing individual livelihood trajectories to elicit the factors that caused upward, downward or unchanging trajectories. Livelihood trajectories are increasingly prescribed as means to analyse livelihoods as a 'moving target' and to break away from the 'pentagon prison' of the SLF (Valbuena *et al.*, 2015, De Haan, 2012). Analysis of livelihood dynamics showed how livelihood responses to change can

drive further change, how livelihood adaptive capacities are differentiated by wealth class and vulnerability context, how adaptation activities of one social group can impinge on the adaptive capacity of another, and also how adaptation opportunities, barriers and limits pose heterogeneous impacts on different groups. Adaptation opportunities, barriers and limits have drawn significant attention in the last decade, producing a large number of case studies dealing with specific barriers under different contexts. The literature acknowledges that adaptation depends on who is adapting, to what, and under which circumstances; thus, creating a need for more context specific studies using social stratifiers (Adger *et al.*, 2007). By using poverty as a lens for differentiation and analysing data from communities with different vulnerability contexts, this study contributed to a better understanding of the differential needs of people, particularly in the context of aquaculture dependent coastal communities in Asia. The study showed that households with limited resource endowments were relatively more dependent on stocks and flows of natural capital for their livelihoods and food security. Those with higher wealth status could exploit the natural capital for further asset accumulation, ultimately, enabling them to move away from natural resource based livelihoods when needed.

The heterogeneous needs, values and perceptions of different people was also studied using the well-being approach, which has recently gained prominence within the literature on resilience and ecosystem services, to understand the trade-offs associated with different resilience building strategies (e.g. Belton, 2016, Hossain *et al.*, 2016a, Armitage *et al.*, 2012, Coulthard *et al.*, 2011). Analysis of the different dimensions of well-being in this study showed that while material gains are important, cultural identities as rice farmers, better environmental quality, social relations, and mental peace, are also crucial to people's subjective and relational well-being. However, there are variations on the notions of well-being between and within different groups. By engaging with human well-being outcomes of socio-ecological change, the study contributed to a better understanding of the trade-offs and inequalities resulting from change. Trade-offs can occur between and within different spatial scales. The findings suggest that economic growth and increased employment at national level may not always translate to enhanced adaptive capacity at household level. Similarly, the study showed the intertwined nature of households' adaptive capacities, whereby successful adaptation by one group of households could adversely affect the adaptation and well-being outcomes of another group. These findings, thus, indicate the need for planned and transparently navigated changes involving participation of all stakeholders.

8.5 Implications

This study implies that sustainable and equitable livelihood options are of utmost importance in enabling households with different wealth endowments to cope with increased exposure to shocks and stresses. Appropriate implementation of government policies and support from local government and non-governmental organisations are essential in fostering livelihood adaptive capacities and outcomes for different groups. In the context of coastal Bangladesh, experts have highlighted the need for integrated coastal zone management that can achieve higher agricultural and aquaculture production and provide increased protection from natural hazards, without degrading ecosystem health or jeopardising human well-being (Afroz and Alam, 2013, Ahmed, 2013b). This requires formulation of appropriate policies that goes beyond the current single sector approach, which not only causes duplication of roles of various government agencies but also results in contradictions among different legal documents (Afroz and Alam, 2013).

In 2014, the government enacted the 'National Shrimp Policy' with the aim of alleviating poverty, increasing foreign earnings and promoting environmentally friendly and pro-poor growth by developing necessary infrastructure, strengthening institutional management and innovating and disseminating new technologies (MOFL, 2014). Among other objectives, the policy seeks to ensure pathogen free breeding of post-larvae in hatcheries, stopping leasing of canals used for water exchange, increased shrimp yield through development of more semi-intensive farms and promotion of integrated rice-shrimp cultivation, crop diversification and crop-intensification based on land characteristics (MOFL, 2014). If properly implemented, this policy has potential to deal with the negative impacts of the unplanned, unregulated growth of the shrimp industry to date. For instance, this study highlighted how elite capture of public canals forced small farmers to depend on large farmers for water exchange, and also prohibited them from catching open-access fish. Management of shrimp diseases could allow small farmers to generate better income from their land, and protect them from the vicious cycle of indebtedness, as reflected by the study findings.

A land zoning policy is also needed to designate specific areas for shrimp, prawn or rice cultivation based on the seasonality of water salinity. While high salinity areas can pursue year-round brackish water shrimp and fish cultivation, medium salinity areas should restrict shrimp cultivation to the dry season only and free up the land for wet season paddy cultivation without delay (Faruque *et al.*, 2016). Medium and low salinity areas should also aim for integrated paddy-prawn-fish production, which can promote sustainable

development, equity and resilience of interlinked social and ecological systems (Ahmed *et al.*, 2014). Land zoning could lead to optimum outcomes from natural resources and increase overall production. Since both the study villages fall under the medium salinity category, this would mean allowing shrimp cultivation in Kamarkhola, and resuming paddy cultivation in Mithakhali. However, the study findings suggest that a shrimp-paddy rotational system may not be as productive as the 1990s, when soil fertility was higher than present. Most of the respondents of this study were skeptical about the sustainability and productivity of a shrimp-paddy rotational system. Yet, experts believe that proper regulation and good land management practices can maintain agro-ecosystem health, generate good yields of both shrimp and paddy, and bring win-win outcomes for all social groups. Hence, to avoid future conflicts and inequalities, policy makers must account for the perceptions of local farmers in devising the land zones.

Farmers are innovators and their abilities to experiment, learn and self-organise are key to strengthening their livelihoods. Historical evidence shows that freshwater prawn farming was actually pioneered by a few prosperous farmers in Bagerhat district and later spread throughout the region with the help of strong social networks within and across villages (Ahmed and Garnett, 2010). This study also found that some innovative farmers were experimenting with prawn and shrimp mixed culture, despite the differences in habitat of the two species. Greater benefits can be reaped if such innovations are supplemented by scientific research and greater knowledge dissemination through demonstration plots. For instance, although freshwater prawn cultivation is touted as both economically and environmentally sustainable (Ahmed *et al.*, 2014, Ahmed, 2013b), farmers in Kamarkhola referred to high investment costs, unavailability of snail feed and good quality post-larvae, and lack of knowledge on farm practices as significant barriers to successfully engage in prawn-fish polyculture or prawn-rice-fish integrated farming. Ahmed and Garnett (2010) found that resource poor farmers often resorted to loans from NGOs or local money-lenders to cover the start-up costs; although most farmers were able to repay them within a couple of years, a few became indebted due to harvest failures from disease outbreaks. As shown in this study, shrimp mortality and subsequent indebtedness led to downward livelihood trajectories for some individuals, thus, suggesting that in the absence of proper training and knowledge dissemination, greater availability of credit may not enhance livelihood outcomes.

Compared to other Asian countries, which practice semi-intensive and intensive shrimp/prawn farming, Bangladeshi farmers are still dependent on extensive and improved

extensive methods. There is huge potential to increase production by adopting best practice from other countries like China, Thailand, Indonesia and Vietnam. For instance, a comparative study of coastal aquaculture in Bangladesh and Vietnam found that the development of elaborate canal networks in the Mekong delta since the 19th century has enabled private access to water for each pond, whereas in Bangladesh the absence of such canal networks have created dependence among farms for water exchange, resulting in disease spreading and friction among large and small farmers (Joffre *et al.*, 2010). Moreover, the frequent emergence and rapid spread of technological innovation led to more diverse and productive culture systems in Vietnam (Joffre *et al.*, 2010). However, as stated in the National Shrimp Policy, if Bangladesh seeks to increase yield by promoting intensive and semi-intensive methods, it must take adequate precautions to avoid the adverse effects experienced by other countries, particularly in terms of discharging antibiotics, fertilisers and other chemicals into adjacent water bodies (e.g. Hatje *et al.*, 2016, Herbeck *et al.*, 2013). Promotion of such culture methods may further exacerbate wealth inequalities in coastal Bangladesh, as small farmers do not have the financial capital necessary for investment.

8.6 Directions for future research

This study emphasised the complex and interactive nature of the challenges associated with SESs, using empirical evidence from coastal Bangladesh. Addressing such challenges necessitates sufficient engagement with the roles of governance and institutions in shaping socio-ecological change and actors' capacity to adapt to that change. While this study addressed the roles of power dynamics in navigating change and highlighted the importance of good leadership and institutional support in fostering transformational adaptation, it did not undertake an explicit analysis of governance and institutions (as identified in section 8.2). The recent literature is increasingly engaging with 'adaptive governance' – *"an emergent form of environmental governance that is increasingly called upon by scholars and practitioners to coordinate resource management regimes in the face of the complexity and uncertainty associated with rapid environmental change"* (Chaffin *et al.*, 2014: Abstract). Adaptive governance requires nested layered institutions (harbouring complexity and redundancy) and institutional diversity (a mixture of market, state, and community organisations) at multiple levels, connected by formal and informal social networks (Karpouzoglou *et al.*, 2016, Folke *et al.*, 2005). By fostering flexibility, diversity and experimentation, adaptive institutions can prepare a SES to take advantage of windows of opportunity and effectively manage transformation to a desirable state when needed

(Koontz *et al.*, 2015, Olsson *et al.*, 2006). Research is needed to understand the policy interventions and legal and administrative reforms required to ensure flexible responses, experimentation, learning and reorganisation within the SES (Chaffin *et al.*, 2014). This also calls for analysis of social networks and social relations, in the form of bonding, bridging and linking social capital, that facilitate knowledge exchange, determine social rules and norms, and mobilise actors for collective action (Chaffin *et al.*, 2014, Olsson *et al.*, 2006). For instance, in the context of this study, it was common in rural areas to borrow farm inputs and sell outputs without paying or receiving cash immediately from other stakeholders in the supply chain; the process was based on mutual trust and verbal contracts. In Mithakhali, it was observed that during cyclone Aila, many people took refuge in the two-storied brick house of the village chairman, as the village lacked cyclone shelters at that time. In Kamarkhola, this study found that social networks outside the village enabled some farmers to gain knowledge on freshwater prawn farming. Thus, further work on governance, institutions and social networks, involving theoretical multiplicity could greatly improve understanding of what needs to be done to enhance future adaptive capacities and distributional equities.

Another limitation of this study (as identified in section 8.2) is its insufficient engagement with ecosystem services and dynamics, which have been addressed descriptively, without involvement of scientific data or mathematical models. The literature on resilience and well-being is increasingly focusing on ecosystem services to assess the trade-offs associated with socio-ecological change (Hossain *et al.*, 2016a, Orchard *et al.*, 2016, Daw *et al.*, 2015, Schoon *et al.*, 2015). The provisioning, regulatory and hazard protection services of the ecosystem are essential to human well-being; although different stakeholders may value different bundles of ecosystem services. An understanding of different ecosystem services and their interactions is essential in assessing the synergies and trade-offs between ecosystem services (Paavola and Hubacek, 2013). Reed *et al.* (2013a), for example, showed how computer models developed in collaboration with decision makers and other stakeholders can help to identify possible trade-offs and complementarities, thus, enabling policy decisions to avoid further environmental degradation and enhance multiple ecosystem services where possible. Hence, in the context of coastal Bangladesh, as well as other aquaculture dependent coastal communities, further research on the changes in ecosystem services is needed to prevent SESs from moving towards undesirable, maladaptive trajectories.

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Appendix A. Tables

Table A.1 Calibration of agricultural land in Kamarkhola in FSA1 and FSA2

Agricultural land (decimals)	No. of households	Percentage	Using frequency-based method (FSA1)				Using quadratic sigmoid function (FSA2)
			a	b = a/100	c = b – 0.260	d = 1- [c/(1-0.260)]	α = 0 decimals β = 100 decimals γ = 1000 decimals
			Cumulative Percent	F(x)	F(x) - f(x^1)	Membership score for agricultural land	Membership score for agricultural land
0	39	26.0	26.0	0.26	0.00	1.00	1.00
4	1	0.7	26.7	0.27	0.01	0.99	1.00
17	3	2.0	28.7	0.29	0.03	0.96	0.99
20	1	0.7	29.3	0.29	0.03	0.95	0.98
33	5	3.3	32.7	0.33	0.07	0.91	0.95
35	1	0.7	33.3	0.33	0.07	0.90	0.94
50	12	8.0	41.3	0.41	0.15	0.79	0.88
66	4	2.7	44.0	0.44	0.18	0.76	0.78
100	9	6.0	50.0	0.50	0.24	0.68	0.50
105	1	0.7	50.7	0.51	0.25	0.67	0.49
110	1	0.7	51.3	0.51	0.25	0.66	0.49
120	1	0.7	52.0	0.52	0.26	0.65	0.48
132	9	6.0	58.0	0.58	0.32	0.57	0.47
165	5	3.3	61.3	0.61	0.35	0.52	0.43
200	8	5.3	66.7	0.67	0.41	0.45	0.40
231	4	2.7	69.3	0.69	0.43	0.41	0.37
264	2	1.3	70.7	0.71	0.45	0.40	0.33
275	1	0.7	71.3	0.71	0.45	0.39	0.32
297	6	4.0	75.3	0.75	0.49	0.33	0.31
300	1	0.7	76.0	0.76	0.50	0.32	0.30
330	10	6.7	82.7	0.83	0.57	0.23	0.28
363	1	0.7	83.3	0.83	0.57	0.23	0.25

396	3	2.0	85.3	0.85	0.59	0.20	0.23
429	1	0.7	86.0	0.86	0.60	0.19	0.20
462	1	0.7	86.7	0.87	0.61	0.18	0.18
500	2	1.4	88.0	0.88	0.62	0.16	0.15
528	2	1.3	89.3	0.89	0.63	0.14	0.14
594	1	0.7	90.0	0.90	0.64	0.14	0.10
660	3	2.0	92.0	0.92	0.66	0.11	0.07
693	1	0.7	92.7	0.93	0.67	0.10	0.06
825	2	1.3	94.0	0.94	0.68	0.08	0.02
957	1	0.7	94.7	0.95	0.69	0.07	0.00
1023	1	0.7	95.3	0.95	0.69	0.06	0.00
1155	2	1.3	96.7	0.97	0.71	0.05	0.00
1650	1	0.7	97.3	0.97	0.71	0.04	0.00
1980	1	0.7	98.0	0.98	0.72	0.03	0.00
2178	1	0.7	98.7	0.99	0.73	0.02	0.00
2310	2	1.3	100.0	1.00	0.74	0.00	0.00

Table A.2 Descriptive statistics for 17 indicators for both study sites

Dimensions	Variables	Type of variable	Kamarkhola				Mithakhali			
			Minimum	Maximum	Mean	Variance	Minimum	Maximum	Mean	Variance
Housing	Wall material	Ordinal	1	5	3.11	2.05	1	5	3.47	0.88
	Roof material	Ordinal	1	4	2.47	1.31	1	4	2.71	0.63
	Floor material	Ordinal	1	3	1.34	0.56	1	3	1.19	0.34
	No. of rooms	Scale	1	7	2.61	1.14	2	8	3.88	1.36
Consumptive assets	No. of furniture items	Scale	0	20	5.31	17.3	3	26	10.1	14.4
	No. of TV	Scale	0	1	0.36	0.23	0	1	0.44	0.25
	No. of Radio/CD player	Scale	0	1	0.13	0.12	0	1	0.04	0.04
	No. of mobile phones	Scale	0	5	1.61	0.91	0	5	2.11	1.08
	No. of motorcycles	Scale	0	1	0.07	0.07	0	1	0.07	0.07
Productive assets	No. of fishing nets	Scale	0	8	1.22	1.13	0	20	2.51	6.71
	No. of tools	Scale	0	12	3.41	4.87	0	10	4.26	4.30
Livestock	No. of cows/buffalos	Scale	0	15	2.04	5.81	0	10	0.57	2.41
	No. of goats/sheep	Scale	0	5	0.41	1.25	0	20	1.14	7.26
Agricultural land	Amount of agricultural land (decimals)	Scale	0	2310	248	174096	0	3960	373	262484
Homestead Area	Amount of homestead land (decimals)	Scale	0	247	20.8	645	0	264	36.6	1937
	Area of pond (decimals)	Scale	0	165	10.5	400	0	200	11.1	462
Education	Percentage of adult with SSC degree or above	Scale	0	100	39.1	1299	0	100	22.8	625

Table A.3 Correlation matrix of 17 indicators under seven dimensions in Kamarkhola

Variables	Wall	Roof	Floor	Rooms	Furniture	TV	Radio/ CD player	Mobile phones	Motorcycles	Fishing nets	Tools	Cows/ buffalos	Goats/ sheep	Agricultural land	Homestead land	Pond	Education
Wall	1.000	0.619	0.446	0.491	0.530	0.272	0.120	0.283	0.282	0.125	0.336	0.308	-0.046	0.458	0.347	0.141	0.211
Roof		1.000	0.459	0.449	0.504	0.449	0.212	0.283	0.363	0.179	0.241	0.296	-0.050	0.503	0.284	0.093	0.233
Floor			1.000	0.378	0.387	0.291	0.084	0.123	0.283	0.159	0.155	0.178	-0.121	0.562	0.445	0.139	0.161
Rooms				1.000	0.707	0.095	0.127	0.512	0.392	0.284	0.430	0.350	-0.015	0.664	0.359	0.085	0.237
Furniture					1.000	0.189	0.151	0.547	0.331	0.248	0.497	0.387	-0.114	0.595	0.415	0.180	0.258
TV						1.000	0.278	0.179	0.269	0.080	-0.069	0.213	-0.041	0.242	0.184	0.120	0.236
Radio/CD player							1.000	0.142	0.191	0.011	0.034	-0.007	0.136	0.135	0.251	0.051	0.243
Mobile phones								1.000	0.251	0.252	0.449	0.252	-0.142	0.356	0.252	0.086	0.252
Motorcycles									1.000	0.038	0.169	0.336	-0.104	0.582	0.161	0.060	0.228
Fishing nets										1.000	0.532	0.225	0.047	0.198	0.223	0.086	-0.148
Tools											1.000	0.344	-0.006	0.255	0.333	0.155	-0.016
Cows/buffalos												1.000	-0.046	0.354	0.312	0.113	0.200
Goats/sheep													1.000	-0.121	-0.071	0.019	-0.117
Agricultural land														1.000	0.456	0.239	0.290
Homestead land															1.000	0.226	0.314
Pond																1.000	0.078
Education																	1.000

Table A.4 Correlation matrix of 17 indicators under seven dimensions in Mithakhali

Variables	Wall	Roof	Floor	Rooms	Furniture	TV	Radio/ CD player	Mobile phones	Motorcycles	Fishing nets	Tools	Cows/ buffalos	Goats/ sheep	Agricultural land	Pond	Homestead land	Education
Wall	1.000	0.587	0.454	0.341	0.435	0.183	0.115	0.272	0.076	0.030	0.309	0.068	0.056	0.286	0.081	0.266	0.166
Roof		1.000	0.226	0.391	0.399	0.165	0.137	0.281	0.140	0.087	0.133	0.087	0.112	0.340	0.044	0.312	0.142
Floor			1.000	0.289	0.450	0.212	0.165	0.197	0.169	0.037	0.058	-0.003	0.097	0.385	0.120	0.274	0.301
Rooms				1.000	0.698	0.034	0.109	0.600	0.161	0.212	0.060	0.183	0.091	0.486	0.134	0.538	0.204
Furniture					1.000	0.288	0.067	0.523	0.345	0.246	0.138	0.111	0.183	0.560	0.155	0.452	0.369
TV						1.000	0.093	0.259	0.214	0.206	0.207	0.040	0.019	0.363	0.108	0.144	0.244
Radio/CD player							1.000	0.045	0.073	0.118	-0.042	0.101	0.293	0.171	0.385	0.085	-0.098
Mobile phones								1.000	0.268	0.240	0.227	0.154	0.148	0.404	0.139	0.409	0.215
Motorcycles									1.000	0.222	0.175	0.046	0.119	0.328	0.200	0.181	0.145
Fishing nets										1.000	0.191	0.239	0.301	0.401	0.258	0.348	0.015
Tools											1.000	0.271	0.150	0.129	0.145	0.138	0.068
Cows/buffalos												1.000	0.352	0.142	0.428	0.231	0.041
Goats/sheep													1.000	0.196	0.536	0.161	0.018
Agricultural land														1.000	0.215	0.682	0.335
Pond															1.000	0.192	0.070
Homestead land																1.000	0.366
Education																	1.000

Legend for correlation matrix	
	Correlations between 0.30 and 0.40
	Correlations above 0.40

Appendix B. Household Survey Questionnaire

1. Identification information

Date of interview	
Name of village	
Name of respondent	
Name of interviewer	

2. Household demographic profile

a. How many people live in your household? ……..

b. Information on household members

Name of HH member	Relation to respondent	Age	Education	Marital status	Main occupation

3. Housing and utilities

a. Housing material

Wall material	
Floor material	
Roof material	
Number of rooms (Only bedrooms and kitchen)	

Wall material: 1 = Golpata/ palm leaves/ grass/ straw/ cardboard/ plastic, 2 = Jute sticks/Bamboo, 3 = Mud or unfired brick/Wood, 4 = Tin/ corrugated iron, 5 = Concrete/ brick

Floor material: 1 = Mud, 2 = Wood, 3 = Concrete/ brick

b. Water and sanitation

	Dry season	Wet season
Water source for drinking purposes		
Water source for other domestic purposes		
Type of sanitation facility		

Water for drinking/ domestic purposes: 1 = Pond or river water, 2 = Rainwater harvesting; 3 = Community TW/Own TW, 4 = Supply water.

Type of sanitation facility: 1 = Open defecation, 2 = Kacha, 3 = Pakka, 4 = Sanitary with flush

c. Energy sources

Does the HH have electricity connection?	☐ Yes ☐ No
Cooking fuel	
Lighting fuel	

Cooking fuel: 1 = saw dust/ leaves/ others, 2 = Cow dung/ coal, 3 = Firewood, 4 = Electricity/ supply gas/ lpg/ kerosene

Lighting fuel: 1 = Kerosene/ candles, 2 = Solar energy, 3 = Electricity/ private

4. Household Assets

a. Durable consumptive assets

Sl.	Type	Number
1	Furniture Items (bed, tables, chairs, cupboard)	
2	Television (B&W/Coloured)	
3	Radio/CD player	
4	Mobile phones in use	

b. Productive assets

Sl.	Type	Number
1	Power tiller/tractor/rice milling machine	
2	Irrigation pump	
3	Bicycle/rickshaw/van	
4	Motorcycle	
5	Boat	
6	Fishing Nets	
7	Small tools (e.g. hammer, axe, spade)	

5. Loans

Does any HH member have any loan at present?	☐ Yes ☐ No
What is the current amount of the loans?	BDT
Where did you take the loan from? (Give multiple codes if there is more than one source)	
What did you use the loans for?	

Source of loan: 1 = Relatives/friends; 2 = money lender/mohajon; 3 = NGO; 4 = Bank

Purpose: 1 = Education; 2 = Loan repayment; 3 = To meet family expenses; 4 = Investment in paddy cultivation; 5 = Investment in shrimp/fish cultivation; 6 = Dowry/Festivals/social obligations; 7 = Land purchase; 8 = Lease in land/pond; 9 = For business; 10 = For treatment; 11 = Others……

6. Food consumption

a. What is the current status of food consumption of your household members?

- We have enough to eat and never face food shortages
- We can manage to eat two/three meals a day, but sometimes have shortages
- We always struggle to get enough food to eat

b. What is the current status of protein consumption of your household members?

- We regularly eat protein items such as meat, eggs or fish
- We eat protein items during few meals a week
- We hardly get to eat protein items
- We are vegetarians

7. Income and savings

a. What is your current status of income and savings?

- We have enough income and can manage to save as well
- Our income is just enough to sustain our daily expenses, we cannot save
- Our income is not even enough to meet our daily expenses, saving is out of question

8. Access to institutions

Did you or your family member receive any help from the government or any NGOs? Y / N

Sl.	Type of help	Organisation	Year
1.	VGF card		
2.	Food materials		
3.	Constructed house		
4.	Gave monetary aid		
5.	Gave livestock/poultry for rearing		
6.	Gave sewing machine		
7.	Gave shrimps/fisheries for cultivation		
8.	Gave trees or vegetable seedlings		
9.	Training in handicrafts/poultry farming/fish farming		
10.	Training in disaster management		
11.	Gave potable water supply/ improved sanitation facilities		
12.	Others …….		

9. Livelihood activities (for Mithakhali only)

a. How much agricultural land do you currently have?

…….. bigha

b. Of this agricultural land, how much did you inherit and how much did you purchase or sell?

- ☐ Amount inherited …… Year ……
- ☐ Amount purchased …… Year ……
- ☐ Amount sold …… Year ……
- ☐ Still cultivating together with father/siblings ……

c. Do you currently lease IN land from others?

- ☐ Amount of land …….. bigha
- ☐ Since which year ……..

d. Do you currently lease OUT land to others?

- ☐ Amount of land …….. bigha
- ☐ Since which year ……..

e. What do you currently do with your own/leased IN land?

Activity	Amount of land (bigha)	Since which year
I cultivate brackish water Bagda shrimp/white fish throughout the year		
I cultivate brackish water Bagda shrimp/white fish for half of the year, then plant Aman crops in the other half		
I cultivate Aman crops only		

f. Before shrimp cultivation started in this area (let's say, about 15 – 20 years ago), what did you do in your land?

- ☐ Own land at that time: ……
- ☐ Leased IN land at that time: ……
- ☐ Leased OUT land at that time: ……

- What did you do in these land ……

g. If you are currently cultivating Aman crops in your own/leased in land, what is the yield? ……maund per bigha

h. If you are not cultivating Aman crops now, when was the last time you planted crops? What was the yield then?

- Year when last planted crops …….
- Yield at that time …… maund per bigha
- Never involved in crop cultivation

i. If you are involved in brackish water shrimp cultivation in your own/leased in land, what type of gher are you involved with?

- Large gher under co-operative system
- Independent gher in land, with/without land leased in from others (NOT POND)
- Leased out land to others; I only obtain rent

j. If you are involved in brackish water shrimp cultivation in your own/leased in land, what is your profit like?

- I always have good profits
- I sometimes have good profit, sometimes not
- Profits are decreasing with time
- I never have profits

k. Do you have your own pond/leased in pond?

Area of pond …… bigha

l. What do you do in this pond?

Activity	**Since which year**
I cultivate brackish water Bagda shrimp	
I cultivate white fish for selling	
I cultivate crab	
I use it for domestic purposes	

m. Before shrimp cum white fish cultivation started in this area (about 15 ago), what did you do in your pond?

……

……

n. Are/were you involved in any of the following activities?

Activities	**Since which year**
Work as day labour in shrimp ghers or agricultural land	
Harvest shrimps from gher	
Collect crabs from gher and sell them at the market	
Buy shrimps from gher and sell them at the market	
Work as gher guard/manager	
Van/nossimon driver	
Small business	
Large business	
Fixed income job	
Others	

o. What is the area of your homestead land (excluding pond area)?

…….. bigha

p. Do you currently grow vegetables/fruits in your homestead gardens?

- ☐ Yes, I have plenty of plants
- ☐ Yes, but the yield is very low
- ☐ No, I do not have enough land
- ☐ No, the soil quality is not suitable

q. Before shrimp cum white fish cultivation started in this area (about 15 ago), did you grow vegetables/fruits in your homestead gardens?

……

……

r. How many livestock do/did you have?

Time Period	Cows/buffalos	Goats/sheep
At present		
Before shrimp cum white fish cultivation started in this area (about 15 ago)		

s. Do/did you or any member of your family currently migrate to other places for work or education?

Time Period	Who migrates	Where	Why
At present			
Before shrimp cum white fish cultivation started in this area (about 15 ago)			

t. Do/did you catch fish from open-access water bodies?

- ☐ Yes I catch now and also in the past
- ☐ Yes I catch now but not in the past
- ☐ I used to catch in the past but not now
- ☐ No I never catch fish

u. Compared to the time when this area was dependent on shrimp cum rice cultivation, how has your well-being changed after shrimp cum white fish cultivation started in this area?

- ☐ I'm better off after shrimp-white fish cultivation started because

  ……

- ☐ I'm worse off after shrimp-white fish cultivation started because

  ……

- ☐ My well-being remained unchanged because

  ……

v. Are you in favour of brackish water shrimp cultivation?

- ☐ Yes, I want shrimp cultivation to continue in this area
- ☐ No, I want shrimp cultivation to stop in this area
- ☐ I'm neither for nor against it

9. Livelihood activities (for Kamarkhola only)

a. How much agricultural land do you currently have?

…….. bigha

b. Of this agricultural land, how much did you inherit and how much did you purchase or sell?

- Amount inherited …… Year ……
- Amount purchased …… Year ……
- Amount sold …… Year ……
- Still cultivating together with father/siblings ……

c. Do you currently lease IN land from others?

- Amount of land …….. bigha
- Since which year ……..

d. Do you currently lease OUT land to others?

- Amount of land …….. bigha
- Since which year ……..

e. What do you currently do with your own/leased IN land?

Activity	Amount of land (bigha)	Since which year
I cultivate only Aman paddy in the wet season		
I cultivate Aman paddy, along with freshwater prawn and fish in the wet season		
I farm freshwater prawn and white fish only		
I cultivate brackish water shrimp in the dry season and Aman paddy in the wet season		

f. Before shrimp cultivation was banned in this area, what did you do in your land?

- Own land at that time: ……
- Leased IN land at that time: ……

- Leased OUT land at that time: ……
- What did you do in these land ……

g. If you are currently cultivating Aman crops in your own/leased in land, what is the yield? ……maund per bigha

h. If you cultivated Aman paddy before the ban on shrimp cultivation, what was your average yield?

- Yield at that time …… maund per bigha
- Never involved in crop cultivation

i. If you were involved in brackish water shrimp cultivation in your own/leased in land, what type of gher are you involved with?

- Large gher under co-operative system
- Independent gher in land, with/without land leased in from others (NOT POND)
- Leased out land to others; I only obtained rent

j. If you were involved in brackish water shrimp cultivation in your own/leased in land, what was your profit like?

- I always have good profits
- I sometimes have good profit, sometimes not
- Profits are decreasing with time
- I never have profits

k. Do you have your own pond/leased in pond?

Area of pond …… bigha

l. What do you do in this pond?

Activity	**Since which year**
I cultivate Bagda shrimp	
I cultivate Galda prawn	
I cultivate white fish for sale	
I use it for domestic purposes	

m. Before shrimp cultivation was banned in this area, what did you do in your pond?

……

……

n. Are/were you involved in any of the following activities?

Activities	**Years**
Worked as day labour in shrimp ghers or agricultural land	
Harvested shrimps from gher	
Bought shrimps from gher and sold them at the market	
Worked as gher guard/manager	
Van/nossimon driver	
Small business	
Large business	
Fixed income job	
Others	

o. What is the area of your homestead land (excluding pond area)?

…….. bigha

p. Do you currently grow vegetables/fruits in your homestead gardens?

- ☐ Yes, I have plenty of plants
- ☐ Yes, but the yield is very low
- ☐ No, I do not have enough land
- ☐ No, the soil quality is not suitable

q. Before shrimp cultivation was banned in this area, did you grow vegetables/fruits in your homestead gardens? How was the yield?

……

……

r. How many livestock do/did you have?

Time Period	**Cows/buffalos**	**Goats/sheep**

At present		
Before shrimp cum white fish cultivation started in this area (about 15 ago)		

s. Do/did you or any member of your family currently migrate to other places for work or education?

Time Period	Who migrates	Where	Why
At present			
Before shrimp cum white fish cultivation started in this area (about 15 ago)			

t. Do/did you catch fish from open-access water bodies?

- ☐ Yes I catch now and also in the past
- ☐ Yes I catch now but not in the past
- ☐ I used to catch in the past but not now
- ☐ No I never catch fish

u. Compared to the time when this area was dependent on shrimp cum rice cultivation, how has your well-being changed after shrimp cultivation was banned?

- ☐ I'm better off after shrimp cultivation was banned because

  ……

- ☐ I'm worse off after shrimp cultivation was banned because

  ……

- ☐ My well-being remained unchanged because

  ……

v. Are you in favour of brackish water shrimp cultivation?

- ☐ Yes, I want shrimp cultivation to continue in this area
- ☐ No, I'm happy that shrimp cultivation is banned
- ☐ I'm neither for nor against it

Appendix C. Sample livelihood trajectory interview

Interviewee	Bilal Ahmed (pseudonym), male, aged 47, Kamarkhola village
Interviewer	Sonia Hoque
Date	12 November 2014
Venue	Interviewee's residence
Duration	25 minutes followed by a tour of the interviewee's farm
Language	Bangla

How many members are there in your household?
We are four people; me, my wife, my 20 year old son, and a new born daughter.
I see a lot of kids here? Who are they?
These are my students. That's why I don't have a TV at home.
Oh, so you are a teacher?
Yes, I'm a private tutor.
Since when have you been teaching?
Almost 12 years, I guess.
So is this your main source of income?
Teaching is one of my income sources, but money is not my only motivation. Some of these kids may not be able to pay at the end of the month. But there is deep satisfaction in supporting the young generation.
Are you involved in farming?
In a sense yes. I have some agricultural land, but most of it has been leased out to others.
How much land do you have?
Umm… 4 acres. No sorry, 5 acres, that's about 15 bigha.
So what do you do with this land?
Like I said, I have leased out around 10 bigha. People grow rice and white fish in that land. In exchange, they pay an annual rent.
If I may ask, how much is the rent?
They pay me BDT 6000 per bigha per year.
Do they give you a share of the crops as well?
No, the crop is theirs. I take the money.
So what do you do with the rest of the land?
The remaining 5 bighas are leased out on a sharecropping contract. They don't give me any money, but I get half of the rice grown in that land.
What is the average crop yield like?
Say, for instance, if we apply fertilisers and pesticides properly, and if there are no ad hoc shocks, we get about 15 – 18 maunds of rice per bigha. This year it was actually very good. We got about 20 maunds!
So has the yield increased in the past 3-4 years after Aila?
Well, the thing is that, immediately after the cyclone, some people got very good yields, while others got almost nothing. This is mainly because of variations in deposition of sand and silt patterns. After the embankment was breached, the tidal water flooded all the agricultural land in this area. In some places, the high velocity water collided with the unbroken parts of the embankment; the sudden loss in speed caused deposit of heavier

particles like sand. In other places, where the water level could smoothly rise and fall with the diurnal tide, silt was deposited. *"Apni obak hoye jaben ekta nichu jomite ki poriman balu jomeche je sheta ekhon koyek haat ucho hoye giyeche!"* (You will be surprised to see how a low land has now increased several feet in height due to deposition of sand). You see this mark on my wall; this was the height of the water during high tide.

So was your land affected by sand or silt deposition?

I was lucky. There was no sand deposition on my land. But if you go to those areas beside the school, you'll still see heaps of sand. Gradually, these land are becoming suitable for agriculture.

How is that happening?

Well, firstly when the gates are opened in the wet season, the tidal water can enter and recede freely. So after a few years, the sand is gradually washed away. Secondly, if they use power tillers to plough their land, over time the sand is spread uniformly across all the land within the embankment.

OK, that's interesting, so coming back to your land, is it used for cultivating any fish along with the rice?

Yes, there are different freshwater fish species. You see you can farm Bagda shrimp, as well as Galda prawn, in these freshwater. Moreover, a number of white fish juveniles come along with the incoming tidal water.

What's the stocking density like?

They release about 1000 post-larvae of Bagda per bigha of land. So that's a total of 10,000 post-larvae in the 10 bigha of land that I have leased out.

But, as far as I know, Bagda shrimp can only grow in saline water. So, how come they are farming Bagda and Galda together in freshwater?

No, Bagda can also survive in freshwater. But the growth rate will be slow. I'm growing Bagda in my pond as well.

And how many Galda post-larvae did they release?

Umm.. We don't release Galda as post-larvae. They are release at a more mature stage, so let's say, we released about 1000 pieces. Actually the thing is that you can't farm Galda in large parcels of land like Bagda. Galda can grow in small trenches dug along the periphery of the land.

So what types of white fish are farmed in that land?

There is Rui, minar carp, grass carp and puti… the Chinese ones.

OK, now let's go back to the time when there was shrimp cultivation in this village? Were you also involved in brackish water shrimp farming like others?

Yes, of course, there was no choice. But I used to lease out all my land. I never wanted to engage in this risky business.

I noticed that you prefer to live on fixed income and do not want to engage in farming yourself. Why is that?

That's true. Actually, farming takes a lot of physical effort as well as time. I'm not like others, who can work day and night.

So what was the land rent at that time?

Same. I used to get around BDT 100,000 per year for 15 acres.

How would you compare your present socio-economic status to the past? Are you better-off or worse-off than before?

It was more or less the same.

But now you get rent as well as paddy and fish?

Ultimately the balance between income and expenditure is the same. But the thing is that the shrimp business was very risky. While I was not directly involved, people farming on my land sometimes got a lot of profit and sometimes couldn't even recover their investment. No we don't allow saline water into our fields. The freshwater farming is less risky.

During shrimp cultivation, did you decide to lease out your land or were you forced to do so?

Nobody forced me as such. But say the landowner adjacent to mine has flushed his land with saline water, then I would also have to do the same. Otherwise, seepage of saline water would destroy my crops.

Do you think the present situation is same as that before the 1990s, I mean even before shrimp cultivation started?

Well… decades ago we used to grow paddy only. Now, we are trying to farm white fish and prawn as well. You see, times have changed. Before you could buy a shirt for BDT 200, now the same shirt will cost BDT 1200. Everything is more expensive. So we need more money. Actually, this was the basic idea for starting shrimp farming in the first place. But there were negative effects as well. For instance, I had ten mango tree, five coconut trees; but none of them bore any fruit due to salinity. There was a gate such beside my house. I had to go through a lot to close this gate permanently.

Was this a government operated gate?

No, it was built by the shrimp cultivators. Have you heard of Amla group? They are a Khulna based company, who leased out local farmland for shrimp farming.

Why couldn't you stop them from making this hole in the embankment?

They had permission from the government. This is a public canal. If government gives them permission, I have nothing to say.

So do you think the situation is better now?

Yes, much better. The cyclone changed our lives. If the cyclone did not happen, many people would have been worse off than they are now. *"Allah jeta kore ta mongoler jonnoi kore"* (Sometimes, what God does is the best interest of His creations). I know you might be thinking that Aila was a disastrous event and we should see it as a curse. Let me explain. A lot of people had their livelihoods based on shrimp. For instance, a poor person, who didn't have any land, could go to a shrimp farm and buy 10 kg of shrimp. He would then sell it to the depot and make a profit of BDT 200 without any investment. So initially when shrimp was banned, everyone was at a loss. They didn't know how to supplement that income. Then came the cyclone in the following year. People had to go through a lot of hardship. But with Aila, came a lot of external support. Everyone, regardless of class, was benefitted. Even I got about BDT 30,000. Initially, the government gave BDT 20,000 for rebuilding houses, then NGOs also gave cash from time to time for subsistence. NGOs, like Shushilon and DSK, gave 20kg rice per person for about 6 months.

But I heard that NGOs were reluctant to support people with land or good socio-economic status? Is it true?

Yes, to some extent. They always looked for *'Hotodoridro! Hotodoridro!'* (extreme poor). I was so pissed off by this attitude that once I had an argument with a NGO employee. You people are always here to help the extreme poor. What did the extreme poor lose after the cyclone? They never had anything to lose in the first place. It's people like me who lost

everything. If I had 10 cows, I lost them all. If I had 10 bigha land, I lost all my crops. They could still use their physical labour like before. What will people like me do? I can't go to the streets and cut mud along with them. The NGO worker admitted I was right. So he put my name on the list of food aid.

It seems international donors and NGOs did a lot to support people in this area.

Of course, aid is still flowing in. Look at that farmer, [pointing towards passer-by with two goats], he got these goats from a NGO. An extreme poor person, who could never even eat two meals a day, now relaxes in bed and asks me whether I'm willing to sell my land to him" ("*Ekjon gorib ekhon amake kombol er nich theke matha ber kore bole, apni ki apnar jomi ta bikri korben naki, amar kinar ichha chilo"*). You can't imagine how much money some of them have saved.

Do you think people have become aid-dependent?

Well, only a handful of people. But most people are hardworking. With hard work and dedication, they made good use of the aid money and changed their fate. That's commendable. Another thing, when the tidal water flooded the village, a number of people earned money by fishing. Every night they could catch BDT 2000-3000 worth of fish. But people like me can't take that opportunity. We are not used to living like this. You can't believe how helpless I felt standing in queue with everyone else for food and water. But I remember the MP (Member of Parliament) saying, don't' be shy to ask for aid, it's not your fault. People who had a better socio-economic status were the ones who suffered most.

What was your experience at the time of Aila? Did you live on the embankment with others?

No, I didn't live on the embankment. My family and I moved in with our relatives in another area. You won't be able to imagine the horror of the event, unless you have experienced it first-hand. Within a few seconds, about 3-4 feet of water inundated the whole area. A relative informed me beforehand that warning signals have been issued and that the embankment has started to collapse on the other side of the union. Since the embankment on our side of the village was still intact, my wife refused to leave the house. But I recalled the fatalities caused by the 2007 cyclone Sidr in nearby districts; so I forcefully took my family to take refuge on the embankment. When the water came, I was just hugging my son and crying, fearing that we might die soon.

Thank God those horrible days are over now.

Yes, before cyclone Aila, only those who possessed good amount of agricultural land were in a good position. But now more or less everyone is in a better position. It would be unfair not to acknowledge the roles played by the government and donor organisations. Relatively speaking, it is the poor and extreme poor households who have benefitted most from these aid and rehabilitation programs. Even this year FAO distributed fish juveniles, tree seedlings, and poultry. I helped FAO in getting access to this area and so I have a good relation with them. In June, they gave me 600 pieces of white fish, like Rui, Katla, Migrel. They specially gave me few trees, like two *amloki* (Indian gooseberry) trees, one tamarind tree, two *boroi* (Indian Jujube) trees and two *sojne* (Drumstick tree) seedlings.

What is the purpose of these trees? Do you sell the fruits?

No, the trees are actually meant for increasing the vegetation cover in the village. As I have some land in my homestead area, they gave these to me. But they are giving out

Khaki Campbell ducks to extreme poor people. These ducks can lay up to 200 eggs during their laying period and each egg has a market price of BDT 8.

Well, thank you so much, you have been very helpful. Not only you described your own situation, you gave a good overview of the changes in this village.

Appendix D. Ethical Approval

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UNIVERSITY OF LEEDS

ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee

University of Leeds

21 November 2016

Dear Sonia Ferdous Hoque

Title of study:	**Poverty, vulnerability and assets nexus: Using an asset-based approach to multi-dimensional poverty and vulnerability assessment in rural Bangladesh**
Ethics reference:	**AREA 13-122**

I am pleased to inform you that the above research application has been reviewed by the ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee and following receipt of your response to the Committee's initial comments, I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	*Version*	*Date*
AREA 13-122 Ethical Review and Risk Assessment (Sonia Hoque).pdf	1	02/05/14
AREA 13-122 Committee Provisional (response from Sonia Hoque).doc	1	22/05/14

Please notify the committee if you intend to make any amendments to the original research as submitted at date of this approval, including changes to recruitment methodology. All changes must receive ethical approval prior to implementation. The amendment form is available at http://ris.leeds.ac.uk/EthicsAmendment.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits.

We welcome feedback on your experience of the ethical review process and suggestions for improvement. Please email any comments to ResearchEthics@leeds.ac.uk.

Yours sincerely

Jennifer Blaikie
Senior Research Ethics Administrator, Research & Innovation Service
On behalf of Dr Andrew Evans, Chair, AREA Faculty Research Ethics Committee

CC: Student's supervisor(s)