Enhancing Disaster Resilience through Human Capital: Prospects for Adaptation to Cyclones in Coastal Bangladesh

I n a u g u r a l - D i s s e r t a t i o n

zur

Erlangung des Doktorgrades

der Mathematisch-Naturwissenschaftlichen Fakultät

der Universität zu Köln

vorgelegt von

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Tag der letzten mündlichen Prüfung: 8. Mai 2017

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ABS	Access to Basic Services
AC	Adaptive Capacity
ADB	Asian Development Bank
AIDMI	All India Disaster Mitigation Institute
BANBEIS	Bangladesh Bureau of Educational Information and Statistics
BARCIK	Bangladesh Resource Center of Indigenous Knowledge
BBS	Bangladesh Bureau of Statistics
BRAC	Bangladesh Rural Advancement Committee
BTEB	Bangladesh Technical Education Board
CARE	Cooperative for Assistance and Relief Everywhere
CATPCA	Categorical Principle Component Analysis
CBOs	Community Based Organizations
CDRF	Community Disaster Resilience Framework
CI	Corrugated Iron
COP21	Conference of the Parties 21
CRED	Centre for Research on the Epidemiology of Disasters
DAE	Department of Agriculture Extension
DFID	Department for International Development
DRI	Disaster Risk Index
DROP	Disaster Resilience of Place
DRR	Disaster Risk Reduction
DUS	Dwip Unnayan Sangstha
EDRI	Earthquake Disaster Risk Index
EM-DAT	Emergency Events Database
FAO	Food and Agriculture Organization
GO	Governmental Organization
GPS	Global Positioning System
HC	Human Capital
HEC	Household Economic Component
HFA	Hyogo Framework for Action
HIC	Household Infrastructure Component
HSoLC	Household Self-organization and Learning Component
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDs	Informal Discussions

IFA	Income and Food Access
IFAD	International Fund for Agricultural Development
IFRC	International Federation of Red Cross and Red Crescent Societies
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
MDGs	Millennium Development Goals
NGO	Non-Governmental Organization
OECD	Organization for Economic Co-operation and Development
PCA	Principle Component Analysis
PSF	Pond Sand Filter
SEM	Structural Equation Modeling
SFYP	Sixth FiveYear Plan
SLF	Sustainable Livelihood Framework
SoVI	Social Vulnerability Index
SPSS	Statistical Package for the Social Sciences
SSN	Social Safety Nets
TANGO	Technical Assistance to NGOs
UNDMC	Union Disaster Management Committee
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VET	Vocational Education and Training
VIF	Variance Inflation Factor
WARPO	Bangladesh Water Resource Planning Organization
WEF	World Economic Forum
WHO	World Health Organization

ABSTRACT

The world continues to face disasters on an unprecedented scale. In the last few decades, a majority of the natural disasters were caused by floods, storms, droughts, and other weather-related stress and shocks. Human, social, natural, financial, and physical capitals are needed in order to cope with stress and shocks as well as for the pursuit of livelihood strategies. Every year, coastal residents of Bangladesh fight against cyclone and storm surge impacts. As a result, the magnitude of fragility and sensitivity to this adverse condition is increasing in terms of the socioeconomic livelihood of coastal households. Therefore, it is a matter of top priority to enhance resilience to cyclones and storm surges at the household level; however, determining how disaster resilience can be enhanced is challenging. Over the last decade, many studies have explored ways in which to strengthen disaster resilience in terms of social, physical, and financial capital. However, few studies have considered the contribution of human capital to the enhancement of cyclone- and storm-surge resilience in the coastal area of Bangladesh. This study seeks to address this lacuna.

The study conceptualized human capital based on six pillars that were knowledge obtained through (a) formal schooling, college, and university education; (b) vocational education and training (VET); (c) learning by doing; (d) interaction and participation; (e) experiences and indigenous activities; and (f) the ability to work. Disaster resilience was measured by the sum of four components: household infrastructure component (HIC), household economic component (HEC), household self-organization and learning component (HSoLC), and social safety nets (SSN).

While applying mostly quantitative research strategies, this study essentially used a mixed-method approach based on quantitative and qualitative data. Adopting a quantitative strategy (household survey), this study first explored the status of human capital (e.g., formal education, vocational education and training, practical skills, knowledge obtained through prior experience, and health) and other forms of capital, including social (bonding, bridging, and linking ties), financial (savings and loans), and physical (housing, household machinery, and access to households facilities). Second, the interrelation between human and other forms of capitals were examined. Third, the relationship between human capital and disaster resilience at the household level was clarified. However, qualitative strategies (informal discussions and key informant interviews) were used to understand the crucial components of disaster resilience, including the impacts of Cyclones Sidr and Aila, effective coping strategies, background reasons for varying capital in different villages, and contribution of various components of human capital to strengthen resilience to cyclone and storm surges.

The empirical findings are based on a household survey conducted from mid-October 2014 to mid-February 2015 (sample size of 1,188, which related to 6,132 individuals in total) in nine coastal villages within the districts of Khulna, Bagherhat, Pataukhali, Lakshmipur, and Noakhali of Bangladesh. To understand the

status of household capital in the study area, descriptive statistics were used. Furthermore, principal component analysis was used to construct capitals and the disaster-resilience index, and logistic regression analysis was performed to investigate the contribution of human capital to the enhancement of disaster resilience.

The study shows that the status of households, such as human, social financial, physical, and natural capitals, is mostly poor in the study area. However, the status of household capitals differed geographically (e.g., inland, shore-land, and island). Status of household capitals inland is relatively better than that of island and shore-land areas. Social, physical, and financial capitals have a significant and positive correlation with human capital, while natural capital does not show any significant correlation. Human capital in the study was found to have a strong and significant correlation with financial capital. Finally, the study proves that human capital makes a significant and positive contribution to disaster resilience at the household level. Particularly formal education, fluency in English speaking, vocational education and training, practical skills, adult education, knowledge obtained through economic co-operatives programs, learning acquired from awareness programs, experience from previous disasters, the ability to work are the key tools for enhancing disaster resilience. These findings indicate that human capital plays a crucial role in enhancing disaster resilience in the study area. Using similar methods, future investigations can deal with the contribution of other forms of capital, that is, social, physical, financial and natural in enhancing disaster resilience.

Keywords: Bangladesh, disaster resilience, human capital, livelihoods, household infrastructure component (HIC), household economic component (HEC), household self-organization and learning component (HSoLC), and social safety nets (SSN)

Zusammenfassung

Die Häufigkeit und das Ausmaß von Naturkatastrophen haben in den letzten Jahrzehnten stark zugenommen. Insbesondere Fluten, Stürme, Dürren und andere wetterbedingte Stress- und Schocksituationen führen zu einem hohen Bedarf an Human- und Sozialkapital und erfordern hohe finanzielle und physische Belastbarkeit sowie Überlebensstrategien. Jedes Jahr werden Bewohner der Küstenlandschaft Bangladeschs von Zyklonen und Stürmen heimgesucht, die zu hoher Verwundbarkeit führen und die sozio-ökonomischen Lebensumstände kontinuierlich verschlechtern. Es ist daher dringend notwendig, die Resilienz auf Haushaltebene zu erhöhen. Die Herausforderung besteht jedoch darin zu definieren, wie diese erhöht werden kann. In den letzten Jahrzehnten wurden in Studien vor allem soziale, physische und finanzielle Komponenten zur Stärkung der Resilienz untersucht. Nur sehr wenige Untersuchungen haben auch die Bedeutung des Humankapitals zur Stärkung der Resilienz bei Zyklonen und Stürmen mit einbezogen. Diese Lücke soll im Rahmen dieser Arbeit geschlossen werden.

In dieser Studie wird Humankapital durch sechs Faktoren berechnet: 1) Wissen, das durch Besuche von Schulen und Hochschulen erworben wurde, 2) berufsspezifisches Wissen, 3) selbst angeeignetes Wissen, 4) durch Interaktion und Teilnahme erworbenes Wissen, 5) indigenes Wissen und 6) die Fähigkeit, zu arbeiten. Die Katastrophenresilienz wurde anhand der vier Faktoren 1) Haushaltsausstattung, 2) Haushaltseinkommen, 3) Selbstorganisation im Haushalt und 4) Soziale Sicherungsnetze berechnet.

Die vorliegende Studie ist quantitativ angelegt, wird aber mit qualitativen Daten über einen Methodenmix ergänzt. Die quantitativen Erhebungen basieren auf einer Haushaltsbefragung, über die 1) der Status von Humankapital und andere Formen von Kapital, u.a. Sozialkapital, Finanzkapital (Ersparnisse und Kredite) und physisches Kapital (Hausstand und Ausstattung) gemessen werden. Darauf aufbauend wird 2) die Abhängigkeit zwischen Humankapital und anderen Formen von Kapital und 3) der Zusammenhang von Humankapital und Katastrophenresilienz ermittelt. Die Erhebungen werden mit qualitativen Parametern, die in Form von informellen Diskussionen und Interviews abgefragt wurden, ergänzt, um so mehr Hintergrundwissen über die einzelnen Komponenten zu erlangen. Betrachtet wurden dabei die Strategien und der Umgang mit den Katastrophen, die von den Zyklonen Sidr und Aila ausgegangen sind, um etwa Unterschiede in der Ausstattung mit verschiedenen Formen von Kapital zu verstehen und zu ermitteln, wie die einzelnen Komponenten auf die Stärkung der Resilienz wirken.

Die empirischen Befunde basieren auf einer Haushaltsbefragung (1.188 Haushalte mit insgesamt 6.132 Personen), die von Mitte Oktober 2014 bis Mitte Februar 2015 in neun küstennahen Standorten in den Distrikten Khulna, Bagherhat, Pataukhali, Lakshmipur und Noakhali durchgeführt wurde. Um den Status des Kapitals auf Haushaltsebene zu berechnen wurden deskriptive statistische Analysemethoden verwendet. Die verschiedenen Komponenten wurden einzeln ausgewertet, um so die verschiedenen Formen von Kapital

zu berechnen und einen Resilienzindex zu bilden. Der Zusammenhang zwischen den einzelnen Faktoren des Humankapitals und der Resilienz wurde mittels einer Regressionsanalyse ermittelt.

Als Ergebnis zeigt die Studie, dass die Ausstattung der Haushalte mit Human- und Sozialkapital sowie finanziellem, physischen und natürlichen Kapital sehr niedrig ist. Dennoch gibt es dabei regionale Unterschiede zwischen dem Binnenland, der Küstenzone und Inseln. Die Ausstattung mit Kapital ist dabei in küstennahen Gebieten und auf Inseln besser als im Binnenland. Drei Formen des Kapitals (Sozialkapital, physisches und finanzielles Kapital) zeigen einen signifikanten Zusammenhang untereinander und eine positive Korrelation mit Humankapital. Der Zusammenhang mit natürlichem Kapitel ist nicht signifikant. Humankapital und finanzielles Kapital korrelieren positiv mit allen Formen von Kapital.

Die Untersuchungen zeigen schließlich, dass es auf Haushaltsebene einen signifikant positiven Zusammenhang zwischen Humankapital und Resilienz gibt. Eine formale Ausbildung, Kenntnisse der englischen Sprache, berufliche Bildung und Weiterbildung, praktische Fähigkeiten, Kenntnisse durch ökonomische Partnerprogramme, Aufklärungsprogramme, Erfahrungen durch vorangegangene Katastrophen und Arbeitsfähigkeit sind zentrale Faktoren, die eine Stärkung der Resilienz positiv beeinflussen. Auf Basis dieser Untersuchung und der gewonnenen Erkenntnisse wird angeregt, nach gleichem methodischen Verfahren weitere Studien zur Untersuchung des Zusammenhangs anderer Formen von Kapital (Sozialkapital, physisches, finanzielles und natürliches Kapital) und der Katastrophenresilienz durchzuführen.

Schlagwörter: Bangladesch, Resilienz, Humankapital, Lebensgrundlage, Haushaltsausstattung, Haushaltseinkommen, Haushaltsorganisation, Soziale Sicherungsnetze

ACKNOWLEDGEMENTS

I am extremely indebted for all the support and encouragement as I have received throughout my candidature. Although it appears impossible to acknowledge everybody who supported me during last years in Germany and Bangladesh, I would like to acknowledge some key individuals.

First of all, I would like to express the deepest appreciation to my supervisor, Prof. Dr. Boris Braun, who supported me in every step of this work. He continually provided me valuable guidance, expertise and helpful suggestions throughout the completion of this thesis. I have been enlightened and have grasped the complex issues through our regular meetings, which has been invaluable in progressing towards the completion of this thesis. I also wish to express my gratitude to Prof. Dr. Gregor C. Falk who readily agreed to be my second supervisor and provided me with his valuable feedback and comments during doctoral committee meetings. I am heartily grateful to my advisor Dr. Amelie Bernzen, who provided various academic and logistic supports.

I am grateful for the financial support provided by Deutscher Akademischer Austauschdienst (DAAD). I am also thankful to the Band-AID project for providing the financial support for all the expenses of my field work. I am grateful to University of Cologne, which has allowed me to pursue as a PhD candidate. I am also indebted to the University of Rajshahi for granting me the study leave to stay abroad.

I am especially thankful to the coastal residents of Bangladesh, whose participation in my survey facilitated the research process. The hospitality and generosity of coastal peaope and their valuable time in answering my long list of questions, are highly appreciated. The enormous support in terms of data collection from Rashed, Ayesha, Sayed, Tuhin, Shaon, and Mehedi, is highly appreciated. Special thanks go to my colleagues Zahurul Islam and Jannat for their support during filed work. I wish to express special thanks to the other research participants, such as members of informal discussions, disaster practitioners, upazila agriculture extension officer, and local union parishad chairman. The acknowledgement would remain incomplete without mentioning support from some key individuals, for example, Shykh Seraj (Head of the News, Channel I TV and agriculture development activist), Shahidul Islam (Director of local NGO Uttaran), Sen Sukanta (Executive director, BARCIK), MD. Nazrul Islam Khan (Director of national land zoning project, Ministry of Land), Dr. Nurun Nahar (Planning Commission of Bangladesh), Towhidul Islam (A/Prof. Noakhali Science and Technology University), Shamsuzzoha (A/Prof of Patuakhali Science and Technology University), Prof. Dr. Md. Mobarak Hossain Khan (School of Public Health, Bielefeld University, Bielefeld), for their kind support during fieldwork in Bangladesh between mid of October 2014 to mid of February 2015.

Many thanks to my colleagues at the Institute of Geography in University of Cologne, in particular, Katharina Molitor, Lisa-Michéle Bott, Sebastian Fastenrath, Maximilian Müller, John-Baptist Naah,

Katharina Esser, and Fabian Sonnenburg. They provided me with enormous academic support and many happy moments, which sometimes helped to relieve the pressures of my PhD. I am grateful to Monika Langer, who provided valuable support to detect errors in our data set. Special thanks go to my colleagues, Prof. Dr. Raquib Ahmed, Prof. Dr. A Z M SHOEB, Dr. Md. Rejaur Rahman, Md Masud Parves Rana, Dr. Rabiul Islam, and Dr. Md. Moniruzzaman, who extended valuable suggestions and recommendations during my research. Special thanks go to my friend Jens Conrad, who provided me lot of logistic supports.

I am indebted to my brother, sisters and their families for their huge support over the years. From the far distance, their inspiration, mental and emotional support, love and care was key to keep patience during the completion of this PhD research. At the end, I would express a deep sense of gratitude to my parents for their innumerable prayers and valuable tears of love, which made me more enthusiastic to achieve my goal.

CHAPTER ONE: INTRODUCTION

1.1 Background

The world continues to face disasters on an unprecedented scale. A majority of natural disasters (90 percent) occurred between 1995 and 2015 in the form of floods, storms, droughts, and other weather-related events (UNISDR, 2015). There were 6,457 weather-related disasters worldwide listed by EM-DAT, the leading international database of such events (EM-DAT, 2015). During this period (1995-2015), these weather-related disasters claimed 606,000 lives, an average of 30,000 per annum, with an additional 4.1 billion people injured, homeless, or in need of emergency assistance (The Human Cost of Weather-Related Disasters, 1995–2015). Cyclones and storm surges significantly affected populations in South and Southeast Asia, the Western Pacific, and the Americas over the past quarter century. These were the deadliest disasters, accounting for 242,000 (40 percent) of the global weather-related deaths, with 89 percent of these occurring in lower-income countries (CRED, 2015). Annually, the economic cost of such disasters has increased 14-fold since the 1950s to USD 67 billion (UNISDR, 1995–2015).

Although some structural and non-structural prevention measures have been taken, future disasters cannot be completely prevented due to their often-unexpected forms, magnitudes, and locations (Zhou et al., 2009). Hence, there is an urgent need to enhance the capacity of affected inhabitants to resist and recover from disasters. To tackle this, the United Nations International Strategy for Disaster Reduction developed the "Building the Resilience of Nations and Communities to Disasters" plan as part of the Hyogo Framework for Action 2005–2015 (UNISDR, 2005).

The Hyogo Framework for Action (HFA) stresses the relation between resilience and recovery. It focuses on steps to be taken by affected households and communities to strengthen their capacities rather than on their disaster vulnerabilities or needs in emergencies (IFRC, 2004; Twigg, 2007). From the experience gained by implementing the HFA, the Sendai Framework for Disaster Risk Reduction 2015–2030 places priority on building resilience at the local, national, regional, and global levels. This framework mentions four priorities for reducing disaster risk, with the third (investing in disaster risk reduction for resilience) clearly focused on disaster resilience. The second priority (enhancing disaster preparedness for effective response and for "building back better" in recovery, rehabilitation, and reconstruction) underlines the importance of strengthening household and community assets or capitals (human, social, economic, natural, and physical) to enhance disaster resilience. Laterally, the long-term Conference of the Parties 21 (COP21) Paris agreement exhorts participant countries to "not increase the exposure of people and economic capitals to natural hazards on flood plains, vulnerable low-lying coastlines or other locations unsuited for human settlement" (UNFCCC, 2015). Nevertheless, there are still conceptual and practical challenges related to resilience, household capital, and adaptation.

In the context of the increased rate of natural disasters in Bangladesh and new disaster risk management methods that center on strengthening resilient communities, an enhanced, in-depth understanding of the dynamics of disaster resilience has become increasingly necessary (Islam et al., 2015; Rahman et al., 2016). Therefore, this study seeks to improve current knowledge on the concept of disaster resilience for policy making with respect to disaster management and planning.

1.2 Problem statement

The coastal zone of Bangladesh is well known for its manifold vulnerabilities (Paul, 2012). Numerous studies have pointed out the recurrent phenomena of cyclones and cyclone-induced storm surges along this coast (Ahmed et al., 2013; Ahsan & Warner, 2014; Azam & Falk, 2013; Mallick & Vogt, 2015). Every year, the coastal residents of Bangladesh fight against cyclone and storm surge impacts. People rarely get adequate support from governmental organizations (GOs) and non-governmental organizations (NGOs) to assist them in their immediate recovery and rehabilitation. Relief operations for cyclone victims are also constrained in reaching the right people within the appropriate timeframe for several reasons, including poor infrastructure (Roy et al., 2015). The efficacy of GOs' and NGOs' disaster preparedness measures has been questioned by different sectors of society (Mahmud & Prowse, 2012). Factors considered responsible for aggravating the calamities over the years include inefficient disaster forecasting systems, poor information dissemination, weak preparedness, and insufficient evacuation and rehabilitation processes. As a result, the magnitude of fragility and sensitivity to this adverse condition is increasing in terms of the socioeconomic livelihood of the coastal community (Kulatunga et al., 2014). Nevertheless, coastal residents sustain and persist through cyclones and storm surges using their limited human, social, physical, natural, and financial capital.

Almost every year, these household capitals are affected by cyclones and storm surges (Islam et al., 2014). Household capital enhances the capacity of households to cope (Obrist, 2010a), adapt (Bene et al., 2012), and transfer (accessing capital and assistance from the wider sociopolitical arena; Lorenz, 2013; Voss, 2008). This in turn enhances household and community resilience (Keck & Sakdapolrak, 2013). However, it is difficult to strengthen all forms of capital of poor coastal households before, during, and after a disaster (Speranza et al., 2013). Hence, the form of capital that can play a key role in enhancing household resilience to cyclone and storm surges is of great importance to academics, policymakers, and practitioners.

This thesis explores the potential role of human capital in enhancing household resilience to cyclones and storm surges in the disaster-prone areas of coastal Bangladesh. It aims to examine how the components of human capital relate to resilience in mitigating or adapting to such disasters. It also investigates the interaction between human capital and other forms of capital, such as natural, social, financial, and physical capital.

1.3 Research objective and questions

The main objective of the study is to identify the role of human capital in enhancing disaster resilience at the household level. The following research questions are addressed:

- What is the status of human capital at the household level in the coastal belt of Bangladesh? (Q1)
- What is the status of other forms of capital, such as natural, social, financial, and physical capital? (Q2)
- What is the association between human and other forms of capital (natural, social, financial, and physical capital)? (Q3)
- What is the relationship between human capital and household resilience to cyclones and storm surges? (Q4)

1.4 Study relevance

Disaster resilience is mostly described as the capacity of individuals or communities to recover from a disaster and return to a functioning state (Adger, 2000; Maguire & Hagan, 2007; Cutter et al., 2008; Norris et al., 2008). According to Lucini (2014), human capital can be a key instrument for strengthening capacities of an individual or a community for enhancing disaster resilience. Human capital is defined as the skills and knowledge individuals acquire through investments in schooling, on-the-job training, and other experiences (Unger et al., 2011). However, why is it important to understand and investigate disaster resilience through the human capital lens?

Resilience through different forms of capital is gradually being recognized as a vital issue in the disaster management domain. Several studies have focused on resilience based on human, social, physical, natural, and financial capital (Rakodi, 1999; USAID, 2013), with many of them focusing on particular forms of capital for strengthening resilience to disasters, for example, social capital (Aldrich, 2008, 2012; Braun & Aßheuer, 2011; Islam, 2010; Islam & Walkerden, 2014, 2015; Murphy, 2007; OECD, 2010), financial capital (Hunder & Kurtz, 2014; Huggins et al., 2015; Thulstrup, 2015), natural capital (Dominati et al., 2014; Ranjan, 2007), and physical capital (Labaka et al., 2015; Pathirage, 2008).

Several earlier studies looked at the specific components of human capital in various contexts. For instance, the OECD (2013) and the WEF (2013) mostly focused on two key components of human capital: formal education and school enrollment. Unger et al. (2011) assessed human capital based on individuals' job training and experiences. Several studies (Nerdrum & Erikson, 2001; WEF, 2013) also considered health and labor force as key components for addressing human capital. Some scholars (Abeysekera & Guthrie, 2005; Baron, 2007; Bontis, 2001; Sullivan, 1999, 2004; Isaac et al., 2009; Santos-Rodrigues et al., 2010; Youndt & Snell, 2003) investigated human capital in terms of individual knowledge and skills. Similarly, numerous

scientists have highlighted leadership ability (Bozbura et al., 2007), migration (Glaeser & Mare, 2001; Hicks, 1932; Sjaastad, 1962), and job experience (Gates & Langevin, 2010; Hudson, 1993) as key to understanding human capital. However, there are relatively less number of studies focusing particularly on improving resilience through human capital when faced with the challenges of cyclones and storm surges in the coastal area of Bangladesh. Although Baez et al. (2010) investigated human capital with regard to disasters, they mostly highlighted the effect of disasters on human capital. In addition, in most of the existing literature, resilience has been addressed at the community level (Aldrich, 2015; Cannon, 2008; Flora & Bregendahl, 2008; Flora & Delaey, 2012), whereas according to Das (2009) and Dasgupta (2014) resilience at the household level is more effective to consider in policymaking to avoid conflicts within communities.

The existing literature dealing with disasters in Bangladesh does not adequately focus on the empirical role of human capital in enhancing resilience (Yamauchi et al., 2009). Formal education has been sufficiently discussed in the literature on regional and global disasters such as the Haiti earthquake in 2010, the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, and the Kobe earthquake in 1995 (Horwich, 1997; Stöök & Gille, 2013). However, a serious discussion on human capital is not found in the literature covering large disaster events in Bangladesh, such as the Bhola Cyclone in 1970, Cyclone Gorky in 1991, Cyclone Sidr in 2007, and Cyclone Aila in 2009.

Considering this gap in the literature, various disaster-related studies have attempted to conduct further research on human capital with respect to disaster resilience. For example, Tyas (2015) suggests that attention should be paid to the role of human capital in building disaster resilience in an anthropological dimension; Baez (2010) emphasizes the relationship between disasters and specific components of human capital (schooling and health); and a group of scholars (Ahmed et al., 2016; Zurich Flood Resilience Alliance, 2014) noted that the disaster-resilience research community should give priority to the empirical investigation of human capital and its use in disaster recovery.

Therefore, a critical evaluation of human capital is essential to understand its role in disaster resilience and adaptation (Jordan, 2015). Based on quantitative and qualitative data, this study aims to fill the highlighted gaps by exploring the role of human capital in enhancing disaster resilience at the household level, with particular reference to the coastal area of Bangladesh.

1.5 How does human capital relate to disaster resilience?

When disaster hits a community, it loses various forms of capital, including agricultural land, crop fields, fish farms, and sources of safe drinking water (natural capital), as well as shelters, household machinery, electricity connections, drainage systems (physical capital), and so on. With regard to social capital, bonding and bridging networks are also affected by disaster, which has consequences for long-term recovery. Theoretically, social capital is a collective good, but not everyone claims equal access or use. Power, privileges, and resource advantages are concentrated among those whose access and usage are highest (Adler et al., 2010). However, human capital (knowledge, skills, ability to work) is comparatively less affected by the shock of a cyclone (Doocy, 2013). It is an asset inherent in individuals and it maintains a vital role in the three stages (before, during, and after) of a disaster. Besides being of intrinsic value, human capital is required to make use of any of the other type of capital (DFID, 2011b). It is therefore necessary, though not sufficient on its own, for the achievement of positive livelihood outcomes (Guiteras et al., 2015).

During a disaster, coastal households must know how to cope using their own capacities, knowledge, skills, and experience. They are simultaneously victims and resource managers, and therefore must know how to handle the situation. During cyclones and storm surges, the first responders are the local residents, because disaster-response organizations usually take a minimum of 48–72 hours to reach the affected areas, or sometimes even longer due to lack of communication and access (Islam & Walkerden, 2014). Institutional relief and goods can take four to five days to reach devastated areas (Khalil, 2012; Haque, 1997; Alam & Collins, 2010). Therefore, households have to use their own skills and knowledge to minimize their losses at this initial stage.

After a disaster, local residents use their human capital for long-term recovery. In Bangladesh, it is common for affected neighbors and relatives to exchange information and expertise. They share particular knowledge and skills, such as repairing houses, fixing livestock enclosures, re-building local roads, and so on. Although relatives and neighbors provide support to each other after disasters by sharing food, money, and labor, this is often rather limited due to their poverty and because they are all equally affected by the disaster. This form of social support works mostly in the early recovery phase. After that, support from relatives and neighbors becomes less prevalent and sometimes disappears due to poor access to resources, community conflicts, and competition over external resources (Islam, 2015). However, affected households are in need of long-term recovery strategies. Households then use their formal, informal, and vocational skills and knowledge to find new jobs, cultivate crops, fix houses and sanitation facilities, and try to increase their income and savings.

Before disaster strikes, local inhabitants need to be aware of the impending disaster, including the assets they need to use to resist the effects of the disaster, and the manner in which they can use these assets. For

example, they need to understand the warning system (Mahmud & Prowse, 2012). In this context, human capital can play a significant role in enhancing households' understanding of the key issues in the phase of disaster preparedness. However, human capital is not clearly articulated in the disaster management policies of Bangladesh. Local governments and NGOs mostly concentrate on emergency disaster relief, but this is not a long-term solution. Although coastal residents use their experience and indigenous knowledge to predict a disaster, their risk perception (particularly with regard to cyclones and storm surges) is still not adequate.

The contribution of human capital in the three stages of a disaster is a key point in understanding resilience to cyclones and storm surges. This study examines the experiences during Cyclones Aila and Sidr in nine coastal villages to reveal how human capital contributed to enhancing household resilience to these events. Aila slammed into southern Bangladesh on May 25, 2009, killing 190 people, injuring more than 7,000, and affecting 3.9 million others. Sidr, which struck on November 15, 2007, killing 3,400 people and rendering millions more homeless, is now described as the most powerful cyclone to strike the impoverished low-lying nation in over 15 years (IRIN, 2009).

1.6 Organization of the study

This thesis is divided into eight chapters, including the introduction and the following outline of the research context.

Chapter 1 provides a basic introduction, the research background, the research justification, the aims and research questions, and definition of key terms.

Chapter 2 lays out the theoretical basis of this thesis, including a discussion on resilience and human capital as the conceptual roots of this study. This chapter illustrates the embedded theories and framework of resilience and the human capital spectrum; it mainly highlights theoretical issues with respect to the existence framework for an analysis of the relationship between human capital and disaster resilience.

Chapter 3 introduces the conceptualization of the current study and elaborates on it. In this chapter, existing literature relating to the notion of human capital and disaster resilience is reviewed, highlighting the paradigm shifts in the research focus. In light of the existing literature, various parts of the research framework for the present study are discussed to define resilience and human and other forms of capital. It explores the components of human capital, such as knowledge obtained through formal schooling, college, and university; vocational education and training; learning by doing; interaction and participation; and experience and indigenous activities, as well as the ability to work. It also lays out the particular components of resilience to tackle cyclones and storm surges in the coastal area of Bangladesh, such as household income, sanitation, housing type, English language competency, and the ability to cultivate mixed crops. This chapter also

reviews the various parts of the research design and describes the methodological approach, the types of data collected, the selection of indicators for measuring disaster resilience and different forms of capital, the data sources, and the data analysis techniques.

Chapter 4 focuses on the study areas and methods applied. It situates the case study by introducing the coastal area of Bangladesh, the disasters it faces, and its socioeconomic status. This chapter gives an overview of Cyclones Sidr and Aila, which struck in 2007 and 2009, respectively. It also reviews the research methods, describing how the study areas were selected and how the empirical data were collected from different villages, and provides reasons for the case study selection. Finally, the chapter provides a detailed description of the household survey.

Chapter 5 addresses the status of different forms of capital and their interrelationships, which addresses research questions Q1 (What is the status of human capital at the household level in the coastal belt?) and Q2 (What is the status of other forms of capital, such as natural, social, financial, and physical capital?). It investigates how the components of human capital are related to the components of other forms of capital. Finally, this chapter elucidates the interrelationships between human and other forms of capital, which provides the answers to question Q3 (What is the association between human and other forms of capital for enhancing household resilience?).

Chapter 6 highlights the relationship between human capital and disaster resilience, which provides the answers to question Q4 (What is the relationship between human capital and household resilience with regard to cyclones and storm surges?). This is done in two steps: first, by measuring disaster resilience through the multi-stage method, and second by exploring the relationship between human capital and disaster resilience.

Chapter 7 presents the general discussion of the results and proposes a resilience model. The proposed model, built on the theories of resilience mentioned in Chapter 2, establishes the linkages and relationships between the central and the supplementary research themes. It concludes the thesis and, based on the major findings, offers suggestions and recommendations on how disaster resilience, particularly in the case of cyclones and storm surges, could be enhanced by strengthening human capital. It explicitly indicates the necessary actions and interventions to be undertaken reiterating the need for building communities that are resilient in the face of cyclones and storm surges along the Bangladeshi coast.

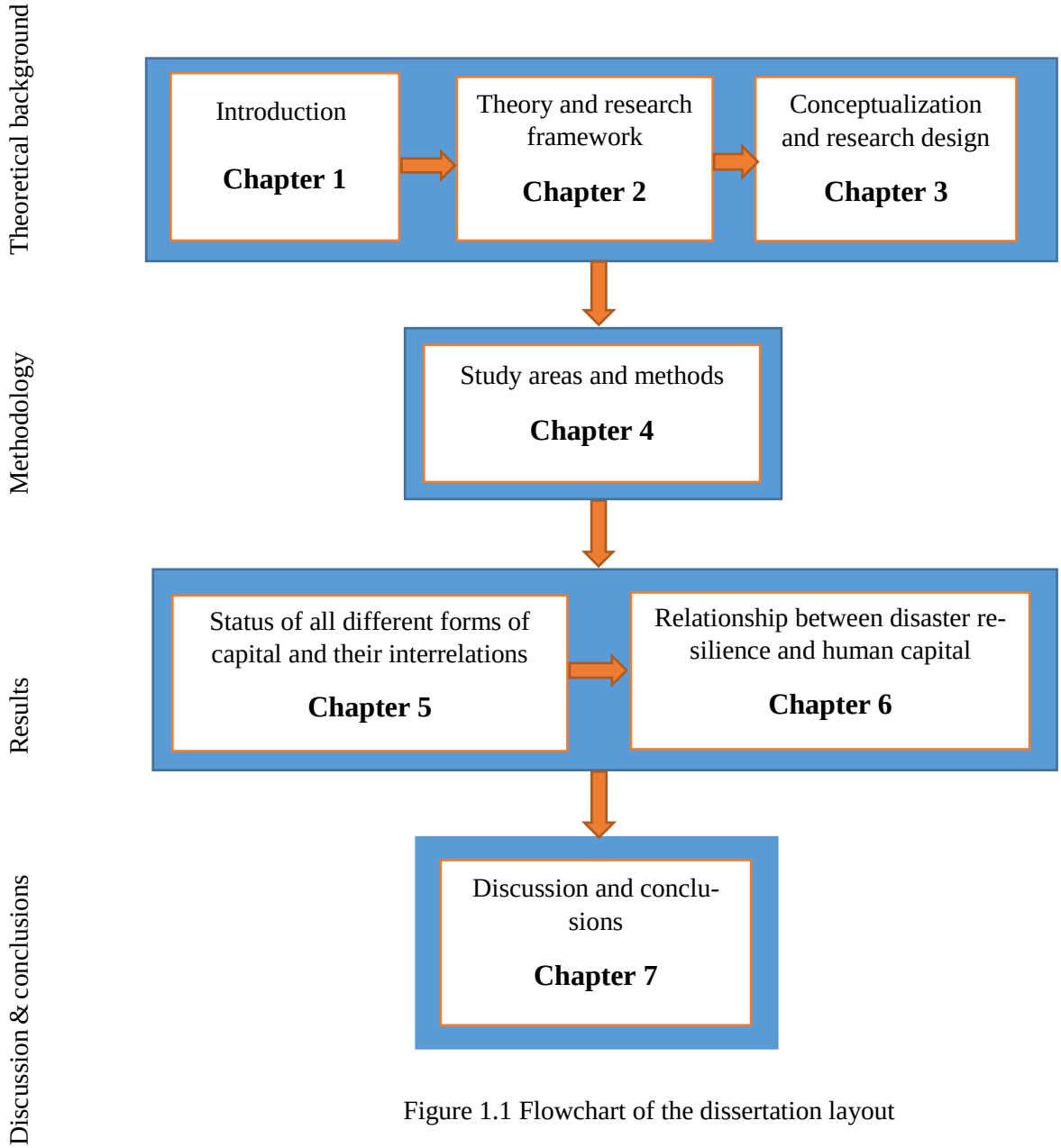


Figure 1.1 Flowchart of the dissertation layout

CHAPTER TWO: THEORY AND RESEARCH FRAMEWORK

The aim of this study is to understand the relationship between human capital and disaster resilience with regard to cyclones and storm surges in the coastal area of Bangladesh. This chapter highlights the theoretical orientation and research framework of the study. Although the theoretical part of the dissertation encompasses both Chapters 2 and 3, this chapter explicitly discusses theories in light of existing frameworks on disaster resilience and the concept of human capital.

2.1 Resilience: Theoretical reflections

Resilience is one of the most important research topics with respect to sustainability (Kates et al., 2001; Foley et al., 2005; Brand & Jax, 2007). However, resilience has been frequently redefined and expanded using different dimensions at various levels (Holling, 2001; Pickett et al., 2004; Zhou et al., 2009). A group of researchers (Pelling, 2003; Cardona, 2005; Zhou et al., 2009; Buckle et al., 2001) point out that resilience is the ability of an actor to cope with or adapt to the stress of a disaster. Other scholars (Folke et al., 2002; Wildavsky, 1991; Paton et al., 2000; Pelling, 2003; Cardona, 2003) stress three characteristics of capacity: the capacity to absorb disturbances, the capacity to self-organize, and the capacity to learn. DFID (2011) and Morrone et al., (2011) define resilience as the ability of individuals, households, and states to absorb and recover from shocks while positively adapting and transforming their structures and means for living in the face of long-term changes and uncertainty. Although the concept of resilience is becoming the de facto framework for enhancing disaster preparedness, responses, and recovery in the short and long terms (Cutter et al., 2014), the debate on measuring disaster resilience is ongoing.

The literature on resilience reveals two views of measuring resilience. The first is that resilience is the sum of various types of household or community capitals (human, social, natural, physical, and financial) (DFID, 1999; Mayunga, 2007; Kulig et al., 2013; Mowbray, 2011; Flora & Flora, 2013; Flora & Bregendahl, 2012; Flora & Delaney, 2012; Thulstrup, 2015). The second is that resilience is a set of particular components, such as age, language competency, learning, housing, income, savings, access to healthcare, sanitation, etc. (Paton, 2001; Tobin & Whiteford, 2002, 2010, 2014; Norris et al., 2008; Morrow, 2008; Akter & Mallick, 2013; Forgette & Boening, 2010; Tierny et al., 2007; Maguire & Hagan, 2007; Zhou, 2009).

In the context of these two views on disaster resilience, numerous studies (Tobin, 1999; DFID, 2011; Carpenter et al., 2001; Cutter et al., 2008; Mayunga, 2007; Alinovi et al., 2010) have proposed frameworks that can be used as a theoretical basis for disaster resilience research (Carpenter et al., 2001). Although several disaster resilience frameworks have been developed to advance the theoretical underpinnings of the concept, none has received wide acceptance. However, these frameworks provide a basic structure to assess disaster resilience (Mayunga, 2007). From the perspective of resilience as the sum of capitals, the sustainable livelihood framework (Chambers & Conway, 1992) and the community disaster resilience framework

(Mayunga, 2009), and from the viewpoint of resilience as a set of particular components, the disaster resilience of place model (Cutter et al., 2008) and the Food and Agriculture Organization (FAO, 2010) resilience tool are reviewed and discussed in the following section. The Sustainable Livelihood Framework (SLF) and the Community Disaster Resilience Framework (CDRF) focus on the role of different household capitals, while the Disaster Resilience of Place (DROP) model and FAO tools focus on the various components of disaster resilience.

2.1.1 Sustainable livelihood framework

The SLF was originally designed by Chambers (1983) and later modified by Chambers and Conway (1992). The SLF concept prioritizes research on enhancing sustainability at the local level. This framework can be used to promote disaster risk reduction, enhance resilience, and reduce poverty (Scoones, 1998; Peacock et al., 2010).

The SLF details a mechanism for coping with and adapting to shocks in the form of livelihood strategies indicated by transforming structures and processes based on household or community assets (DFID, 1999). The SLF helps in understanding the circumstances around individuals and their livelihoods and describes the main factors that affect the livelihood of households and the relationship among them (DFID, 1999).

This framework simplifies the complexity in the interactions among various forms of capital when adapting to and coping with vulnerabilities through livelihood strategies (Tyas, 2015). Figure 2.1 depicts the SLF, its factors or components, and their interactions. As the arrows show, the SLF presents different patterns shocks, relationships (e.g., between capitals and policies, institution and processes), and their effect on livelihood strategies, but not the causal relationships (Chambers & Conway, 1992; DFID, 1999; Manyena, 2009; Peacock et al., 2010). In the context of vulnerability, this framework reveals the social, political, and physical conditions of communities, and the livelihoods that are affected by external trends, shocks, and seasonal shifts. Although the SLF approach mainly focuses on the concept of sustainability, it is also related to the concept of disaster resilience (Tobin, 1999; Mileti, 1999). According to the capital-based approach, capital comprises components that are vital to the development of a sustainable community economy (Mayunga, 2009). The common understanding is that the more the economic opportunities in a community, the more the potential to reduce disaster impacts, and hence, the more resilient the community becomes. The concept of sustainability is related to individuals' abilities to cope with and recover from stresses and shocks (Peacock et al., 2010). This is why it is related to disaster resilience (Smith et al., 2001).

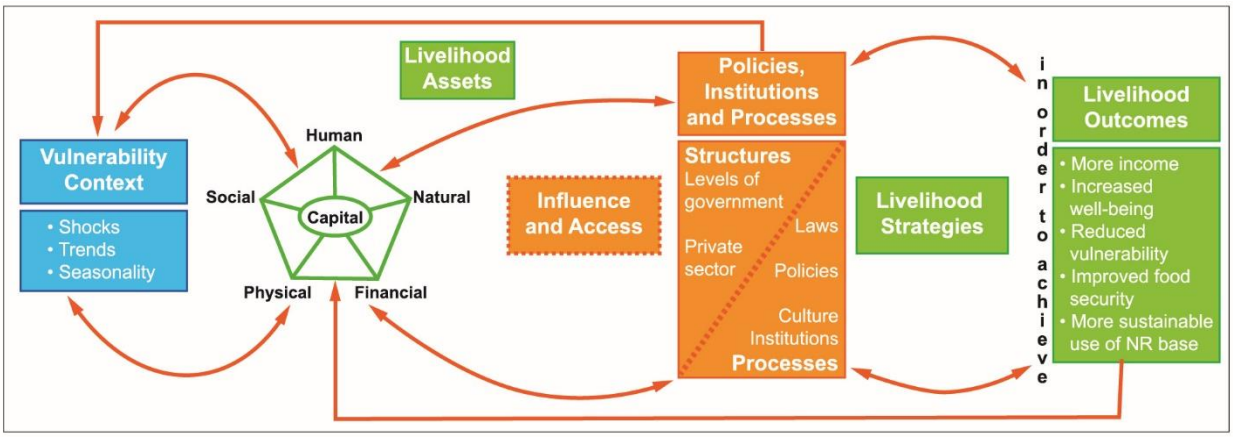


Figure 2.1 Sustainable livelihood framework. Adapted from DFID (1999)

The SLF distinctly emphasizes improving capital assets to reduce vulnerability and enhance disaster resilience (Burton, 2012). In addition, it makes it clear that resilience is the sum of various forms of capital (human, social, natural, physical, and financial). The five-capital or asset pentagon is the key to the SLF.

Human capital: Education, skills, labor ability, and good health enable people to pursue different livelihood strategies and achieve their livelihood goals. Human capital describes the amount and quality of labor available at the household level. It depends on household size, skill levels, leadership potential, health status, etc. DFID (1999) points out that human capital refers to education and skills, age, and any other advantages that people have (including prior disaster experiences) that enhance their capacity to cope with and recover from the impact of a disaster.

Social capital: Social networks facilitate collective action. In addition, social capital focuses on aspects of social structure, trust, and norms (Green & Haines, 2002; Mayunga, 2007; Peacock et al., 2010). Social capital considers the effect of the quantity and quality of social cooperation on community resilience. Resilient communities are those that adequately address collective concerns, allow individuals to produce social resources, and have residents that work together to achieve common objectives. Social networks (e.g., friends, relatives, and coworkers) are important in building disaster resilience because they provide resources that can help households during the disaster response and recovery periods (Lindell & Prater, 2003).

Physical capital: Physical capital refers to the built environment, for example, the resilience of residential housing, public buildings, commercial and industrial buildings, dams and levees, and shelters. It also includes lifeline factors such as technologies, electricity, water, sewers, telecommunications, and transportation systems (Peacock et al., 2010).

Natural capital: Natural capital describes the stock of natural resources from which resource flows and ecosystem services (e.g., nutrient cycling, erosion protection) are derived. A large variation can be seen in

the resources that build up natural capital, from intangible public goods such as the atmosphere and biodiversity to divisible assets used directly for production (trees, land, etc.). The relationship between natural capital and vulnerability is particularly close. Many of the shocks that devastate the livelihood of the poor are themselves natural processes that destroy natural capital (e.g., fires that destroy forests, or floods and earthquakes that destroy agricultural land). Seasonality is largely due to changes in the productivity of natural capital over the years (DFID, 1999).

Financial capital: Financial capital refers to financial resources that people use to achieve their livelihood goals. Livelihood resources include monetary income, savings, access to credit and loans, and investments that increase the ability of communities to absorb disaster impacts and speed up the recovery process. At the household level, this can be measured through household savings, income-generating employment, property values, or investments (Peacock et al., 2010).

From the discussion above, it becomes clear that various types of capital are important elements in building community disaster resilience. However, although the SLF approach highlights the key components required to reduce vulnerability and poverty, the framework remains rather general and unspecific with respect to potential variables.

2.1.2 Community disaster resilience framework

The CDRF developed by Mayunga (2009) is based on the SLF. It is a composite framework including activities of both disaster management and community capitals. Four phases (mitigation, preparedness, response, and recovery) and four community capitals (social, economic, physical, and human) are included within this framework. This framework mostly focuses on social systems rather than physical ones, and natural capital is considered more a part of physical systems than of social ones. Hence, natural capital was excluded from this framework. Proponents of the CDRF have pointed out that excluding natural capital from the framework does not mean that it is less important in enhancing disaster resilience (Mayunga, 2009). Natural capital, for example, plays a significant role in protecting coastal communities. This point of view indicates the importance of natural capital in coastal resilience (Mayunga, 2009).

The CDRF is focused particularly on the significance of integrating the different forms of community capital and disaster management activities in order to create a platform on which disaster resilience indicators can be developed. Based on this, the indicators of community disaster resilience can be measured. The main approach of the CDRF involves four major forms of capital as important assets for successfully performing the activities of the four phases of disaster management. These four major forms of capital determine the strength, capacity, and resources that enable a community to enhance its resilience when initiating various disaster management activities (Mayunga, 2009).

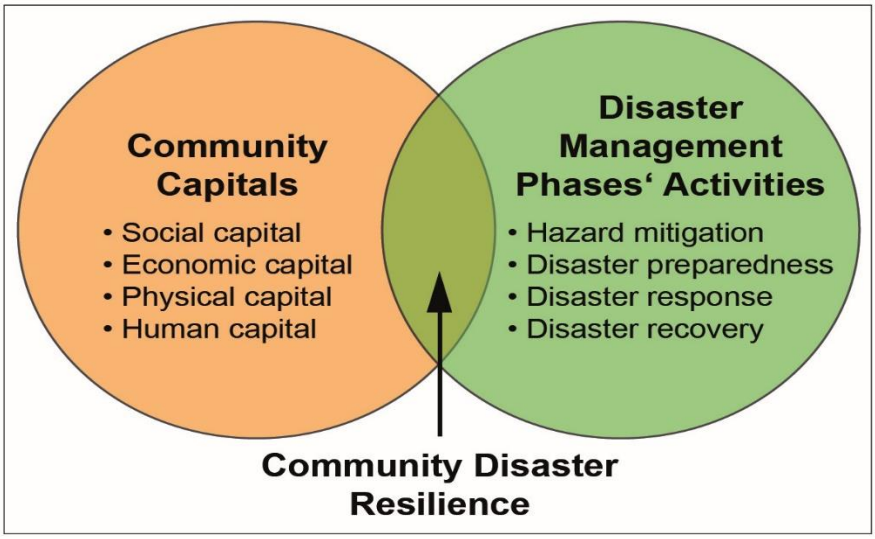


Figure 2.2 The community disaster resilience framework. Adapted from Mayunga (2009)

On the basis of the CDRF framework, community disaster resilience can be understood and measured by assessing a community's major forms of capital vis-à-vis the major activities that must be undertaken during the four phases of disaster response (mitigation, preparedness, response, and recovery). The CDRF explains the successful implementation of such activities during each phase based on the various forms of community capital (Burton, 2012). Various studies suggest that the relationship between these two components is strong and distinct and the importance of these components in building community disaster resilience is comprehensive (Peacock et al., 2010).

2.1.3 The disaster resilience of the place model

The DROP model (see Figure 2.3) developed by Cutter et al. (2008) takes a geographic perspective. It consists of two components that focus particularly on the community level. The first component is a community's antecedent conditions, which are the product of the interactions of the social, natural, and built environmental systems. The antecedent conditions encompass the inherent vulnerability and inherent resilience of the community. The impact of a hazard is the outcome of three components, which are the antecedent conditions, hazard events, and the ability to cope and respond. Inherent vulnerability and inherent resilience present the core point of the DROP model, as present conditions serve as a baseline from which the effectiveness of programs, policies, and interventions designed to enhance disaster resilience can be measured. The second component is the activities or actions intended to be taken to deal with the disaster's impact. This component includes disaster response, disaster recovery, disaster preparedness, and hazard mitigation.

This model couples a community's antecedent conditions with various attributes of a physical hazard to determine the immediate impact of the hazard. The attributes of a physical hazard event include elements

of exposure such as frequency, duration, intensity, magnitude, and rate of onset, which reduce or increase the immediate consequences in the presence or absence of mitigating actions and coping responses found within communities. The coping responses are directly related to a community's antecedent conditions.

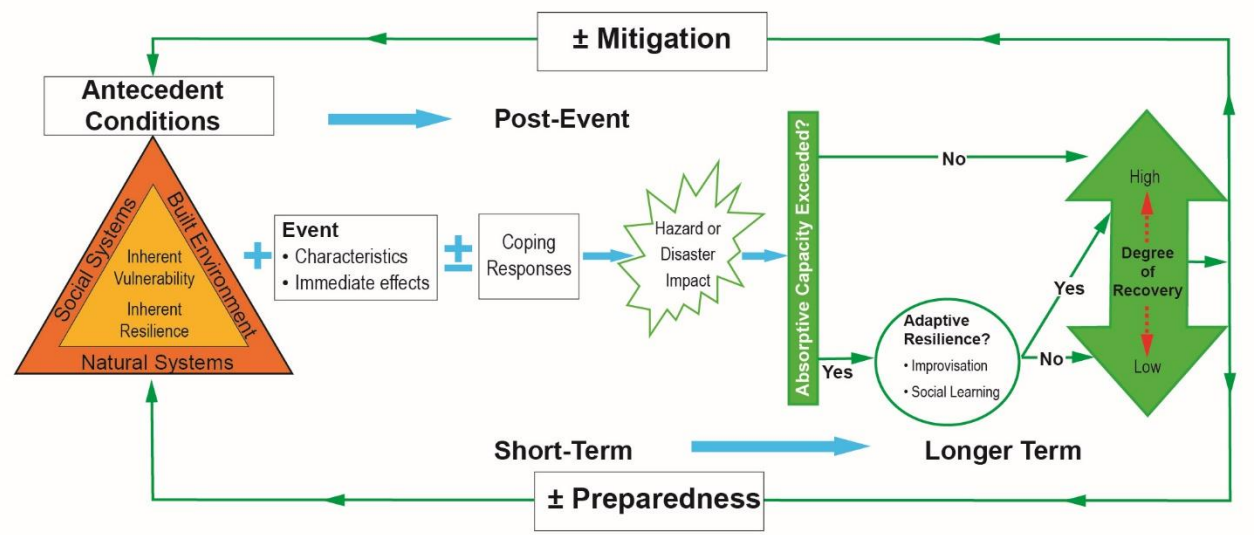


Figure 2.3 The disaster resilience of place model. Adapted from Cutter et al. (2008).

According to this model, the impact of a disaster is considered the cumulative result of the antecedent conditions and event characteristics, coupled with the coping responses of the community. It also indicates that the total hazard or disaster impact may be reduced through social learning or the absorptive capacity of the community. According to Cutter et al. (2008), absorptive capacity is the ability of a community to absorb impacts using predetermined coping responses. Therefore, if a community implements sufficient coping responses, the impacts of a hazard event may be reduced and the absorptive capacity of the community will no longer need to be increased to accelerate the degree of recovery.

Various aspects of the DROP model such as antecedent conditions, event characteristics, and absorptive capacities are assessed through a dynamic and cyclical understanding of disaster resilience. The first component of this model, inherent resilience, is measured through ecological, social, economic, infrastructural, institutional, and community components (see Table 2.1). For instance, the resilience of ecological systems is associated with several components, such as biodiversity, governance, management plans, response diversity, etc. (Adger, 2006; Adger et al., 2005; Folke, 2006; Cutter et al., 2008). Social resilience can be enhanced by improving communication, risk awareness, and preparedness (Paton et al., 2000). Table 2.1 displays the different dimensions of community resilience and their associated components in light of the DROP model.

Table 2.1 Community resilience indicators.

Dimension	Candidate variables
Ecological	Wetland acreage and loss
	Erosion rates
	Percentage of impervious surfaces
	Biodiversity
	Coastal defense structures
Social	Demographics (age, class, gender, occupation, etc.)
	Social networks and social embeddedness
	Community values cohesion
	Faith-based organizations
Economic	Employment
	Property value
	Wealth generation
	Municipal finance/revenues
Institutional	Participation in hazard reduction programs (NFIP, Storm Ready)
	Hazard mitigation plans
	Emergency services
	Zoning and building standards
	Emergency response plans
	Interoperable communications
	Continuity of operations plans
Infrastructure	Lifelines and critical infrastructure
	Transportation network
	Residential housing stock and age
	Commercial and manufacturing establishments
Community competence	Local understanding of risk
	Counseling services
	Absence of psychopathologies (alcohol, drug, and spousal abuse)
	Health and wellness (low rate of mental illness, stress-related outcomes)
	Quality of life (high satisfaction)

Adapted from Cutter et al. (2008)

2.1.4 FAO resilience tool

The Food and Agriculture Organization (FAO) resilience tool introduced a framework for understanding resilience at the household level. This framework describes resilience as a latent variable made up of a number of context-specific components. It also indicates that the resilience of a given household at a given point in time, T_0, depends primarily on the options available to that household for making a living. This comprises a set of particular components, such as access to assets, income-generating activities, public services, and social safety nets. At time T_0, each component is measured separately to develop a composite

index of household resilience. The different components observed at time T_1 indicate how changes in these factors influence household resilience (Alinovi et al., 2010).

This framework determines the resilience index using the following algebraic formula:

$$R_i = \int IFA_i\,,\ ABS_i,\ \ A_i,\ SSN_{i\,,}\ S_i\,, AC_i$$

Where, R = resilience; S = stability; SSN = social safety nets; ABS = access to basic services; A = assets; IFA = income and food access; and AC = adaptive capacity. This framework describes the particular components to measure resilience at the household level.

Table 2.2 Components of disaster resilience

Component	Indicators
Income and Food Access	• Average daily income per person • Average daily expenditure per person • Household food insecurity access score • Dietary diversity and food frequency score • Dietary energy consumption
Social Safety Nets	• Amount of cash and in-kind assistance • Quality evaluation of assistance • Job assistance • Frequency of assistance • Overall opinion of targeting
Access to Basic Services	• Physical access to health services • Quality score of health services • Quality of educational system • Perception of security • Mobility and transport constraints • Water, electricity, and phone networks
Assets	• Housing • Durability index • Tropical livestock units • Land owned
Stability	• Number of household members that have lost their job • Income change • Expenditure change • Capacity to maintain stability in the future • Safety net dependency • Education system stability
Adaptive Capacity	• Diversity of income sources • Educational level • Employment ratio • Available coping strategies • Food consumption ratio

Adapted from Alinovi et al., (2010); Frankenberger and Nelson (2013)

The aforementioned models and frameworks have generally demonstrated that there are two approaches to conceptualize disaster resilience: (1) the sum of household or community capital, and (2) resilience as a set of particular components or indicators. The SLF and the CDRF mainly focus on community capital. More specifically, the CDRF focuses on community capital in particular disaster phases, such as hazard mitigation, disaster preparedness, and disaster response and recovery. On the contrary, the DROP model and the FAO resilience framework focus on the various components of resilience. The DROP model emphasizes two components (antecedent conditions and the activities or actions to deal with disaster fallout), while the

FAO resilience framework looks at various components such as stability, social safety nets, access to basic services, assets, income and food access, and adaptive capacity.

Although these frameworks provide a general understanding of disaster resilience, they remain abstract in nature (i.e., SLF) and cannot be easily operationalized to assess disaster resilience (Manyena, 2009). Although the FAO resilience measurement approach is rather straightforward, the framework includes assets as one of six components, which gives room for overlap between components and assets/capital. On the contrary, the CDRF was not considered natural capital in terms of disaster resilience, although natural capital is vital for coastal resilience (Momtaz et al., 2015). Regarding the scale of analysis, SLF, DROP, and CDRF focus on disaster resilience at the community level. Although the FAO emphasizes resilience at the household level, this model is mostly interested in food security. In addition, all models and frameworks presented have been developed with general disasters in mind, with no clear indication of their applicability to particular disasters such as cyclones and storm surges, floods, or riverbank erosion. There is thus a need to develop a disaster resilience concept that accounts for both dimensions (capital and components) in specific disasters at a particular level (e.g., regional, community, or household).

Many scholars (e.g., Mayunga, 2007; Gill & Ritchie, 2011) argue that human capital is one of the most important factors of resilience, because it can increase or decrease the efficiency of the other types of capital in resilience-building efforts by providing access to a skilled and trained workforce for economic development and capacity building. A group of scientists (Bahadur, Ibrahim, & Tanner, 2010; Buckle, 1998) has also argued that acquisition and maintenance of human capital at the community level are necessary to manage collective responses effectively in the wake of a shock or disaster. Hence, it is essential to discuss the theoretical insights of human capital as discussed in the following sections.

2.2 Human capital: Theoretical reflections

The modern theory of human capital has been developed over the past half century. However, the notion of human capital was introduced at least as far back as the early seventeenth century, when William Petty considered it the value of laborers. In 1619, Petty put a value on the work of laborers, asserting that the value of human capital demonstrated the power of England. Petty also estimated the cost of the lives lost to war and other causes (Kiker, 1966, p.482). Following Petty, Adam Smith (1776, p.179) focused on the individual's abilities to theorize human capital. In 1776, Adam Smith popularized the idea that human beings are investments that produce returns, pointing out

…the acquired and useful abilities of all the inhabitants or members of society. The acquisition of such talents, by the maintenance of the acquirer during his education, study, or apprenticeship, always costs a real expense, which is a capital fixed and realized, as it were, in his person. Those talents, as they make a part of his fortune, so do they likewise that of the society to which he belongs. The improved dexterity of a

workman may be considered in the same light as a machine or instrument of trade which facilitates and abridges labor and which, though it costs a certain expense, repays that expense with a profit.

Smith noted that human capital is the part of capital dealing with the individual laborer who acquires economically useful abilities. Subsequently, W. Farr (1853) argued that the present value of a person's net future earnings, which he defined as earnings less living expenses, represented wealth in the same way as did physical property and should be similarly taxed (as cited in Hodgson, "What Is Capital?," 2014). In 1867, T. Wittstein argued that Farr's calculation of the present value of net future earnings should be used to measure compensation for claims involving loss of life. Later, Louis Dublin and Alfred Lotka (1930) used Wittstein's approach to determine the amount of life insurance a person needed to purchase. Their work extended Wittstein's present value of net future earnings to consider mortality statistics (as cited in Stanko et al., 2014). In addition, numerous early contributors to the literature on human capital, such as Jean Baptiste Say (1821), Von Thünen (1875), John Stuart Mill (1909), William Roscher (1878), Henry Sidgwick (1901), and Fischer (1906), explained the various ways in which a human being can be an investment that generates a return, which addressed the initial notion of human capital.

However, a contemporary understanding of human capital theory was popularized by Johnson, Theodore W. Schultz, and Gary S. Becker in the 1960s. In 1960, Johnson found that laborers gain experience and thus become capitalists when they acquire knowledge and skills that have economic value, rather than from the accumulation of stock, as in the case of landlords. Hence, laborers with new knowledge and skills can demand payment beyond the exchange value for their labor (Bontis, 2001). Johnson (1960) explicitly focuses on the knowledge and skills of laborers.

As a means of production, in terms of knowledge and skill, Theodore W. Schultz (1961, p. 3) states

The failure to treat human resources explicitly as a form of capital, as a produced means of production, as the product of investment, has fostered the retention of the classical notion of labor as a capacity to do manual work requiring little knowledge and skill, a capacity with which, according to this notion, laborers are endowed about equally. Counting individuals who can and want to work and treating such a count as a measure of the quantity of an economic factor is no more meaningful than it would be to count the number of all manner of machines to determine their economic importance either as a stock of capital or as a flow of productive services.

The understanding of human capital by Schultz (1961) is based on an individual's aspects and characteristics. Most researchers agree that Schultz considers the capacity of an individual to be the knowledge and skills embedded in that individual (Beach, 2009). Schultz (1961) recognized human capital "as something akin to property," breaking with the classic concept of labor force. Based on the same notion, human capital

concentrates "on the agency of human beings—through skill and knowledge as well as effort—in augmenting production possibilities" (Sen, 1997, p. 2). In 2001, the OECD (2001) also understood human capital in a similar context. According to OECD (2001, p. 18), human capital is the knowledge, skills, competencies, and attributes embodied in individuals that facilitate the creation of personal, social, and economic well-being.

However, Gary S. Becker (1992) said that the concept of human capital was controversial, as it was seen as narrow and unfeeling, and seemed to assert that humans were treated as machines by the schooling process rather than by cultural experience. Becker argued that education and training are the most important investments in human capital, and stated that "all in all I believe the case is overwhelming that investments in human capital are one of the most effective ways to raise the poor to decent levels of income and health" (1995, p. 13). Therefore, it is clear that investment in human capital is believed to contribute to lifting people out of poverty. Becker (1995) too indicated that machinery and physical capital are of negligible importance in a modern economy: "…you need good machinery, equipment, and factories. But you also need skilled workers and managers, and innovative entrepreneurs to utilize this machinery effectively" (1995, p. 9). Human capital is not like physical capital, as the value added by physical capital seems to be separated from the laborer (Bontis, 2001).

Despite their differences, the views of Johnson (1960), Schultz (1961), and Becker (1992) are quite similar in essence. They mostly focused on the value of human capital in the market because it increases firms' profits and general welfare (Dae-Bong, 2009).

Although the above discussion highlights that human capital corresponds to any stock of knowledge or characteristics the worker has, which contributes to his or her "productivity," there is also a critical debate over this approach. It is very difficult to postulate that high levels of productivity or wage labor means a high level of human capital investment in every sector. There are many notable exceptions to this aspect of human capital, particularly compensation for differentials, labor market imperfections, and taste-based discrimination. Compensation for differentials is the practice of paying a worker less money because he or she is receiving compensation in terms of other (intangible) characteristics of the job, which may include lower effort requirements, more pleasant working conditions, better amenities, etc. On the contrary, due to labor market imperfections, two workers with the same human capital may be paid different wages. Jobs differ in terms of productivity and pay; one worker may have a high-productivity job while another may have a low-productivity one. Finally, taste-based discrimination is the practice of employers paying lower wages to certain workers because of their gender or race, due to prejudice (Acemoglu, 2013).

In addition, an examination of the literature on human capital shows that the discourse on human capital moves into various dimensions. One stream of studies explored human capital investment and theory (Baron

and Armstrong, 2007; Hall, 2004; Hansson, 2001). Other scientists addressed human capital as a component of intellectual capital (Nerdrum and Erikson, 2001; Roos et al., 1997; Stewart, 1997; Sullivan, 1999), and much has been written about the evaluation and measurement of human capital (Bechtel, 2007; CIPD, 2006; Gates and Langevin, 2010; Scarborough and Elias, 2002; Whitaker and Wilson, 2007). As a result, still there is no common consensus on the definition of human capital. A number of scholars define human capital in the context of their own research perspectives and at various levels, such as the individual, the organizational, and society as a whole (Afiouni, 2013). However, to understand the views of human capital, this study has highlighted some of these definitions, which help us to understand the development of the concept of human capital in various contexts. The selected definitions of human capital are listed chronologically in Table 2.3.

Table 2.3 Selected definitions of human capital

Authors	**Year**	**Definition**	**Level**
Becker	1993	Knowledge and skills embodied in an individual	Individual
Sveiby	1997	The capacity to act in different situations to create both tangible and intangible assets	Individual
Bontis	1999, 2001	The individual stock of knowledge embedded in a firm's collective capability to extract the best solutions from its individual employees	Organizational/ firm/company
Horibe	1999	Knowledge and experience of the people related to work	Individual
Nerdrum and Erikson	2001	Knowledge and skills complemented with productive capacity such as having the time and health	Individual/ organizational
OECD	2001	The knowledge, skills, competences, and other attributes embodied in individuals that facilitate the creation of personal, social, and economic well-being	Individual/ organizational/ society
Youndt and Snell	2004	Individual employees' knowledge, skills, and expertise	Individual
Luthans et al.	2007	Personal experiences, level of education, professional skills, knowledge, and creative ideas	Individual
Choudhury and Mishra	2010	An individual's knowledge, skills, and expertise and the ability of employees to do things that ultimately make the company work and succeed	Organizational
Unger et al.	2011	Skills and knowledge that individuals acquire through investments in schooling, on-the-job training, and other types of experience	Individual/ organizational
DFID	2011	The skills, knowledge, ability to labor, and good health that together enable people to pursue different livelihood strategies and achieve livelihood objectives	Society
World Economic Forum (WEF)	2013	The skills and capacities that are inherent in people and put to productive use	Individual/ society

Sources: Compiled from Gennaioli et al., 2012; Afiouni, 2013; Han et al., 2008; Bozbura et al., 2007; Harpana & Draghicia, 2013; Yamauchi et al., 2008.

Table 2.3 indicates that there are various definitions and ideas associated with the concept of human capital. Some theorists define human capital as an intangible asset (Sveiby, 1997; Wiig, 2004), while others define it as an employee's knowledge, skills, and abilities (Bontis, 2001; Nerdrum and Erikson, 2001; Sullivan, 1999; Luthans et al., 2004; DFID, 2011; Unger et al., 2011; Youndt and Snell, 2004). However, the World Economic Forum (WEF) (2013) included particular capacities with the skills of an individual in its definition of human capital.

From this above discussion, it can be understood that human capital is a set of skills and knowledge that increases a worker's productivity. The question is, what types of knowledge and skills can enhance human capital? Measuring human capital is still a big challenge. Due to the diverse understandings of the concept, human capital measurement is gradually gaining recognition as a vital issue in social sciences. However, despite the increasing use of human capital, it is difficult to find any complete approach to measure it (Han et al. 2008). Numerous scholars and organizations measure human capital through different indicators and based on different approaches (Afiouni, 2013).

Table 2.4 Different measurement approaches of human capital

Focused aspects	**Authors/publications**
Formal education/year of formal education	Schultz, 1961; Becker, 1964; DFID, 1999; Grossman, 2000; Ng et al., 2005; OECD, 2008; Singh et al., 2009; Fleisher et al., 2011; Braun & Aßheuer, 2011; Baron, 2011; WEF, 2013
Job training	Mincer, 1962; Singh et al., 2009; Unger et al., 2011
Individual knowledge and skills	Snell & Dean, 1992; Becker, 1993; Huselid, 1995; Wright et al., 1995; Finkelstein & Hambrick, 1996; Pennings et al., 1998; Sullivan, 1999; Mayo, 2000; Bontis , 2001; OECD, 2001; Nerdrum & Erikson, 2001; Walker, 2001; Sheffin, 2003; Wiig, 2004; Abeysekera & Guthrie, 2005; Bozbura et al., 2007; Isaac et al., 2009; Gates & Langevin, 2010; Santos-Rodrigues et al., 2010; Choudhury & Mishra, 2010
Health	Anson & Anson, 1987; World Bank, 1993; Olson & Pavetti, 1996; Ross et al., 1997; Jayakody et al., 1998; Grossman, 2000; Pindius et al., 2000; Bloom & Canning, 2003; WEF, 2013
Leadership ability	Bozbura et al., 2007; Paul & Routray, 2012
Experiences	Hudson, 1993; CDIP, 2006; Baron, 2011; Gates & Langevin, 2010

Source: Compiled by the author.

Although many researchers have explored and measured human capital, some methodological problems persist. As Bukh et al. (2001) argue, hardly any literature on human capital presents a comprehensive perspective on and discussion of human capital indicators. Harpan and Draghici (2013) mention three approaches to human capital measurement. The first approach is based on individual aspects, such as health. The second approach to human capital is understood and explained in association with an individual's process of accumulating knowledge and skills through education, namely compulsory education, postsecondary

education, and vocational education (Alan, Altman, & Roussel, 2008). The third approach focuses on specific factors such as education, experience, training, intelligence, energy, work habits, trustworthiness, and initiative, all of which affect the value of a worker's marginal product (Frank & Bemanke, 2007). Sheffrin (2003) presents a similar point of view, stating that human capital is the stock of skills and knowledge embodied in the ability to perform labor to produce economic value. Taking a more holistic view and combining these three approaches, the current study identified six pillars for assessing human capital as knowledge obtained through (1) formal schooling, college and university education; (2) vocational education and training; (3) learning by doing; (4) interaction and participation; (5) experience and indigenous activities; and finally (6) the ability to work.

Based on the two theoretical concepts of disaster resilience and human capital, this study aims to introduce a framework that accommodates a broader spectrum of the two concepts with regard to tackling cyclones and storm surges at the household level in coastal Bangladesh. The research framework aims to combine the dimensions discussed above and develop a composite framework that includes both household capital (based on the SLF) and the other components (based on DROP and the FAO) in particular phases (CDRF) of disaster resilience to assess it in the context of the research questions.

2.3 Research framework

The outlined research framework covers two interrelated concepts: disaster resilience and household capital. The relevant literature was reviewed to identify and determine the components of disaster resilience, such as sanitation, English language competency, access to safe drinking water, household income, housing type, ability to understand risk, non-farm self-employment, learning from past disasters, reduced dependency on purchased food, ability to use mixed-crop cultivation, capacity of women to make decisions on land use, and the ability to exchange knowhow with neighbors (Akter & Mallick, 2013; Bene et al., 2015¸ Barrett et al., 2013; Cutter et al., 2014; Twigg, 2009).

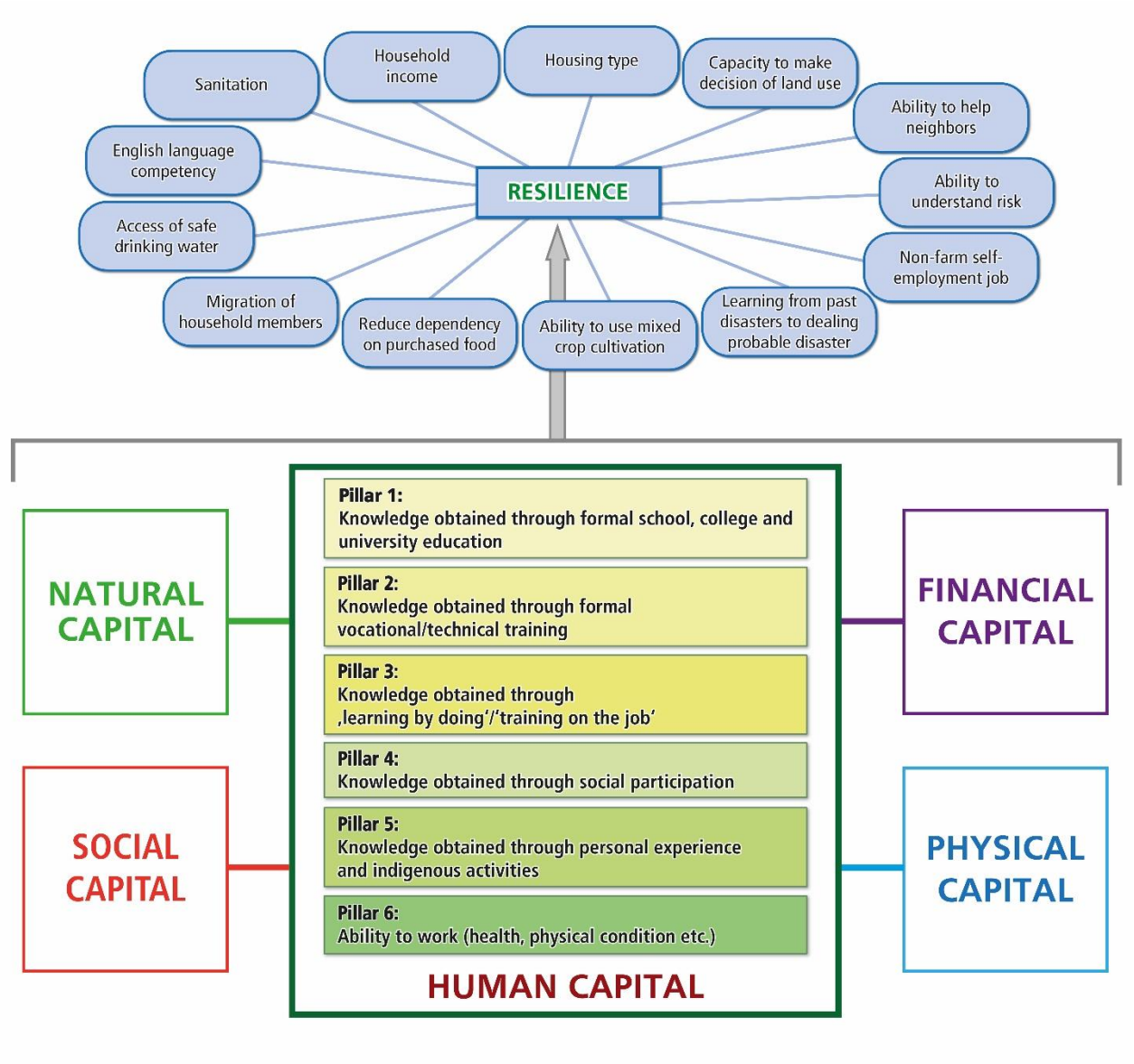


Figure 2.5 Research framework of the study. Based on Chambers and Conway (1992), Mayunga (2009), Cutter et al. (2008), and Frankenberger and Nelson (2013).

Five types of household capital are included in this framework. However, the emphasis is on human capital. The next chapter will discuss the various parts of the research framework, that is, the conceptualization of disaster resilience and the six pillars of human capital and other forms of capital in the context of disaster resilience. It will also present a description of the study's research design.

CHAPTER THREE: CONCEPTUALIZATION AND RESEARCH DESIGN

The objective of this chapter is to discuss the conceptualization of human capital and disaster resilience and elaborate on this study's adopted research framework. The existing literature on disaster resilience and human capital is first reviewed highlighting the paradigm shifts. Next, the concept of disaster resilience at the household level and this study's conceptualization of human capital are presented. Finally, the research design is presented.

3.1 Conceptualization of disaster resilience

3.1.1 The term "resilience"

The word "resilience" originates from the Latin word *resilire*, which means "to back up, recoil, or leap or spring back" (Davoudi, 2012). The emergence of the theoretical application of resilience is disputed as it has been argued that its roots can be found in a number of disciplines (Morrow, 2008). For example, Batabyal (1998) found that the essence of resilience was present in ancient thinking, and that it was developed in mathematics and physics. The concept of resilience is also seen from an environmental perspective (Carpenter et al., 2001; Davoudi, 2012) emerging in the ecological literature in the 1960s and the 1970s (Folke, 2006; Holling, 1973; Lewontin, 1969; Mayer etal., 2006). Holling (1973, p. 17) defined resilience as "a measure of the persistence of systems and of their ability to absorb change and disturbances and still maintain the same relationships between populations or state variables." Later, many academic fields began drawing from this conceptualization of resilience, including geography (Cutter, 2008; Cutter et al., 2014; Zhou et al., 2009), psychology (Bonano et al., 2010), sociology (Mileti, 1999), socio-ecological systems research (Folke 2006; Adger et al., 2005), and sociological disaster research (Bruneau et al., 2003; Manyena, 2006). Based on the literature from these various fields, resilience can be classified as one of the two types: engineering resilience and ecological resilience (Holling, 1996). Engineering resilience (Gunderson, 2000) refers to the ability of a system to return to a steady state after a disruption (Tilman & Downing, 1994). It emphasizes efficiency, constancy, and predictability and is a concept that engineers consider in their designs (e.g., "fail-safe" designs) (Alinovi et al., 2009). Ecological resilience is defined as the magnitude of disturbance that a system can absorb before it redefines its structure by changing the variables and processes that control behavior (Walker et al., 1999; Holling, 1973); it is always judged in the context of risk or adversity (Riley & Masten, 2005), for example, resilience to food insecurity, disasters, wars, and so forth. This study understands resilience in the context of natural disasters, particularly cyclones and storm surges.

3.1.2 Disaster resilience

The entry of the resilience construct in the field of disasters is relatively new, emerging in the disaster and hazard literature only during the previous two or three decades (Gallopín, 2006). The term "disaster resilience" was probably first used by Timmerman (1981; see also Klein et al., 2003; Burton, 2012), who said, resilience is the measure of a system's or part of a system's capacity to absorb and recover from hazardous incidents. Since then, many definitions of disaster resilience have gained prominence in academic literature. For example, Wildavsky (1988) stated disaster resilience as the ability to exploit opportunities and resist and recover from negative shocks. Subsequently, the Institute for Development Studies (1998) defined disaster resilience as the ability of individuals to cope with and recover from stresses and shocks, including both temporary adjustments in response to change (i.e., individuals' ability to cope) and long-term shifts in livelihood strategies (i.e., adaptive capacity; Institute for Development Studies, 1998). Walker et al. (2002) addressed resilience as the capacity for absorbing disturbances, for self-organization, and for learning and adaptation. All these definitions indicate the lack of consensus among researchers and practitioners on a common definition for the concept of disaster resilience, reflecting the complex nature of the concept. McEntire et al. (2002) pointed out that one of the major challenges that limits agreement on a common definition is the fact that individuals, groups, and communities may possess different magnitudes of resilience that may vary significantly over time. Thus, it is essential to understand the various characteristics of disaster resilience from its diverse definitions in order to conceptualize disaster resilience for this study. Table 3.1 shows a summary of the selected definitions of disaster resilience published in natural hazard- and disaster-related literature over the past two decades.

Table 3.1 Selected definitions of disaster resilience

Author	Definition	Characteristics	Subject/or level of analysis	Strengths and weaknesses
Timmerman, 1981	Resilience is the measure of a system's or part of a system's capacity to absorb and recover from the occurrence of a hazardous event	Mostly focuses on the capacity of a system	Ecological system	Focuses on capacity to absorb and recover, no indication of transferability
Walker et al., 2002	Capacity (i) for absorbing disturbances, (ii) for self-organize, and (iii) for learning and adaptation	Three types of capacities, such as capacity to absorb, to self-organize, and to adapt	Ecological system	Focuses on capacities; a long debate continues on capacities and abilities
Adger, 2000	The ability of groups or communities to cope with external stresses and disturbances due to social, political, and environmental changes	Focuses on the abilities of groups and communities in the context of stresses and disturbances	Social	Addresses resilience in terms of different forms of stresses
Folke et al., 2002	The underlying capacity of an ecosystem to maintain its desired ecosystem services in the face of a fluctuating environment and human use	Reveals the capacity of an ecosystem regarding the interaction between man and the environment	Natural and human ecosystems	Introduces resilience in the context of nature and humans; however, fluctuations are seen in a system
Ganor & Ben-Lavy, 2003	The ability of individuals and communities to deal with a state of continuous, long-term stress; the ability to find unknown inner strengths and resources in order to cope effectively; and the measure of adaptation and flexibility	Defined in terms of the ability of individuals and communities to deal with stress; also examines potential strengths that can be used to adapt to adverse conditions	Community	Distinctly focuses on resilience with regard to communities, but gauging inner strengths can be a big challenge
Hyogo Framework of Action (UNISDR, 2005b)	The capacity of a system, community, or society, potentially exposed to hazards to adapt by resisting or changing in order to reach and maintain an acceptable level of functioning and structure	Elaborates on the capacity to adapt, resist, or change in order to reach a functional stage	Community	Concerned with disaster resilience, although it is a broad approach
Resilience Alliance, 2006	The capacity of a system to recognize and absorb disturbances while undergoing change to retain essentially the same function, structure, and feedback, and therefore the same identity	Includes the definition of resilience by the Hyogo Framework of Action (2005) although Resilience Alliance (2006) added another type of capacity	Community	Introduces the dimension of resilience, the capacity to absorb; however debate continues on what constitutes the same function, structure, and identity in the recovery stage
Frankenberger et al., 2007	The collective capacity to respond to adversity and change while maintaining function. A resilient community can respond to a crisis in ways that strengthen community bonds, resources, and the capacity to cope	Draws on community capacity through consideration of resources	Community and individual	Precise from the perspective of adversity and change
Cutter et al., 2008	The ability of a social system to respond and recover from disasters, which includes inherent conditions that allow a system to absorb impacts and	Related to the ability to re-organize, change, and learn in response to a threat	Community	Focuses mainly on two states: response and recovery; however, less

	cope during an event as well as post event, and adaptive processes that facilitate the ability of a social system to reorganize, change, and learn in response to a threat			attention is paid to preparedness before disasters
Norris et al., 2008	Resilience is a process linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance	Understands disaster resilience as a set of capacities of individuals and communities	Community	Focuses on positive changes, although only post disaster
IPCC, 2012	The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner through preservation, restoration, or improvement of its essential basic structures and functions	Defined on the basis of three forms of ability, including anticipating, absorbing, and accommodating the effects of a hazardous event	Social and ecological	Focuses on two areas: ecological and social, although there is limited discussion on the complex concept of abilities
DFID, 2011	The ability of countries, communities, and households to manage change by maintaining or transforming living standards in the face of shocks or stresses—such as earthquakes, droughts, or violent conflicts without compromising long-term prospects	Prioritized the abilities at different levels to manage change, for example, countries, communities, and households (both DFID 2011a and 2011b)	National, community, and household	Precise with regard to particular events, such as earthquakes, droughts, and conflicts
OECD, 2013b	The ability of individuals, communities, states, and institutions to absorb and recover from shocks while positively adapting and transforming their structures and means for living in the face of long-term changes and uncertainty	Emphasizes the ability to adapt	National, institutional, community, and individual	Concrete and precise approach, although there is discussion surrounding the concept of uncertainty

Sources: Compiled from Walker et al. (2002); Folke et al. (2002); UNISDR (2005b); IPCC (2012).

A number of scientists focus on the concept of resilience from an ecological perspective, which consists of three aspects: 1) the amount of change a system can absorb while essentially retaining the same function, structure, and feedback; 2) the capacity of a system for self-organization; and 3) the capacity of a system to learn and adapt (Carpenter et al., 2001; Folke, 2006).

Many scholars include the notion of adaptation in their definition of resilience (Mayunga, 2007), resulting in more of a process-oriented perspective, which has implications for policies (Manyena, 2006). This view supposes that a social system can change to maintain an essential structure and process within a coping and/or adaptation mechanism. Therefore, both the concept of adaptation and the process perspective are desirable because when disaster strikes, the process can examine a community's recovery (Klein et al., 2003) phases.

Another line of research defines resilience from a sociological perspective (Ager, 2000; Brock et al., 2002; Perrings, 2006), in which scientists emphasize the abilities of communities, groups, and individuals to cope with disasters or adversities resulting from social, political, or environmental change (Adger, 2000). Some authors also focus on the ability of systems to strengthen community-based management (Berkes et al.,

2003), build cross-scale management capabilities (Moser, 2000), enhance institutional memory, and nurture learning organizations and adaptive co-management (Olsson et al., 2004).

Some authors also consider resilience as one of the guidelines for strong sustainability (Otto, 2003). The term "sustainability" denotes the maintenance of natural capital in the long term by creating a balance in the ecosystem so that human society can gain instrumental as well as eudemonistic values (Brand & Jax, 2007). This means that sustainability is largely dependent on natural resources (Smith et al., 2001), and it is therefore desirable because it facilitates a more conscious use of community resources.

Numerous other studies have considered disaster resilience in relation to vulnerability. This is a complex and "process-oriented" relationship and although the concepts appear inherently linked, they are distinct (Cutter, et al., 2014; Maguire & Cartwright, 2008; Sapountzaki, 2012). Many scholars understand resilience to have a negative correlation with vulnerability (see Berkes, 2007; Birkmann & Teichman, 2010; Barrett & Constas, 2014); when social vulnerability is high, the level of resilience tends to be low, and vice versa. According to Klein et al. (2003), the problem with defining resilience in this way is that it lends itself into a circular reasoning that a community is vulnerable because it is not resilient, and it is not resilient because it is vulnerable. The relationship between vulnerability and resilience can also be observed in contexts where enhanced resilience can cause increased vulnerability. For example, while protective structures such as levees/polders can reduce the number of hazardous events and assist in recovery after a flood event, communities may become more vulnerable to prospective flood events due to an increased sense of security leading to further development on the flood plains (Gunderson, 2010). Hence, resilience is not "just the absence of vulnerability," as argued by Buckle et al., (2000), as aspects of vulnerability may co-exist with features that improve the adaptive capacity (Sapountzaki, 2012).

Researchers have also tried to understand disaster resilience from a geographical perspective. As seen in Table 3.1, resilience is often understood as a social or a social–ecological attribute within a particular area or geographic domain, which is why some definitions tend to consider resilience as specific to a certain area and as essentially geographic in nature (Cutter, 2008; Hewitt, 1997). For instance, local resilience refers to a locale's ability to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life without a large amount of assistance from outside the community (Miletti, 1999; as cited in Zhou et al., 2009). Hence, it is important to assimilate physical and socio-ecological information from sites in unique geographic areas to analyze disaster resilience (Shahid & Behrawan, 2008). Disaster resilience measured by the place-DROP model (Cutter et al., 2008) (discussed in the Chapter 2) is from a geographic perspective.

To summarize, the concept of resilience has been viewed from various perspectives offering different definitions, although one common aspect among them is that resilience is concerned with the capacity to resist,

respond, recover, deal with, cope, and adapt to adverse situations. The current study looks at disaster resilience in terms of the capacity of households, which comprises various components (Fig. 2.5 in Chapter 2). Although disaster resilience can include different scales (e.g., individual, household, community, national, and societal), this study focuses on household disaster resilience. In rural Bangladesh, households constitute a decision-making unit in which predominant decisions are made regarding managing and coping with disasters. Dasgupta (2014) noted that the study of disaster resilience at the household level is more effective in policy making to avoid conflicts within communities. Therefore, households can be the most suitable entry point for the analysis of disaster resilience (Paul, 2013). This does not, however, undermine the importance of community resilience to disasters because work done to increase the resilience of households translates into improved resilience of the community as a whole, which then potentially improves the effectiveness of disaster management (Arbon et al., 2016). In other words, household strategies for managing and coping with risks prove to be more effective in a given neighborhood and over a finite time span (Nguyen & James, 2013). The next section discusses household resilience.

3.1.3 Household disaster resilience

Before we attempt to understand household disaster resilience, it is essential to define a household. According to De Haas (2003, p. 415), a "household is a group of people who are generally but not necessarily relatives, who live under the same roof and normally eat together, including individuals who live for part of the year or the entire year elsewhere without having established their own family (with a spouse and/or children) in that other place." However, Spedding (1988) defined a household as a group of interacting components that operate together for a common purpose and are capable of reacting as a whole to external stimuli; as such, a household is affected directly by its own outputs and has a specified boundary based on the inclusion of all significant feedback. According to this definition, a household comprises interrelated components with common objectives.

Therefore, in light of these definitions of a "household," household disaster resilience refers to the ability of household members to cope with disasters. This is in line with the definition put forward by the Torrens Resilience Institute (2013), which states that household disaster resilience is the capacity of a person or people sharing a living space to sustain their household even under stress and adapt to changes in the physical, social, and economic environment. Furthermore, household disaster resilience refers to how self-reliant households are if external resources are limited or cut off, and how households learn from the experience to be better prepared the next time. The components of disaster resilience at the household level are discussed in the following section.

3.1.4 Components of household disaster resilience

A comprehensive literature review was conducted to identify and determine the reliable components of disaster resilience at the household level. Both academic and non-academic literature are in agreement that community resilience measures are a function of different components, characteristics, or aspects of individuals, households, and communities (Arbon et al., 2016). Researchers agree that resilience is a multi-dimensional concept that contains social, economic, institutional, infrastructural, self-organizational, and natural/ecological components (Berkes 2007; Bruneau et al. 2003; Cutter et al. 2010; Cutter et al 2008b; Gunderson 2009; Norris et al. 2008). The FAO resilience tool includes six components (as discussed in Chapter 2) to assess a household's disaster resilience, which this dissertation uses as its theoretical basis along with the disaster resilience of place (DROP) model (see 2.13 and 2.14). However, these components may vary depending on the study area and community in question (Mayunga, 2009). Based on the theoretical orientation, level of investigation, and study area, the study selected the following four key components of resilience with regard to cyclones and storm surges.

3.1.4.1 Household infrastructure component (HIC)

The household infrastructure component comprises four basic attributes of housing: structure, sanitation, sources of drinking water, and availability of electricity, which are crucial in protecting life and property in coastal areas during the three stages of cyclones and storm surges (Hossain, 2015). The International Federation of Red Cross (IFRC, 2012) points out that well-maintained and accessible infrastructure is the main determinant of disaster resilience. Household infrastructure represents a household's response and recovery capacity (Ahmed et al., 2016), and hence is a key component for enhancing household resilience in case of cyclones and storm surges.

3.1.4.2 Household economic component (HEC)

The household economic component is another crucial aspect of disaster resilience. HEC refers to a household's economic capacity to cope with and adapt to a certain shock, enabling that household to continue performing its key functions. Rose (2007) notes that, economic resilience refers to the ability and speed of a system to recover from a severe shock by using economic assets in order to achieve a desired state. This component has four main attributes: household income, ability to sell excess produced food, less dependency on purchased food, and non-farm self-employment. The higher the household income the lower the risk of losing the essential basis of the household's livelihood during a crisis. For instance, having the ability to sell excess food and therefore less dependency on purchased food means that the household is more likely to mitigate food insecurity after, say, losing a job (Alinovi, 2009).

3.1.4.3 Household self-organization and learning component (HSoLC)

A household's self-organization and learning from a disaster reflects its absorptive capacity. Absorptive capacity may be carried forward into collectively organized adaptations or into advocacy efforts that influence transformative capacity (DFID, 2013). The capacity to self-organize depends on five attributes: short-term migration by household members, the decision-making ability of household heads, the combined decision-making ability of household heads (wife and husband) regarding land use; the ability to use machines, and mixed crop cultivation. This component is most important after a disaster event or during the recovery phase (Ahsan & Warner, 2014). Representative and accountable leadership is another defining feature of effective self-organization. However, leadership is focused at the level of community resilience. Therefore, this study did not consider leadership as an attribute of household disaster resilience.

3.1.4.4 Social safety net (SSN)

Social safety nets are social welfare services geared toward eliminating poverty in a specific area (Awal, 2013). These services include access to conducting business deals with households over the phone, access to fresh water, health, public authorities, cyclone shelters, friends, and so on. Social safety nets are a useful tool for enhancing households' capacity to collectively organize for and mitigate the risk of natural disasters (Pelham et al., 2011; Alinovi et al., 2009), and they have traditionally been used to help households through short-term stresses and calamities like climate shocks (e.g., cyclones, floods, etc.; Hassan et al., 2013).

Thus, household disaster resilience can be expressed algebraically as follows:

$R_h = \int HIC,\ HEC,\ HSoLC, SSN$

where R_h = household disaster resilience, HIC = household infrastructure component, HEC = household economic component (HEC), HSoLC = household self-organization and learning component, and SSN = social safety net.

However, the selection of the key tool for enhancing disaster resilience remains open. As discussed in Chapter 2, this study hypothesized that human capital can be the key for enhancing disaster resilience in the study area. The next section discusses the conceptualization of human capital.

3.2 Conceptualization of human capital

The current study conceptualized the knowledge and skills involved in human capital based on six pillars, which are discussed below:

3.2.1 Pillar 1: **Knowledge obtained through formal education, such as college or university**

Formal education is a predominant component of human capital frequently mentioned in the literature (DFID, 1999; Smith et al., 2005; Walter, 2004). It includes knowledge and skills accumulated through school and college education. Although most personal characteristics of human capital are difficult to measure directly, data on educational attainment are readily available; it gives a rough indication of people's cognitive and even non-cognitive skills, and remains one of the most useful proxy indicators of overall human capital.

Formal education in the Bangladeshi education system is divided into three categories: primary, secondary, and tertiary. Primary education offered at primary schools is for five years (grades I to V), and it can be further divided into two major types: general and *madrasha* (religious institution) education. Secondary education is for twelve years (grades VI to XII), and it is provided in high schools and colleges. It can be divided into three major types: general, technical-vocational, and *madrasha*. Tertiary education (beyond grade XII) includes education at specialized colleges (e.g., medical college) or universities (Bangladesh Bureau of Educational Information and Statistics, 2015). This is again divided into three types: general (pure and applied science, arts, business, and social science), *madrasha*, and technology-based education, which includes agriculture, engineering, medical technology, textile-making, leather-making, and information and communications technology (ICT). *Madrasha* education is functionally equivalent to the three levels of education (i.e., primary, secondary, and tertiary) and has similar core courses to the general stream except that it also offers religious studies. *Madrasha* education provides five types of degrees: Ibtadayee (equivalent to primary), Dakhil (equivalent to secondary), Alim, (equivalent to higher secondary), Fazil (equivalent to bachelor); and Kamil (equivalent to masters) (Ministry of Education, 2015).

One of the most obvious ways in which education contributes to material well-being is through employment and income (WEF, 2013). According to Burgess (2016), better-educated residents tend to be healthier, have higher wages, and hold more secure jobs. A number of studies (Ross & Wu, 1995; OECD, 2007, 2011) have found that educated people tend to be more satisfied with their housing conditions and sanitation, have higher levels of social support, are more civically engaged, and report higher life satisfaction. Higher levels of educational attainment also increase the likelihood of re-employment (Evans & Koch, 2006) and reinforce the accumulation of human capital throughout a lifetime. Individuals with higher levels of educational attainment are more likely to continue to invest in human capital accumulation by accessing adult education and receiving employer-provided training later in life (Field, 2011). However, although high educational

attainment contributes to secure jobs, it is not always the case; nor does high educational attainment always result in higher wages; rather, access to and quality of education are stronger determinants of wage differences in the labor market (Caponi, 2006). Nevertheless, since higher levels of education are commonly regarded to increase the wages of individuals, people tend to prolong the duration of unemployment in order to pursue an education. However, this reflects a personal choice and suggests that such people can afford to delay taking up employment.

3.2.2 Pillar 2: Knowledge obtained through vocational education and training

Vocational education and training (VET) is considered by development experts and donor agencies a specific human capital development tool that can be effective in promoting socioeconomic progress (Rufai et al., 2013). VET exposes the learner to the acquisition of demonstrable knowledge and skills that can lead to economic benefits and a sustainable livelihood (Akerele, 2007). VET is therefore the formal training of persons to acquire skills, knowledge, and aptitudes for gainful employment in a particular occupation (Viertel, 2010). Rauner (2008) states that, VET is a link between primary vocation training and further education within the structure of lifelong learning. This means past and present experiences could be accredited to the present and future labor force and the result would be lower operating requirements through better employment and workforce capability (Attwell, 1999). VET also plays an important role in the development of a skilled workforce that can lead to innovation and economic competitiveness.

Although knowledge-based economies are enhancing employment opportunities for non-academic post-secondary and university graduates, developing countries apparently need another type of human capital stock. Wallenborn (2010) argued that rising industries and the modern crafts sector are demanding professional qualifications that cannot be acquired through general secondary education.

As the Bangladesh Bureau of Educational Information and Statistics (BANBEIS, 2014) points out, out of approximately 100 students in grade one, only 32 will remain enrolled until the secondary level and the other 68 will drop out. Without any particular technical knowledge, these students are not able to compete in the job market. As a result, a large number of individuals cannot contribute to their household's economic productivity and the unemployment rate gradually increases (SFYP, 2011). To address the common difficulties in the general education sector in Bangladesh, VET can be an alternative option; however, the effect of public sector VET on poverty alleviation is undermined because it mainly serves urban young males who have completed at least grade VIII. The rural poor, who do not survive progression to grade IX, are mostly ruled out (SFYP, 2011). Hence, it is necessary to develop VET in order to enhance job opportunities in the labor market.

There are various technical education programs under the Bangladesh Technical Education Board (BTEB) encompassing a wide range of courses and methods (Newaz et al., 2013). The present study considers the

"basic trade" (1 to 6 months) course under the BTEB and non-government organizations' (NGO) curriculum, which includes courses related to livestock and crop cultivation, fishing and aquaculture, and beekeeping.[1]

3.2.3 Pillar 3: Knowledge obtained through "learning by doing"

Many researchers of human capital focus on the knowledge and skills obtained through educational activities such as compulsory education, postsecondary education, and vocational education (Kwon, 2009; de la Fuente & Ciccone, 2003; Alan at al., 2008); however, this perspective neglects the fact that human beings also acquire knowledge and skills through informal learning activities and experiences.

"Learning by doing" applies to situations in life that come about spontaneously (e.g., within the family circle, neighborhood, friends, etc.) and constitutes a person choice of reading, viewing, listening, hobbies, and social life (Tamir, 1990). Learning by doing is distinguished from other types of learning as it has no authority figure or mediator; the learner is motivated intrinsically (Csikszentmihalyi & Hermanson, 1995) and he or she determines the path to acquire the desired knowledge and skill. Thus, learning by doing is also a process of accumulating knowledge and skill that can add value to human capital; however, it is difficult to measure all the activities related to learning by doing.

Coastal households in Bangladesh possess various types of knowledge and skills that they have gained without any formal education or training, such as those pertaining to fishing and aquaculture, simple construction work, tailoring and running boutiques, bicycle/rickshaw/vehicle repairs, and so on. Although, this type of knowledge and skill is ignored, it can often play a crucial role, particularly during and after disasters. For example, households with members able to pull rickshaws or row a boat could easily earn a small amount of money during the recovery phase (Nasreen, 2012) of a flood. Simultaneously, household members who know how to construct houses and roads can repair their own houses and lay local road networks during and after a disaster.

3.2.4 Pillar 4: Knowledge obtained through interaction and participation

Interaction and participation is another way of gaining knowledge and skills. According to Catania (1998: 227), "It is one thing to learn about other people, but another thing to learn something from them." As many scholars (Brown and Duguid, 2001; Lave and Wenger 1991; Blackler 2004; Gherardi and Nicolini, 2000) have stated, learning is a process that generates knowledge "situated" in social practices. Moreover,

[1] According to the Bangladesh Technical Education Board (BTEB, 2015) curriculum, various sectors are included under "basic trade" courses in VET, including livestock and crop cultivation, fishing and aquaculture, beekeeping, business and trade, tailoring and boutiques, *talacabi* (lockers), bicycles, rickshaw/vehicle repair, general electric and mechanical repair, electrical, construction work (building and roads), sanitation, medical training, practice of Ayurveda (Kobiraji), swimming, and forestry.

knowledge and learning are not individual mental processes, but are conceived as social and cultural phenomena that happen together.

Individuals can enhance their awareness and preparedness with regard to disasters through active participation and interactions in social meetings, workshops, or any other formal or informal discussions. In the Bangladeshi context, participation and interaction mostly occur between household heads (male/female). However, children and other members of households also need to be engaged in social participation in order to enhance human capital. Their participation results in better decisions, higher quality services, greater access to those services, and better development outcomes as a result of those services (Plan, 2010).

3.2.5 Pillar 5: Knowledge obtained through prior experiences and indigenous activities

Crawford (1991) states that human capital can be expanded by endogenous or exogenous components. Original knowledge and skills can be continuously elaborated upon and developed through experiences and other indigenous activities, and individuals can accumulate knowledge and skills through ordinary experiences. This is called *implicit* knowledge; it draws heavily from traditional approaches (Maiese, 2005) a great deal of such knowledge is unconsciously gained rather than developed through scholarly studies and systematic observations. Josiah Osamba (2011) pointed out that knowledge is largely a matter of common sense and personal experience in many cultures. Thus, the enhancement of human capital does not depend solely on jobs or formal experiences, but on informal experiences as well. Knowledge can also be gained from one's ancestors or predecessors. Parents pass down insights derived from their experiences to their children, and this knowledge evolves from generation to generation (Maiese, 2005). For instance, coastal residents of Bangladesh can predict possible disasters through their experience and indigenous knowledge acquired from their forefathers. From an economic viewpoint, prior experiences can be a core element for solving the "problem of scarcity" as resources can then be distributed equally to economic agents. Through an expanding and self-generating human capital, it is possible that the proportion of that capital as an economic agent is extended (Dae-Bong, 2009). Hence, this study looks at experiences and indigenous activities as key elements of human capital that can contribute to before and after disasters. However, it is difficult to measure the various experiences that people accumulate during their lives. Therefore, experiences and indigenous activities undertaken by coastal residents after previous disasters from which they gained knowledge are considered in this study.

3.2.6 Pillar 6: Health

Health is considered a critical component of human capital because an unhealthy population is not able to harness other forms of capital (Smith et al., 2001), and thus sickness, ill health, and the risk of death are key issues when examining human capabilities and behavior. Health is an important component of an individual's welfare and standard of living; it is central to a person's ability to make use of his or her knowledge

and skills. For example, in an individual with excellent professional abilities, academic qualifications, and work experience, if there is a physical or mental disability, the productivity of the individual is undermined (Morrone et al., 2011). In addition, a family member in poor health can cause financial and emotional burden on households that can increase the risk of poverty or other adverse outcomes. Therefore, a strong argument can be made for health spending on the grounds that it has a direct impact on human capital (Bloom & Canning, 2003).

However, it is very difficult to measure individuals' health status (McCarthy et al., 2000) because it is shaped by a multitude of contributing social factors and outcomes. The World Health Organization (WHO) defined health in a broader sense in its 1948 constitution, stating that health is "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity" (Official Records of the World Health Organization, no. 2, p. 100). Therefore, good health is a positive state, not merely the absence of negative indicators. However, most investigations related to health status measure negative outcomes, such as the incidence of disease and obesity or risky behavior such as smoking or alcohol consumption (Tyas, 2015). Hence, it is easier to understand how poor health can reduce resilience rather than how good health can increase resilience. This study focused on how health and age can pose difficulties for work when assessing human capital.

Although the present study considered human capital as key for enhancing disaster resilience, it does not mean that other forms of capital are considered less important. Human capital is important, but on its own, it is not enough for achieving positive livelihood outcomes (DFID, 1999). Natural, social, physical, and financial capitals are also necessary for human capital. For example, a person needs access to physical capital such as schools, colleges, or universities in order to attain a formal education and enhance human capital. Tyas (2015) points out that while human capital looks at people as a single unit, social capital focuses on the interconnections between human beings. It is, therefore, clear that other forms of capital are also required to enhance human capital. Hence, it is important to understand other forms of capital and their interrelations as well. The next section provides a basic understanding of social, natural, physical, and financial capital.

3.3 Understanding other forms of capital

3.3.1 Social capital

Social capital can be described as the quantity and quality of social resources (e.g., membership in groups, social relations, networks, and access to wider institutions in a community) upon which people draw in pursuit of their livelihoods (Frankenberger & Garrett, 1998). According to Putnam (1995), social capital encompasses social organizations such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit. Social capital has often been called the "glue" that binds people in a society

together (Frankenberger et al., 2013). The interactions between residents in tight-knit communities, the ability to rely on others in times of crisis, and open communication between stakeholder groups are mostly seen as symbols of well-developed social capital. Earlier literature found that the extent and application of social capital is a crucial element in determining community disaster resilience (Aldrich, 2012; Wilson, 2012; Elliott et al., 2010). It is also important to enhance social capital to build resilience at the household level. For example, social capital provides information, knowledge, and access to members of a network during pre-disaster events (Aldrich, 2012). This information and knowledge increases human capabilities for handling future disasters.

Aldrich (2012) provides a straightforward analytical approach for measuring the influence of social capital through bonding, bridging, and linking networks. Bonding and bridging refer to networking among people, while linking concerns relationships across networks, as it involves governments and NGOs (Aldrich, 2012). Most previous research has measured social capital by considering participation in various forms of civic engagement, such as membership in voluntary associations, churches, or political parties, or at levels of expressed trust in other people (Schuller, 2001). Based on this groundwork, the current study mostly focuses on household networks and membership when measuring social capital because in the context of the study area, networks and membership within various organizations are crucial factors with respect to household resilience (Islam and Walkerden, 2014).

3.3.2 Natural capital

Natural capital refers to natural resources available to individuals and communities, such as land, water, forest, wildlife, and biodiversity; environmental conditions for life and work; and ecosystems that maintain clean water, air, and a stable climate (TANGO, 2006; Smith et al., 2001). Natural capital is key to sustaining all forms of life, including human life, and natural resources form a key capital that can be managed through collective action.

Several authors have found that the resilience of a community is linked to the condition of its natural environment and the maintenance of its productive natural resources (Gill & Ritchie, 2011; Cutter et al., 2008; Folke, 2006). In addition to simply possessing natural capital, the management of natural resources and ecosystem services while maintaining a sustainable livelihood base is a key element of community resilience (Pasteur, 2011; Twigg, 2009). From the viewpoint of disaster resilience, natural resources such as wetlands and vegetation play an important role in protecting coastal areas from weather-induced hazards such as cyclones and storm surges (Frankenberger et al., 2013). However, human activities are often responsible for the depletion of the stock and quality of this natural capital (Mayunga, 2007). Hence, it is necessary to understand how natural capital can be utilized in combination with other capitals to sustain livelihoods (DFID, 1999), which again reflects on the importance of human capital.

Although natural capital can be assessed through water quality, air quality, soil quality, land, forests, and national and local parks, land is the predominant factor for aquaculture and agriculture production in the coastal villages of Bangladesh. In addition, water scarcity and quality are key challenges in this coastal area. Hence, the current study considers access to land and water when assessing natural capital in the study areas.

3.3.3 Physical capital

Physical capital denotes basic infrastructure (e.g., transportation, shelter, communications, water systems, health facilities, and markets), production equipment, and other material means that enable people to maintain their safety and enhance their relative level of well-being (Gill & Ritchie, 2011; Mayunga, 2007). Physical capital is one of the most important resources for communities when building capacity to cope with disasters, as it can operate at a level that provides households and groups the means to survive and recover during and after natural or man-made disasters (Longstaff et al., 2010; Pasteur, 2011). However, access to physical capital is difficult for poor rural residents, although, as Longstaff et al. (2010) indicate, while communities are not always directly able to control some of the physical assets available to them (e.g., power systems), they may be able to influence them through indirect means. Mayunga (2007) noted that critical facilities are important for ensuring that residents have resources and support during a crisis. Moreover, lack of physical infrastructure or critical facilities may have direct negative impacts on the capacity of households or communities to cope with disasters. Physical capital can therefore be assessed based on access to educational institutes, housing, mass media (TV, newspaper, computer), toilets/latrines, and household machineries.

3.3.4 Financial capital

Financial capital describes the financial resources that households rely on to achieve their economic and social objectives. According to TANGO (2006), financial capital refers to cash and other liquid resources, for example, savings, credit, remittances, pensions, and so on. Researchers (Buckle et al., 2001; Gahin et al., 2003) have shown that financial capital can directly ward off vulnerabilities through mechanisms such as insurance schemes and construction of protected homes and businesses. Investing financial capital in recovery phases can have direct and positive consequences for community infrastructure (through construction of roads, bridges, dams, etc.) and human capital development (through funding of health care and education; Gill & Ritchie, 2011). Financial capital can play a key role in supporting community resilience by providing financial services (e.g., microfinance) and by sustaining small- and medium-size enterprises in the event of social and economic disruptions (Twigg, 2009; Pasteur, 2011). Numerous studies have concluded that financial capital can be measured through household income, property value, employment, and investments (Frankenberger, 2013). However, some scholars (Hudner & Kurtz, 2015) point out that income

is the outcome of all other forms of capital. Hence, this study measured financial capital through various forms of savings and loans.

Based on the above theoretical and conceptual reflections, this section reframes the four research outlined in the Introduction (see section 1.3) and identifies the different aspects that need to be considered in the course of the theoretical orientation to resolve them.

3.4 Reframing the research questions

What is the status of human capital at the household level in the coastal belt of Bangladesh? (Q1)

To answer this question, six aspects are taken into account for measuring human capital by considering the status of the following:

(1) formal education in schools, colleges and universities,

(2) formal vocational/technical training,

(3) practical skills acquisition,

(4) knowledge gained through social interactions and participation,

(5) knowledge and skills acquired through personal experiences and indigenous activities, and

(6) health.

What is the status of other forms of capital, such as natural, social, financial, and physical capital? (Q2

This key question looks at the status of the following:

(1) natural capital (access to land and clean water),

(2) social capital (bridging, bonding, and linking ties),

(3) financial capital (household savings and loans),

(4) and physical capital (housing and access to production machineries, drainage systems, toilets/latrines, mass media, and education facilities).

What is the association between human capital and other forms of capital (i.e., natural, social, financial, and physical capital) for enhancing household resilience? (Q3)

What is the relationship between human capital (HC) and household resilience with respect to cyclones and storm surges? (Q4)

3.4 Research design

The research design of the current study follows the protocols of case study research. It started with a plan; formed a design with the support of the literature review; prepared, collected, and analyzed data; and shared the results of the study in writing (Yin, 2009). The study design included various parts (e.g., data collection methods, data analysis, and interpretation), which are represented in figure 3.1.

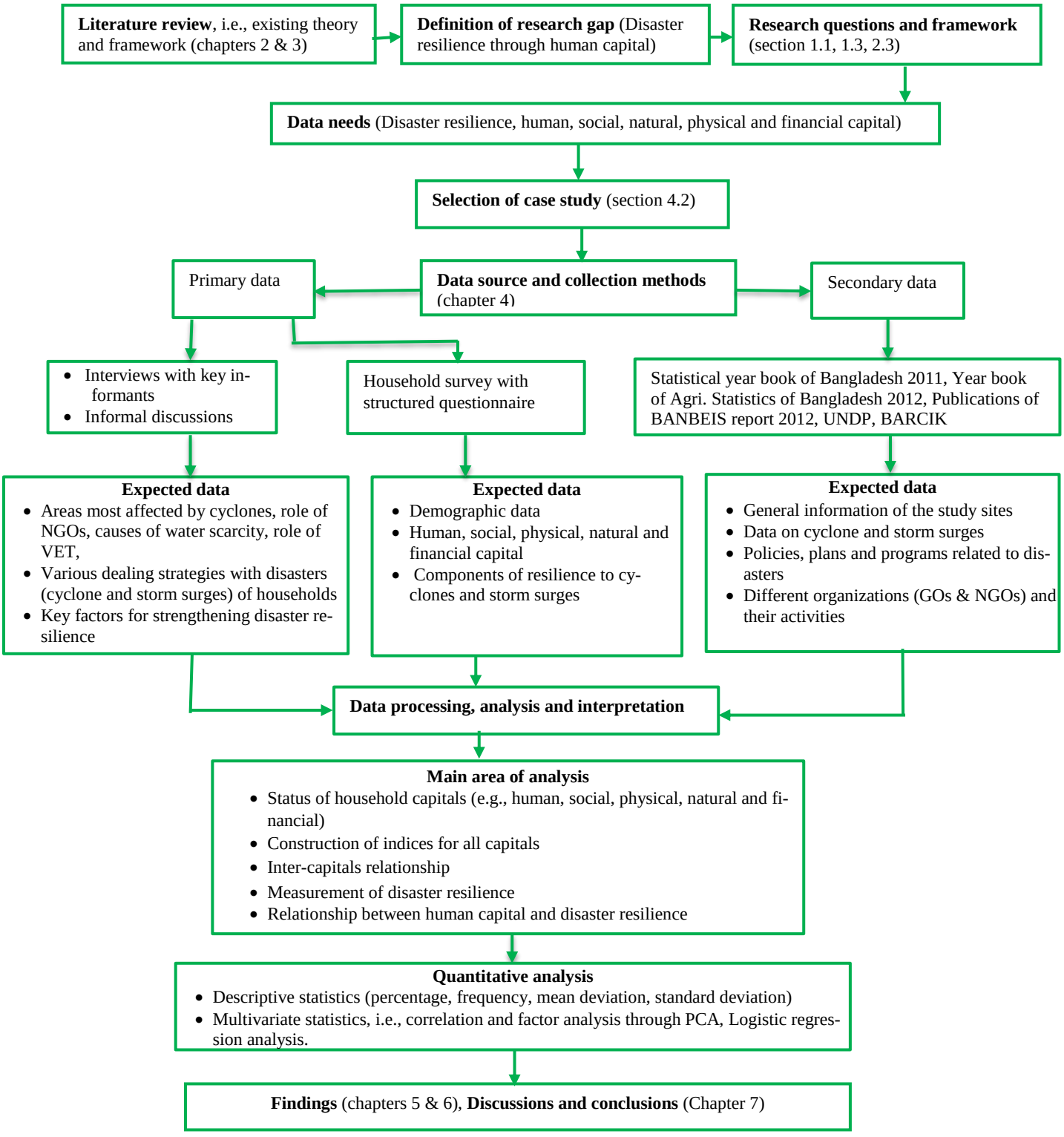


Figure 3.1 Description of the research design

CHAPTER FOUR: METHODOLOGY

This chapter describes the research methodology and procedures used to collect and analyze data for the research questions. This chapter is divided into seven main sections. The first section illustrates the methodological approach, the second section discusses the selection and description of the study area, and the third section provides an overview of the Sidr and Aila cyclones. The fourth section highlights the sampling procedures, section five elaborates on the data collection, and section six discusses the data analysis process. The last section explains the challenges of the data collection and analysis and the mitigation strategies applied.

4.1 Methodological approach

While applying mostly quantitative research strategies, this study essentially used a mixed method approach based on quantitative and qualitative data. The mixed method approach is commonly used in social sciences when the limitations of quantitative and qualitative methods are relevant to the enquiry (Creswell, 2003). Scientists (e.g., Hanson et al., 2005; Creswell, 2009) have indicated that researchers can enhance their ability to understand the characteristics of the object of research by combining more than one research method into a single design. In addition, the mixed method approach allows not only for providing more in-depth data, but also allows for validating findings, and hence increasing study reliability (Yin, 2009). There were different objectives for using the mixed method in this study. First, the mixed method can help to develop a complete understanding of the research problem. Second, the mixed method can help to explore overlapping issues that may emerge. Third, it is useful when utilizing multiple data such as quantitative data (household surveys) and qualitative data (key informant interviews, informal discussion), which maximizes the strengths and minimizes the weaknesses of individual data sets (Creswell, 2011). Fourth, it aids in furthering the development of the study; that is, an earlier method is used sequentially to help inform the second method, and so on, so that a mixed method can be used to broaden the scope of a study (Djalante, 2013). In the current study, quantitative methods were used to identify the status of human capital (e.g., formal education, vocational education and training, practical skills, etc.) and other forms of capital, including social (bonding, bridging, and linking ties), financial (savings and loans), and physical (housing, household machinery, and access to households facilities) as well as to investigate the interrelations between them, and identify the relationship between human capital and disaster resilience. However, qualitative strategies were also used to understand crucial components of disaster resilience, including the impacts of cyclones Sidr and Aila, effective coping strategies, background reasons for varying capital in different villages.

Data were collected for this current study from secondary and primary sources. The secondary data were from national statistical records (Bangladesh Bureau of Statistics, 2010) and primary data were collected

mainly by conducting a comprehensive household survey in the study area and through informal discussions and key informant interviews.

4.2 Selection and description of the study area

This study area was nine coastal villages: Amadi, Bagali, Jhonjonia/Gabbunia, Itabaria, Latachapli, Deuli-subedkhali, Char Alexander, Tamaruddin, and Char Ishwar, which represent five coastal districts in the southern part of Bangladesh (i.e., Khulna, Patuakhali, Bagherhat, Lakshmipur, and Noakhali). All nine villages are by the sea, frequently affected by cyclones, storm surges, and tidal bores (Doocy, 2013). In the last decade (2004–2013), six cyclones have struck the study area: Sidr (November 15, 2007), Rashmi (October 26, 2008), Bijli (April 19, 2009), Nisha (November 28, 2008), Aila (May 25, 2009), and Mahasen (May 16, 2013), which resulted in severe damage and losses (Alam & Rahman 2014; BMD, 2013).

Figure 4.1 Location of the study sites

Table 4.1 Description of the study sites

District	Villages	BBS Union code	Population in 2011	Population change 2001–2011 (%)	Number of households in 2011	Distance of households to coast or next major river (approx. km)	Recent natural disasters
Khulna	Amadi	40/47/53/99/10	33184	18.1	7434	0.3	Aila: severe damage Sidr: moderate damage
Khulna	Bagali	40/47/53/99/11	33027	13.9	8863	1.1	Aila: severe damage
Bagerhat	Jhonjhonia-Gabbunia	40/01/73/99/83	24276	14.8	5840	3.5	Aila: severe damage Sidr: moderate damage
Patuakhali	Lata Chapli	10/78/66/99/47	25925	22.2	5835	1.1	Sidr: moderate to severe damage Mahashen: moderate to severe damage
Patuakhali	Itabaria	10/78/95/99/20	21478	7.7	4490	0.5	Sidr: severe damage Aila: moderate damage
Patuakhali	Deuli Subidkhali	10/78/76/99/27	32169	15.0	5033	0.4	Sidr: severe damage, about 250 casualties Aila: moderate damage
Lakshmipur	Char Alexandar	20/51/73/99/23	40978	-23.3	8447	1.2	Severe river bank erosion
Noakhali	Tamaruddin	20/75/36/99/95	27979	10.9	6166	0.9	Riverbank erosion, mildly affected by Sidr/Aila. Severely affected by 1991 cyclone
Noakhali	Char Ishwar	20/75/36/99/28	26228	-29.5	5381	1.5	Riverbank erosion, but also char land quickly rising, mildly affected by Sidr/Aila. Severely affected by 1991 cyclone

Source: Own draft based on the Bangladesh Bureau of Statistics (BBS, 2010), informal discussions, and key informant interviews (2014–2015)

As indicated in Chapter 1, this study analyzes households' experiences with Cyclones Aila and Sidr to provide a better understanding of the contribution of human capital to disaster resilience. Thus, a brief overview of these two cyclones is provided in the next section.

4.3 Cyclones Sidr and Aila

Cyclone Sidr roared across the southwestern coast of Bangladesh with heavy rains and high waves on November 15, 2007. About 30 districts, 200 Upazilas, and 1950 unions were affected by the cyclone, which caused extensive casualties, damage to crops, livestock and property, and flooding of low-lying land. The devastating cyclone-induced storm surge reached a maximum height of approximately 20 feet in some areas with winds up to 220 km/h. Sidr was a category 4 cyclone with a diameter of nearly 1,000 km and winds up to 240 km/hour. It was the second most destructive cyclone of the 14 that have hit the coast of Bangladesh in the last 15 years (1991–2007). About 3,406 people died due to the cyclone (Government of Bangladesh, 2008a), and according to ReliefWeb (2008), over 55,000 people were injured and more than 1,000 were dead. The total damage was estimated to be USD 1.6 billion by the World Bank Damage Assessment (2007).

On May 25, 2009, the coastal region was struck by category 1 tropical cyclone Aila. Aila generated wind speeds up to 120 km/h and a storm surge of 3 meters above the normal tide. About 11 coastal districts were severely affected. Cyclone Aila claimed 190 lives, injured 7,000 individuals, killed 100,000 livestock, and caused USD 170 million worth of economic damage, as reported by UNDP (2010). About 350,000 acres of cropland was damaged, 500,000 houses were destroyed, 8,000 km of roads were fully or partially destroyed, and around 1,400 km of coastal embankments were washed away (UNDP, 2010). Following Cyclone Aila, government and non-government organizations provided relief assistance including food, cash, drinking water, emergency medicine, and other materials to the affected residents.

4.4 Sampling and recruitment of participants

The current study used purposive sampling strategies (Palinkas et al., 2016). The first stage involved identifying the five disaster-affected coastal districts; next, the seven worst affected upazilas were selected from these districts; and last, nine villages were selected from these seven upazilas (second lowest administrative unit; see Table 4.1). These villages had been substantially impacted by Cyclones Sidr and Aila. The coastal area of Bangladesh constitutes nineteen districts located across three types of geographical regions (i.e., inland, shore-land, and islands; Islam & Koudstaal, 2003). Therefore, this study ensured that the villages represent these three regions (Khulna District represents the inland; Patuakhali, Bagherhat, and Lakshmipur districts represent the shore-land; and the Hatiya and Noakhali districts represent the islands). The findings

on the role of human capital in disaster resilience are therefore expected to apply generally along the Bangladeshi coast. This regional diversity also helps in understanding the geographical context of disaster resilience.

From among 6,132 responses to a standardized questionnaire, 1,200 household heads were selected for the interview round (300 from Koyra and Rampal; 450 from Kalapara, Patuakhali sader, and Mirjaganj; and 450 from Ramgati and Hatiya). From these 1,200 interviews, ten were discarded due to incomplete and mismatching data and one due to duplication. Therefore, of the 1,200 interviews, 1189 were included in the final data.

In Bangladesh, household heads are mainly responsible for household savings, loans (financial), housing, sanitation, machinery (physical), land, and access to safe water (natural capital). Hence, the data to examine the status of financial, physical, and natural capital were obtained primarily from them. However, data from other household members were used to analyze human capital (i.e., formal education, vocational education and training, and practical skills) and social capital (bonding, bridging, and linking ties), as these vary among individuals. Participation in the survey was voluntary. Data collectors were asked to obtain the consent of the participants (i.e., household heads, key informants) before the interview (see Appendix 2) and participants were given the option of withdrawing any time from the study.

4.5 Data sources and collection methods

Primary data were primarily collected through a standardized and structured questionnaire survey conducted at households through face-to-face interviews. Some data were also collected from key informant interviews to identify the components of household resilience. In addition, observations and informal discussions were used to gather additional and supplementary information on cyclones and storm surge disasters, their impact on the livelihood activities of residents, residents' ability to cope with disasters, and their access to GO and NGO support services. A detailed description of the primary data collection procedures are discussed in the following section.

4.5.1 Description of the household survey

The household survey was conducted in co-operation with the BanD-AID project, as the current study is closely related with this project. BanD-AID is a project by an international, cross-disciplinary team comprising natural and social scientists from various countries including Bangladesh and Germany. It focuses on causes of sea-level-rise hazards and on integrated development of predictive modeling for mitigation and adaptation in the Bangladesh Delta. Data collection in the study area was undertaken in various phases as illustrated below.

Phase 1: Developing the questionnaire

The main instrument of a survey is a standardized questionnaire. To collect primary data from study villages at the household level, a coordination scheme was prepared and a structured questionnaire was developed (partly based on the questionnaire used by Braun and Aßheuer, 2011; Aßheuer et al., 2013). The aim of this questionnaire was to obtain human capital-related information (i.e., education level, ability to read and write, vocational skills, practical skills, etc.) as well as information on other forms of capital, daily living conditions, and characteristics pertaining to disaster resilience. Thus, the questionnaire comprised three sections, including geographical setting and demographic characteristics, land-use changes, and forms of household capital (natural, financial, human, social, and physical) and components of disaster resilience. The first stage included creating 39 questions using robust indicators of capital and disaster resilience based on an extensive literature review. To ensure the reliability of the questionnaire, it was pre-tested and necessary modifications were made during the first field phase (mid-March to mid-April 2014). While pre-testing, some questions, which could not be understood by local households, were excluded. For instance, the first version of the questionnaire used "bigha" as a unit of land measurement. However, land measurement units vary from one place to another in this coastal area (e.g., paki, kani, katha, kora), and hence the term *shotangsho* was used as a unit of land measurement in the final questionnaire instead. Appendix 2 provides an overview of the questionnaire used for the household interviews.

Phase 2: Translating the questionnaire

The final version of the questionnaire was translated to Bangla by a professional translator, who was the co-editor of a national leading newspaper, *The Daily Star*. To retain the original meaning of the questions, this study ensured semantic equivalence across languages, conceptual equivalence across cultures, and normative equivalence to the source survey. Semantic equivalence refers to word and sentence structures in the translated text retaining the same meaning as the original. Conceptual equivalence refers to the similarity of the concept measured across groups, even if the wording was different. Normative equivalence refers to the capacity of the translated text to address social norms and values that may differ across cultures (Sheheli, 2012).

Phase 3: Forming the survey team

Ten members, all of whom had prior experience in fieldwork, were part of the survey team. Two data collectors were PhD candidates from Rajshahi University and six other members had graduated from different universities majoring in Geography and Environmental Studies. These six data collectors were from the

coastal districts of Khulna, Patuakhali, and Noakhali. Two experts (volunteers), from two different universities (i.e., Patuakhali Science and Technology University and Noakhali Science and Technology University) located in the coastal region were also part of the survey team. The data collectors were hired on the recommendation of these two experts, although the criteria of educational background (geography or disaster management), prior experience, and location of permanent residence were also considered. Educational background and survey experience were considered to understand candidates' academic competency, while location of permanent residence was necessary to ensure proper communication through local dialects, as local dialects play a significant role in meaning construction and interpretation and expression of specific characteristics or events (Howitt, 2010). The recruitment of local data collectors was not only for gathering data but also for understanding social customs and the cultural context. The survey team also included a female data collector. Throughout the survey period, the local data collectors provided substantial information pertaining to the survey questions and their interpretation of the different responses.

Phase 4: Training session on data collection

After selecting the data collectors, a three-day-long training session was organized for them at the Department of Geography and Environmental Studies at the University of Rajshahi, Bangladesh. The training helped the data collectors in understanding the interview questions, and after a pilot testing, the process of interviewing households was initiated. It also provided other important information to the data collectors pertaining to ethics, types of questions, and follow-up questions. Besides these, the training also provided some technical support such as using the Global Positioning System (GPS) to input data of particular household locations.

Phase 5: Conducting household survey in the study area

The household survey involved face-to-face interviews with household heads using the standardized questionnaire. Because household heads make the major economic, social, and household decisions and provide information about other members of their families (Paul B.K, 1998a), they were the ones predominantly relied on for information. In a few instances, however, other members of the household participated in the discussion and gave deeper insights. For example, some households with female heads were not able to answer the question regarding the highest level of education attained by their sons or daughters. In such cases, older members of the family helped provide accurate answers. All household information was recorded on paper and later transferred online using the Lime Survey software.

4.5.2 Informal discussions

Our interviews with household heads were accompanied by nine informal discussions with residents and members of the local government in the study villages, including chairpersons and members of the Union Parishad (lowest administrative unit of Bangladesh). These informal discussions were conducted through unstructured interviews; they highlighted personal perceptions and histories. Information pertaining to the benefits of the awareness program, adult education, the most resilient forms of housing, the most important practical skills for daily activities, and different challenges and household experiences during and after cyclones was collected.

4.5.3 Key informant interviews

A key informant is an individual who has in-depth knowledge of a particular field and can provide perceptive information to the investigator (Kun et al., 2013). The current study conducted six interviews with key informants selected from local, regional, and national organizations (see Table 4.2). All key informant interviews were carried out in English. The interviews were conducted in a natural and relaxed environment, and the interview process was flexible and open rather than structured. The important information was noted on paper and recorded on a smart phone. These key informant interviews provided not only important information on the overall characteristics and decision-making processes involved in coastal areas but also an opportunity to understand the contribution of particular components (e.g., mixed crop cultivation, mixed cultivation with bagda and golda shrimp, etc.) in enhancing disaster resilience. Table 4.2 illustrates an overall description of the key informant interviews.

Table 4.2 Interviews with selected key informants, 2014–2015

Position	Organizations/ Department	Collected information
Head of the news	Development journalist, Channel i	Areas most affected by Cyclones Sidr and Aila, salinity intrusion, salinity tolerant rice varieties, adaptation strategies of local farmers, shrimp cultivation
Director	Uttaron (local NGO)	Household savings, early marriages cause low levels of literacy and unemployment
Assistant director	Bangladesh Resource Center of Indigenous Knowledge (BARCIK)	Role of NGOs in coastal areas, keys for youth development, impacts of polders
Scientific officer	Bangladesh Water Resource Planning Organization (WARPO)	Main causes of water scarcity in coastal areas, community-based water distribution
Assistant director	Dwip Unnayan Sangstha (DUS) (local NGO)	Role of volunteers during disasters, suitable crops, story behind state land (khash) distribution
Project officer	Land zoning project, Dhaka	Land utilization, process of land distribution to the marginal farmers
Member	Union Disaster Management Committee (UNDMC), Ramapal, Khulna	Important initiatives during last disasters, what type of help was provided by neighbors and friends during disasters, existing programs related to preparedness and awareness of disasters

4.6 Data processing and methods of analysis

Data processing and analysis is an important part of data collection (Bogdan and Biklen, 2006). First, all collected data were carefully entered online using Lime Survey software, and thereafter the data were exported to Microsoft Excel. Exported data were checked randomly against the original completed questionnaire (paper version), errors were investigated, and necessary corrections were made accordingly. Further consultation with data collectors, and in some cases with local households, was required with regard to corrections. Finally, data were transferred from Microsoft Excel to SPSS/windows version 24.0, which provided the necessary statistical tools for analysis.

4.7 Research challenges

As the case study site was located on the Bangladeshi coast, a variety of ethical, methodological, and logistical issues existed regarding completion of the data collection procedure.

Language limitation was a challenge in obtaining an accurate understanding of the opinions, attitudes, and perceptions of local households (Steger, 2004). Although the author is a native speaker of the Bangla language, in a few instances, local dialects proved to be a challenge to translate (e.g., regarding references to rice varieties and units of land, which varied from one study village to the next).

Although skilled translators and data collectors were employed, there are chances of misinterpretation (Hutchings, 2004). In some cases, the data collectors provided a brief explanation of the questions when respondents were not able to understand. This may have led to misinterpretations and misperceptions, although all efforts were made to clarify and repeat statements back to the interviewees to ensure accuracy.

Culture and the societal context of the study area also had an impact on interviewee responses. Particularly with the poorer, more marginalized, households, there were difficulties associated with respondents feeling uncomfortable in stating their opinions about income, cash, and savings. Households with female heads were often shy in expressing their opinion regarding health difficulties. In addition, many local people were present when data collectors talked with specific household heads. As a result, interruption by others was another difficulty in some of the surveys, which may have misguided the answers of the selected respondents.

As can be expected in any investigation, occasionally, there were issues related to the data collectors themselves. Sometimes, research assistants did not ask or follow-up with all interview questions, resulting in a significant lack of data for some questions. In some instances, data collectors may have conducted interview questions in a leading manner, particularly if interviewees had problems responding to a particular question. In addition, there were logistical limitations pertaining to transportation or accommodations for data collectors in the study villages. Poor internet connection was another major barrier in conducting the online survey for remote study villages. Finally, the missing values in the final data set proved to be another crucial challenge in the analytical stage of the study.

Since the study investigated disaster resilience at a household level, using data of human and social capital at the individual level was another challenge. However, although there are many ongoing scientific debates, some scholars (Vijaya, 2014; Beaman, 2011; USDA, 2015) argue that individual-level data can be used for household-level analysis bearing in mind the research objective and the social and cultural context of the study area. This fact is supported by Jenkins (2006), who points out that as each individual is attributed with the "living standards" of the household to which he/she belongs (i.e., per capita expenditure),and every person within the same household is attributed with the same value. Thus, the current study considered individual-level data to analyze its relationship with human capital at the household level.

4.6 Mitigation strategies of research challenges

Three major strategies were used throughout the research to mitigate the issues associated with conducting the survey. The first was to deploy the use of local data collectors to conduct interviews. The second was to pilot test the interview and have discussions with community leaders (chairpersons and members) and research participants in order to allow input and influence over the data collection process. Third, training and daily discussions among the data collectors, the author, and the survey manager on interpretation and language issues (i.e., local dialects) helped to ensure that the data collectors gained a better understanding of the requirements of the survey. In the initial stage of the survey, the author accompanied data collectors to some household interviews, which helped in further clarification where required.

There are various options for dealing with missing values in data sets, Schafer and Graham (2002) point out. Gwatkin et al. (2007b) assigned missing values as the mean value for a particular variable. However, this method may lead to a reduction in the variation of the data (Schafer & Graham, 2002). Some authors use a case deletion method for dealing with missing values. For example, Cortinovis et al. (1993; cited by Vyas & Kumaranayake, 2006) exclude households' missing values from the analysis (case deletion) in their study. However, this may led to decreased sample sizes and statistical power of the results (Vyas & Kumaranayake, 2006).

The categorical principal component analysis (CATPCA) application of SPSS also provides a few options for handling missing values (Browne, 2011), for instance, creating an extra category, which achieves a quantification that is independent of the analysis level of the variable (Linting et al., 2007). Linting et al. (2007) indicate that the benefit of this method is that it allows the investigator to deal with variables that include categories such as "no response" or "don't know" as well as numerical or ordinal categories.

The passive method is another option for dealing with missing values. This method only takes into account non-missing data when the loss function is minimized (Meulman et al., 2004b), which results in entries in the data set that are only valid values used in the statistical analysis. Hence, a household with a missing value on one variable does not contribute to the solution for that variable; however, it does contribute to all other variables for which it has valid values (Linting et al., 2007). This strategy is suitable in PCA (Linting et al., 2007).

Since the current study used PCA to construct an index of disaster resilience and all forms of capital, the passive method was applied to deal with missing values; this means that only those entries in the data that had valid values were used in the statistical analysis.

CHAPTER FIVE: STATUS OF HOUSEHOLD CAPITALS AND THEIR RELATIONSHIPS

This chapter presents the descriptive and analytical results of two research questions in the study, that is, "what is the status of human and other forms of capitals?", and "how do they interact?" The findings derived from the analysis of quantitative data are presented here bearing these questions in mind. Some qualitative data too have been used as a supplement, especially with regard to the capital status of the residents in the study area. This chapter is divided into three sections. Section 5.1 explains the status of human capital and section 5.2 considers the other types of capital (social, physical, natural, and financial) in the study area. Section 5.3 addresses the relationships among the different types of household capital. As indicated in Chapter 3, individual-level data have been used to identify the status of human and social capital, while household-level data have been used to explore the status of the financial, physical, and natural capital.

5.1 Status of human capital

5.1.1 Formal education

The analysis shows that, overall, 75.9% of the individuals were literate while about one-quarter of the individuals (24.1%) were not. However, the literacy rate varied by age group, as shown in Table 5.1. The literacy rate of individuals aged 5 to 7 years was higher than the national average of 55.1% (Literacy Assessment Survey, Bangladesh Bureau of Statistics-BBS, 2013). On the contrary, the literacy rate of older people was lower than that of the other age groups (see Table 5.1). This indicates that although a large number of coastal individuals begin their study at the primary level, most of them fail to continue their education because of poverty and the lack of access to educational institutes. Their poor socioeconomic conditions force children to leave school and start working to generate income. In recent years, the government has taken various important initiatives to promote education, such as establishing new schools, distributing free books, providing stipends for girls, granting education fee waivers, and offering food for students undergoing education programs. These initiatives have greatly improved the literacy rates among children, but have had little impact on the literacy rates of older individuals.

Table 5.1: Literacy rates by age group (N = 4658)

Age (in years)	Number of cases (n) and percentage (%)	Literate		Total
		No	Yes	
Child (7–14)	*n*	20	200	220
	%	9.5	90.5	
Youth (15–25)	*n*	73	1454	1527
	%	4.8	95.2	
Adult (26–65)	*n*	853	1833	2686
	%	31.8	68.2	
Elder (> 65)	*n*	145	80	225
	%	64.4	35.6	
Total	*n*	1091	3567	4658
	%	24.1	75.9	

$\chi^2 = 599.38(3)$***; *** = p < .0001
Source: Household survey, 2014–2015

Regarding educational attainment, about half of the individuals surveyed have no formal education (Table 5.2), which indicates the poor condition of human capital in the study area. In addition, the percentage of individuals with one to five years of formal education was almost the same among male and female individuals.

However, gender became a significant factor in education as children aged. In fact, the average number of study years of male individuals was higher than that of female individuals according to the number of years of educational attainment (see Table 5.2). In the context of rural Bangladesh, girls usually take up household work, and parents are willing to send only boys to school for education. A common belief among the rural people is that girls will get married and move out; therefore, educating boys is deemed more important than educating girls. As a result, a large number of rural women are deprived of extensive education and possessed only few years of formal education. This educational disparity likely correlates to a higher incidence of early marriage of girls (Momtaz & Shameem, 2016).

Table 5.2: Years of formal education by gender (*N* = 5699)

Number of years of formal education	Number of cases (*n*) and percentage (%)	Gender		Total
		Male	Female	
None	*n*	770	788	1558
	%	49.4	50.6	
One to five	*n*	926	942	1868
	%	49.6	50.4	
Six to 10	*n*	1022	853	187
	%	54.5	45.5	
11 or more	*n*	233	165	398
	%	58.5	41.5	
Total	*n*	2951	2748	5699
	%	51.8	48.2	

$\chi^2 = 599.38(3)$***; *** = p < .0001
Source: Household survey, 2014–2015.

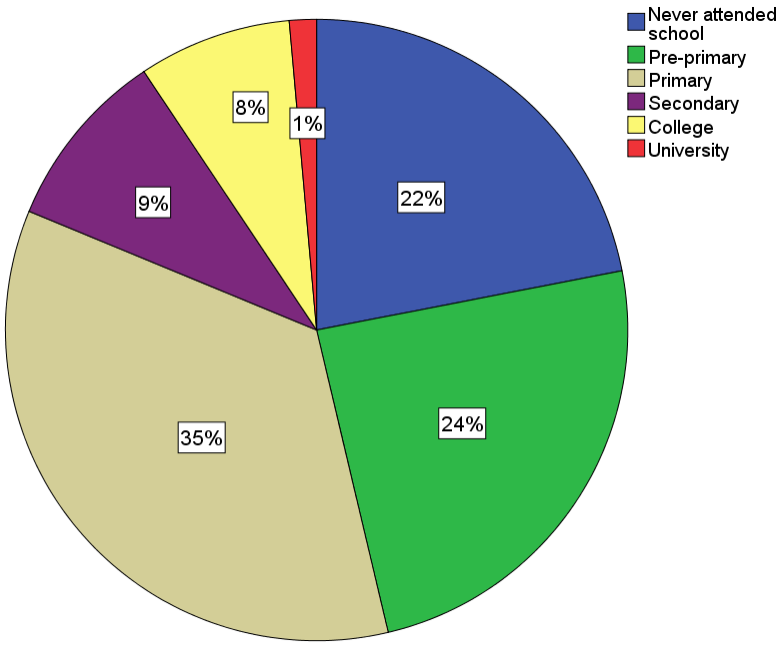


Figure 5.1: Highest level of education (*N* = 5842)

Source: Household survey, 2014–2015

Figure 5.1 illustrates that the number of individuals with university degrees is extremely low. The majority of the residents in the study area attained only pre-primary or primary degrees.

The lack of quality education is a challenging issue in achieving higher education in the coastal areas. Access to higher education in coastal villages has gradually decreased. The majority of students usually cannot compete due to lack of sufficient knowledge especially in English, Mathematics, and General Knowledge (Rashid, 2014). During an informal discussion in the study (2014 & 2015), local residents provided insights into the limited opportunities for higher education. These residents explained that lack of monitoring in char lands and inaccessible coastal areas, lack of qualified teachers, high fees for private lessons from teachers, poor communication, and lack of qualified laboratory instructors and materials were the reasons for limited educational opportunities.

5.1.2 Vocational education and training (VET)

VET helps to empower households to obtain better livelihoods (ADB, 2015). VET in Bangladesh can be formal or non-formal. Students receiving formal general and vocational education enter a diploma level in monotechnics or polytechnics after obtaining secondary school certificates. Non-formal VET is a certificate course ranging from one to twelve months with the duration determined by the non-formal VET providers. The non-formal VET courses are not affiliated to the Bangladesh Technical Education Board (BTEB) (ADB Country Report, 2015). Although this study examined both types of VET, non-formal VET mostly focuses on short-term educational gains and affordability. To assess the status of VET, the study concentrated on those individuals who were 15 years or older.

The survey found that VET is not well established in the coastal villages of Bangladesh (Table 5.3). A majority of individuals had no access to vocational training and education, mainly because of the limited number of vocational institutes in the area or because they are mostly unaware of the positive effects VET on their livelihood. Very few individuals had access to VET conducted by governmental organizations (GOs) or non-governmental organizations (NGOs). Among the individuals who had taken up VET, most of them studied VET on livestock and crop cultivation, fishing and aquaculture, business and trade, handicrafts and tailoring, and medical training. The coastal economy is dominated by rice production, fishing and shrimp cultivation, and small businesses. Thus, the GOs and NGOs are interested in providing VET particularly in these subjects. Few others had participated in other types of VET such as vehicle repair, general electrical and mechanical repair, or construction.

Table 5.3: VET status in the study area (*N* = 4283)

Type of training program	Frequency	Percent
No vocational educational and training	3785	63.1
Livestock and crop cultivation	142	2.4
Fishing and aquaculture	136	2.3
Business and trade	103	1.7
Handicraft, tailoring	43	0.7
Vehicle repairs (e.g., rickshaw)	1	-
General electric and mechanical repairs	2	-
House wiring	1	-
Construction work (e.g., roads)	1	-
Medical training	16	0.3
Other	53	0.9
Total	4283	69.8
Not applicable (<15 years old)	1849	30.2
Total	6132	100.0

Source: Household survey, 2014–2015

5.1.3 Practical skills

A diverse set of practical skills is key to building a community resilient to the effects of natural disasters (ISDR, 2007). The results suggest that many households had no access to formal or vocational education, and the households conducted their economic activities using diverse practical skills, such as livestock and crop cultivation, fishing and aquaculture, business and trade, and so on. Households gain these types of practical skills by hands-on learning without any formal education or training. Although coastal residents have many practical skills, this study focused on those most important to their livelihood activities.

Data from the household survey shown in Table 5.4 indicate that the majority of coastal individuals reported practical skills in livestock and crop cultivation, handicrafts and tailoring, and fishing and aquaculture. Business and trade, beekeeping, construction, and climbing trees were also reported. Despite the lack of formal education and training options, these individuals generated household income using practical knowledge. Some villagers stated that they use new agricultural methods without formal education or training, such as mixed shrimp cultivation (mixing *bagda* with *galda* shrimp), mixed crop cultivation (rice and fish), and shrimp larvae production (IDs, 2014 & 2015). Ratna Begum, a woman of Deuli Subedkhali, explained that she stitched *kantha* (cotton wrappers, patched cloths, or bed sheets made of patchwork) and fishing nets. These items were the key sources of household income post Sidr. Individuals who were skilled at repairing houses and sanitation systems were also valued highly during and after disasters.

Table 5.4: Practical skills in the survey area (*N* = 4958)

Type of practical skill	Frequency	Percent
Livestock and crop cultivation	2025	33.0
Fishing and aquaculture	308	5.0
Beekeeping	7	0.1
Business and trade	77	1.3
Handicraft and tailoring	1165	19.0
Vehicle repairs (e.g., rickshaw)	2	-
General electric and mechanical repairs	8	0.1
Construction work (e.g., roads)	25	0.4
Sanitary latrine construction	4	0.1
Medical training	3	-
Ayurvedic treatment	24	0.4
Swimming	1122	18.3
Climbing	27	0.4
Other	161	2.6
Total	4958	80.9
Not applicable (<10 years old)	1174	19.1
Total	6132	100.0

Source: Household survey, 2014–2015

5.1.4 Knowledge obtained through interaction and participation

Knowledge obtained through interaction and participation is crucial in engaging people in discovery and problem solving for disaster risk reduction (IFRC, 2011). GOs, NGOs, and community-based organizations (CBOs) provide various participatory learning programs, such as adult education, volunteer assistantships, economic co-operatives, and awareness-building programs aimed at building resilient communities in the coastal areas (Shakil & Bhuiya, 2014). With respect to these programs, most of the individuals had participated and interacted with economic co-operative programs. Through this participation and interaction, coastal individuals learned techniques for cultivating rice, shrimp, and freshwater fish. They learned how to nurse high-yield varieties of paddy plants and *ghers* (shrimp fields) and learned how to improve the quality of sharing freshwater fish cultivation, which was pointed out by local residents of Lata Chapli village in Kalapara Upazila (IDs, 2014 & 2015). In addition, the coastal individuals learned various concepts through adult education such as improving goat breeding; using tube wells to access water during disasters receiving services from family planning activists; and implementing proper healthcare methods with regard to preventing tuberculosis, diarrhea, and so on; and learning about immunization and nutrition.

Table 5.5: Participation in knowledge building programs provided by GOs, NGOs, and CBOs (*N* = 6132)

Types of knowledge-building programs (GOs, NGOs, CBOs)	Frequency	Percent
Adult education program	95	1.5
Volunteers program	1027	16.7
Economic co-operative program	1250	20.4
Awareness-building program	103	1.7
Health program (family planning)	613	10.1
No participation in any program	3044	49.6
Total	6132	100.0

Source: Household survey, 2014–2015

5.1.5 Knowledge obtained through prior experience and indigenous activities

As stated in Chapter 3, individuals gain knowledge and skills through the activities they undertook when dealing with past disasters, which can be important for enhancing human capital. Some scholars refer to this as "implicit knowledge," which draws heavily from traditional activities (Maiese, 2005). This study explored individuals' previous experiences during the recovery phase of the most recent disaster. To assess this, the study considered individuals who were 15 years or older.

Table 5.6 provides data on such activities of individuals used in the past when dealing with disaster. About a quarter of the individuals used their savings to deal with disasters leading us to understand how savings can be useful during crisis. Although there were external supports, a considerable number of coastal residents repaired their household damages themselves. As seen from the survey, not all individual activities are directly related to enhancing human capital. However, individual activities can indirectly affect human capital. Human capital can be enhanced both directly and indirectly (Michie, 2001). For example, the study found that some households took out loans from banks or NGOs, while some borrowed money from family or friends. Although these activities are not directly related to human capital, they have an indirect impact on human capital. For instance, individuals can learn through these activities how to communicate with banks or NGOs and how to use money (from loan or lending) in the recovery phase. In particular, NGOs in the study area provide loans with particular instructions (e.g., how to make a homestead vegetable garden, which crop varieties are profitable, and so on.) for using the loan money in a proper way. Coastal residents thus enhance their knowledge and skills in this particular aspect, which might play an important role in the next disaster. The survey also found other interesting strategies that individuals used to deal with disaster, such as cultivating salt-resistant crops, constructing houses on higher ground, adjusting food consumption, changing crop cultivation patterns, and using less water.

Table 5.6: Experience gained during the recent cyclones and storm surges (10–15 years) (N = 6132)

Activities	Frequency	Percent
Fixed damage myself (repairs)	1133	18.5
Used personal savings	1478	24.1
Sold productive assets	12	0.2
Used formal loan (bank, NGO)	122	2.0
Borrowed money from family or friends	83	1.4
Took child out of school	4	0.1
Migrated temporarily	4	0.1
Cultivated salt-resistant crops	6	0.1
Cultivated crops that need very little water	5	0.1
Changed pattern of crop cultivation	6	0.1
Adjusted amount of food/meals	8	0.1
Constructed house on higher ground	74	1.2
Sold land	4	0.1
Asked NGO for help	84	1.4
Asked CBO for help	4	0.1
Total	3025	49.3
Not involved with these activities (e.g., children, too old, disable)	3107	50.7
Total	6132	100.0

Source: Household survey, 2014–2015

Monwar Hossain, a farmer living in the village of Deuli Subedkhali stated:

In 2007, all of my paddy land [was] submerged and damaged by saline water due to cyclone Sidr. Afterwards, I cultivated saline-tolerant rice, such as Jatabalam, Ashfall, Benapol, on some part[s] of my land. It was very effective for me when we were affected by cyclone Aila in 2009. Saline-tolerant rice was not completely damaged by Aila. Basically, I capitalized on this agro-technique through the experience of the last cyclone, Sidr.

Frequent experience of cyclones and storm surges in coastal areas has developed in residents an innate perceptiveness about the frequency of disasters, which helps them to be prepared for future ones (UNISDR, 2008). More than 90% of the individuals experienced cyclones and storm surges during the past 10 to 15 years. However, individuals had different perceptions about the frequency of cyclones and storm surges. The analysis reveals that about 50% of the individuals reported that the frequency of cyclones and storm surges had increased over the past 10-15 years. Nearly 20% of them reported that the frequency of cyclones and storm surges was about the same as before, and over 20% reported a lower frequency in cyclones and storm surges.

5.1.6 Health

Health status was measured subjectively because it was expected to capture numerous dimensions that reflect the physical, social, emotional, and biomedical health (compare Baert and de Norre, 2009) of individuals. In the context of disasters, a descriptive indicator of perceived individual health status measures whether individuals have difficulty in undertaking daily activities due to health limitations. If a household's poor health limits its capacity to carry out daily activities, we can assume that it is a robust indicator that the household's stock of human capital is insufficient (OECD, 2013).

In Bangladesh, people are considered able to work if they fall within the 15-65-year age range (Ahsan, 2007). Of all the individuals aged 15-65 in the study (n = 4230), more than 50% reported difficulty in doing work. Among them, more than 20% of females and more than 25% of males reported difficulty because of age-related limitations (too old), such as physical disabilities, chronic diseases, or illness (household survey, 2014–2015; IDs, 2014–2015). A few individuals (2%) could not work because of physical injury from accidents, mental disabilities, or other reasons. However, some males and females were unable to work for reasons unrelated to health, such as lack of job opportunities, homemaker responsibilities, or religion. Therefore, those individuals who are not able to work are a financial burden for the family. In addition, household heads must invest money on medical care for those that have health problems, which can be burdensome on the household finances (IDs, 2014-2015).

Age is an important indicator in assessing human capital. The age of rural individuals in Bangladesh has a great influence on their ability to take part in economic activities (FAKIR, 2008). Therefore, this study considered age as a proxy to investigate health status in the study areas.

The population pyramid of the study area (Figure 5.2) shows that the proportion of those aged 14 to 25 years was larger than that of the other age groups. Most of these individuals are dependent on the household heads as reported by local key informants.

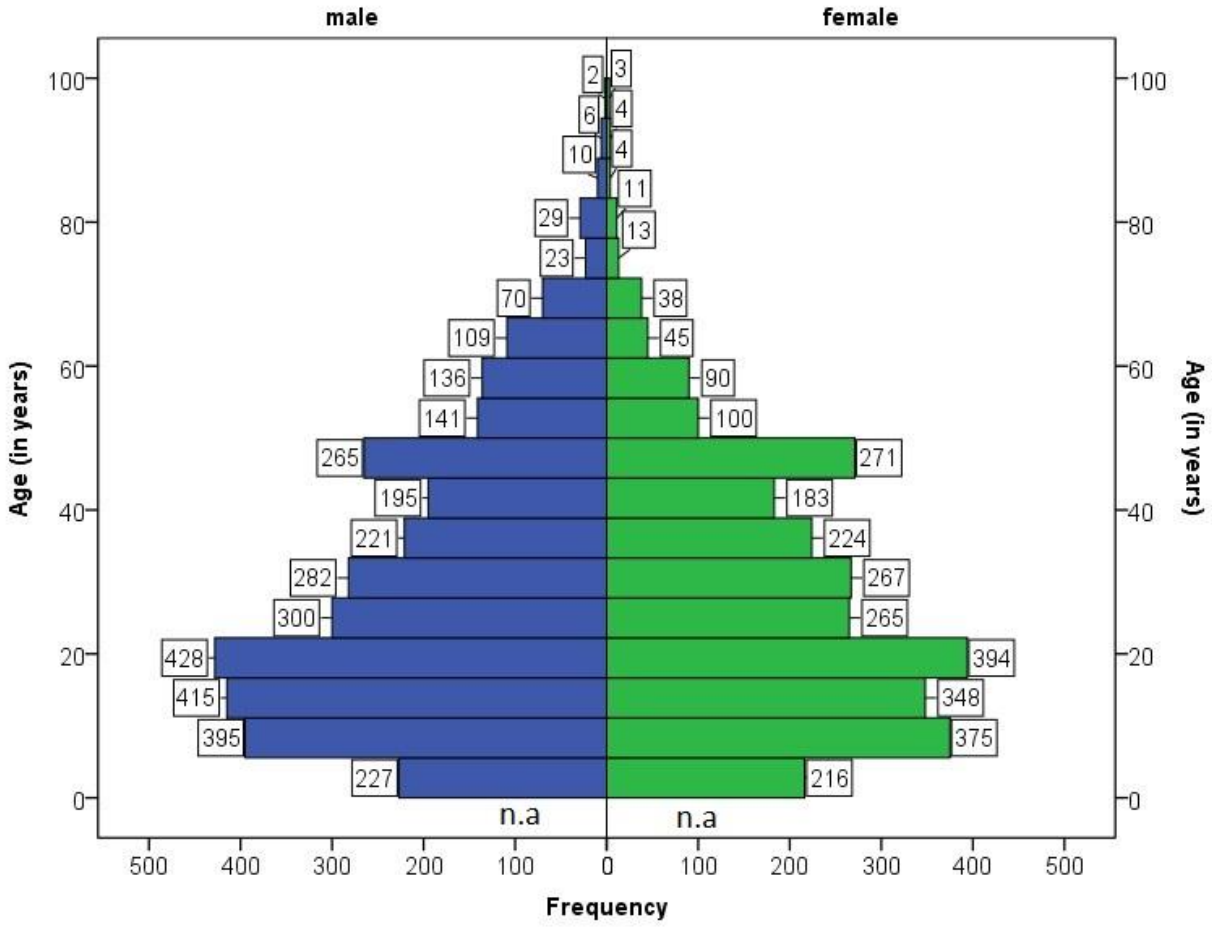


Figure 5.2: Population pyramid of the study area

Source: Household survey, 2014–2015 (*N* = 6132)

5.2 Status of other forms of capital

5.2.1 Social capital

Crucial components of social capital are social networks and shared norms and values (Halpern, 2005). This study investigated social capital through bonding, bridging, and linking networks following Aldrich's (2012) measurement approach (see Chapter 3). Bonding refers to relationships with family members and bridging concerns ties with neighbors and friends. Linking networks are about individuals' relationships with organizations (GOs and NGOs) that have an influence over their circumstances (Aldrich, 2012). Networks, including types of support, that are provided by family members, neighbors, friends, and organizations in rural Bangladesh relate to social capital (Jordan, 2014). Islam and Walkerden (2015) note

that networks providing particular support (e.g., helping people gain access to shelters, loans, food, safe water, and child care) are predominant in assessing social capital in terms of cyclone and storm surges in the coastal area of Bangladesh. Using the perspective of Islam and Walkerden (2015, this study addressed six types of support to analyze bonding, bridging, and linking networks. These six types of support include help in gaining access to (1) cyclone shelters, (2) cash loans, (3) house repairs, (4) food and water, (5) other useful items, and (6) childcare and/or medical care.

5.2.1.1 Bonding networks: Family members

Hanies (1996) says, individuals provide significant support, which is crucial to recovery. Table 5.7 shows households' support from family members during and after Cyclones Aila and Sidr. A majority of individuals received support from family members in the form of childcare or medical care. This is particularly important because childcare and medical care support from GOs and NGOs are limited during cyclone and storm surges due to the inaccessibility of the affected area. As a result, on most occasions, individuals care for children and provide them medical care (i.e., Ayurvedic medicines; Kim et al., 2016).

Table 5.7: Social support from family members (N = 6132). Multiple response.

Support	**Responses**	
	Frequency	Percent
Getting to cyclone shelters	819	10.5
Cash loans	701	9.0
House repairs	847	10.9
Food and water	641	8.2
Useful items	119	1.5
Childcare or medical care	1599	20.5
No answer	3060	39.3
Total	7786	100.0

Source: Household survey, 2014–2015

Individuals also received financial assistance through their bonding networks. However, a small number of individuals were assisted through donations of useful items, such as bamboo, jute sticks, rice straw, and so on, suggesting the limited physical and financial capital of coastal residents. However, the study reveals that many individuals invested in labor to repair houses and other property that had been damaged; this common practice is helpful during recovery in rural Bangladesh (Dhakal & Mahmood, 2013).

5.2.1.2 Bridging networks: Support from friends and neighbors

Support from friends (Table 5.8) and neighbors (Table 5.9) plays an important role during and after disasters for provision of food, clothing, and house repairs. In addition, neighbors and friends are often sources of emotional support, which is also important for recovery in disastrous situations.

Table 5.8: Support from friends (*N* = 6132). Multiple response.

Support	**Responses**	
	Frequency	Percent
Getting to cyclone shelters	850	13.5
Cash loans	723	11.4
House repairs	875	13.8
Food and water	666	10.5
Useful items	120	1.9
Childcare or medical care	1661	26.2
No answer	1440	22.7
Total	6335	100.0

Source: Household survey, 2014–2015

Interestingly, individuals received diverse types of support from friends than from neighbors, which could explain the different magnitude of the effects of disasters and the mutual trust that existed among individuals and their friends (Islam, 2010):

> Our neighbors were also equally affected by Cyclone Aila and they were extremely engaged with [their] own household's activities. However, some of my close friend[s] who were less affected [came] from adjacent *upazila* just after [the] disaster and helped to repair houses [and] provided some dry foods, for example, *muri* [puffed rice] and *gur* [juice from boiled sugarcane]. (Mobrak Ali, a household head from Itabaria Union, Patuakhali)

However, the study result indicates the greatest support from neighbors was in getting to cyclone shelters (Table 5.9). When a cyclone strikes, communication is disrupted and external emergency support often cannot get local residents to cyclone shelters quickly and efficiently. Thus, support from neighbors at that time is crucial.

Table 5.9: Support from neighbors (N = 6132). Multiple response.

Support	Responses	
	Frequency	Percent
Getting to cyclone shelters	1238	18.7
Cash loans	109	1.6
House repairs	107	1.6
Food and water	446	6.7
Useful items	8	0.1
Child care or medical care	279	4.2
No answer	4426	66.9
Total	6613	100.0

Source: Household survey, 2014–2015

Households received other support from friends, such as cash loans, house repairs, and food and water. These types of support were rarely provided by neighbors.

5.2.1.3 Linking networks: GOs and NGOs

The study individuals used their limited resources, reduced their food intake, repaired their houses, and used their labor capacities as much as possible, which demonstrates their strong desire to independently resolve their problems. However, they were not able to completely resolve their problems by themselves because of money and asset limitations. Hence, support received from GOs and NGOs was very important to the coastal households. The household survey suggests that NGOs helped the respondents get to cyclone centers (40%) and provided them food and water (21%), cash loans (12%), and other essential items (10%). GOs were most likely to provide food and water (57%) because many international NGOs (such as UNICEF) worked with GOs to provide food and water, which was considered as GO support (Chairman, Jhonjhonia-Gabbunia Union Parishad, Rampal, Khulna).

Although coastal households received a variety of support from linking networks, support as a micro-credit recipient from NGOs or GOs was common in the coastal area. In particular, NGOs organized landless and poor households into small groups and formulated *samity* (cooperative organizations). The main objective of a *samity* is participatory development and economic empowerment of coastal households. Coastal households invariably became members of a NGO microcredit facility. The household survey (2014–2015) indicates that over 30% of the individuals were microcredit recipients from NGOs; however, individuals were seldom credit recipients from GOs. During informal discussions (2014-2015), the local residents reported that NGOs provide microcredit for various purposes, such as buying vegetable seeds, improving the breed of goats, and managing livestock and poultry diseases, which was an effective support in the recovery stage of cyclone disasters. Furthermore, to receive microcredit, it was easier to access NGOs rather than GOs because many NGOs work at the local level.

5.2.2 Financial capital

5.2.2.1 Household savings

Household savings were used to indicate the level of resilience at times of disasters. Households with savings were considered to have more resilience to external shocks and stresses than households without savings (DFID, 1999). This study found that about half of the respondents had savings (Table 5.10). The highest percentage of households with savings among the nine villages was found in Bagali. Other villages with high percentages of savings were Amadi and Jhonjonia-Gabbunia. The reason for a higher amount of savings in these villages was the increased income from shrimp cultivation and high-yield rice varieties (BR10, BR11, BD 38). On the contrary, the village with the highest percentage of households without savings was Char Ishwar, which was located on Hatiya Island, where riverbank erosion was a regular phenomenon.

Table 5.10: Respondents' household savings (N = 1184)

Study sites (villages' union-level names)	Number of cases (n) and percentage (%)	Households savings		Total
		No	Yes	
Amadi	*n*	19	47	66
	%	28.8	71.2	100.0
Bagali	*n*	16	66	82
	%	19.5	80.5	100.0
Char Alexander	*n*	109	38	147
	%	74.1	25.9	100.0
Char Ishwar	*n*	87	63	150
	%	58.0	42.0	100.0
Deuli Subdikhali	*n*	77	77	154
	%	50.0	50.0	100.0
Itabaria	*n*	64	73	137
	%	46.7	53.3	100.0
Jhonjonia, Gabbunia	*n*	62	91	153
	%	40.5	59.5	100.0
Lata Chapli	*n*	84	71	155
	%	54.2	45.8	100.0
Tamaruddin	*n*	74	66	140
	%	52.9	47.1	100.0
Total	*n*	592	592	1184
	%	50.0	50.0	100.0

$X^2 = 88.13(8)$***; *** = p < .0001
Source: Household survey, 2014–2015

Households used various means to save money, such as depositing it in banks, keeping cash on hand, in cooperative or group savings, or in pensions and remittances (Table 5.11). To understand the overall savings behaviors in the study area, this study examined the total amount of savings by type. Table 5.11 shows that the households were most likely to save money in banks. This could be the reason for the various profitable savings scheme offered by banks (i.e., BRAC, Dutch Bangla, Prime), as they are relatively more profitable than other options.

Table 5.11: Types of household savings (N = 752)

Type of savings	Frequency	Percent	Total in BDT	Total in USD
Pensions	11	1.4	6,600,900	83,899
Remittances	13	1.7	2,105,991	26,768
Cooperative/group savings	265	35.2	4,366,283	55,497
Bank	350	46.5	65,416,397	831,476
Cash	113	15.0	10,695,664	135,947

Source: Household survey, 2014–2015

5.2.2.2 Cash loans

Loan availability is another factor that influences resilience to disasters (Joakim, 2013). The analysis shows that more than half of the total households have no access to loans. Loans were mostly received from NGOs or from non-formal lenders of small loans. Due to the complex and lengthy loan sanction procedures of GOs, coastal households were reluctant to take loans from NGOs. Few households had access to GOs for loans, which could be due to insufficient government resources to meet the excessive demand. In addition, in the context of rural Bangladesh, land ownership was key to accessing credit from governmental institutions and since land ownership is not common among coastal households, only a few mid-sized and large farmholders had access to land ownership. Thus, households obtained loans from a variety of non-governmental formal and informal sources, such as NGOs, private banks, neighbors, friends, and so on. In fact, a few households borrowed from moneylenders, despite high interest rates, because these types of loans were easier to access.

Among the households that obtained loans, most of them borrowed money in the range of BDT 20,000–BDT 29,999 and very few obtained loans larger than BDT 200,000. In informal discussions during the survey, some households stated that access to loans was relatively better during the recovery stage after Cyclones Sidr and Aila when compared to before the cyclones. Banks and other credit sources provided low-interest credit to support housing reconstruction. In addition, loan programs were established to support the recovery of livelihoods and to help households establish new entrepreneurial activities.

5.2.3 Physical capital

5.2.3.1 Housing

The socioeconomic status of households (income, social status, and household size) largely determines the dwelling types in rural Bangladesh (Farah, 2015). The *pacca* houses have cement floors, brick walls, and concrete roofs, but they were rare in the study area. Figure 5.3 illustrates that the majority of the households in the study area lived in small *kaccha* houses, which are dwellings built of local materials. *Kaccha* houses have mud floors with walls made of straw, jute sticks, bamboo, mud, or tin and roofs made of thatch or CI (corrugated galvanized iron or steel sheets) sheets. In the study area, a number of houses were *semi-pacca* dwelling structures, which have brick walls and CI sheet roofing. Thus, the survey results suggest that most of the houses were poorly built and were not adequate protection against cyclones and storm surges.

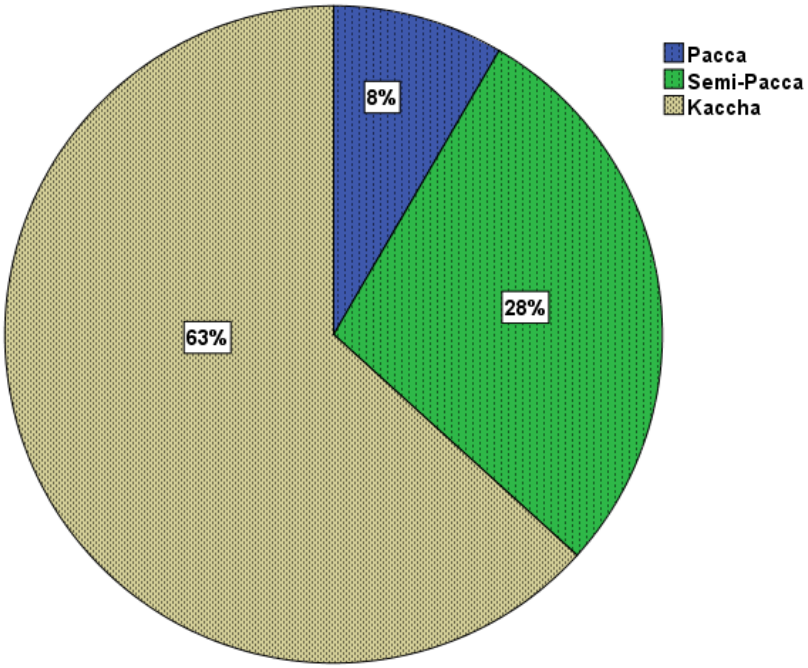


Figure 5.3: Housing types in the study area (*N* = 1189)

Source: Household survey, 2014–201

5.2.3.2 Access to production machines

The coastal households owned agricultural and non-agricultural machines crucial to their livelihood. Among these types of physical capital, fishing nets were the most common (38%), followed by tractors (23%), fishing boats (18%), and harvesters (15%). These types of physical capital are common because agriculture and fishing are the main sources of income and employment in the study area. Anwar (2012) found that using tractors and harvesters in crop cultivation increased the overall speed of farming activities. Households that used tractors and harvesters were able to reduce the time spent in farming and invest this extra time in others activities, such as taking care of livestock, repairing houses, cultivating shrimp and freshwater fish in ponds, and so on. Fishing nets and boats are also important livelihood assets in the coastal area where most households depended on fishing as an income source. In addition, the analysis indicates that about one-quarter of the households owned bicycles (24%), which was the main mode of transportation in the coastal villages.

5.2.3.3 Access to household facilities

Some of the essential facilities for coastal livelihoods in Bangladesh were drainage systems, toilets/latrines, educational institutes, and access to mass media (Toufique, 2015). A vast majority of the households had access to educational institutes (98%). However, the local residents said that the number of primary schools was sufficient while colleges, universities, and vocational education institutes were still rare (Key informant interviews, 2014-2015). Almost all households (97%) responded that they had access to toilet facilities; however, the quality and condition of the toilets were questionable. During the household survey, it was observed that access to hygienic toilets (i.e., sanitary toilets) was rare. Most households had access to unhygienic and unsafe toilets, that is, they used open spaces or hanging toilets.

Access to mass media and drainage was limited. Only 31% of the households had access to mass media (i.e., newspaper, radio, or television), which limited their access to weather forecasts and cyclone warnings before and during disasters. About one-third of the respondents (31%) reported having a drainage system. This household limitation created unhygienic conditions, particularly during the recovery phase after cyclones and storm surges.

5.2.4 Natural capital

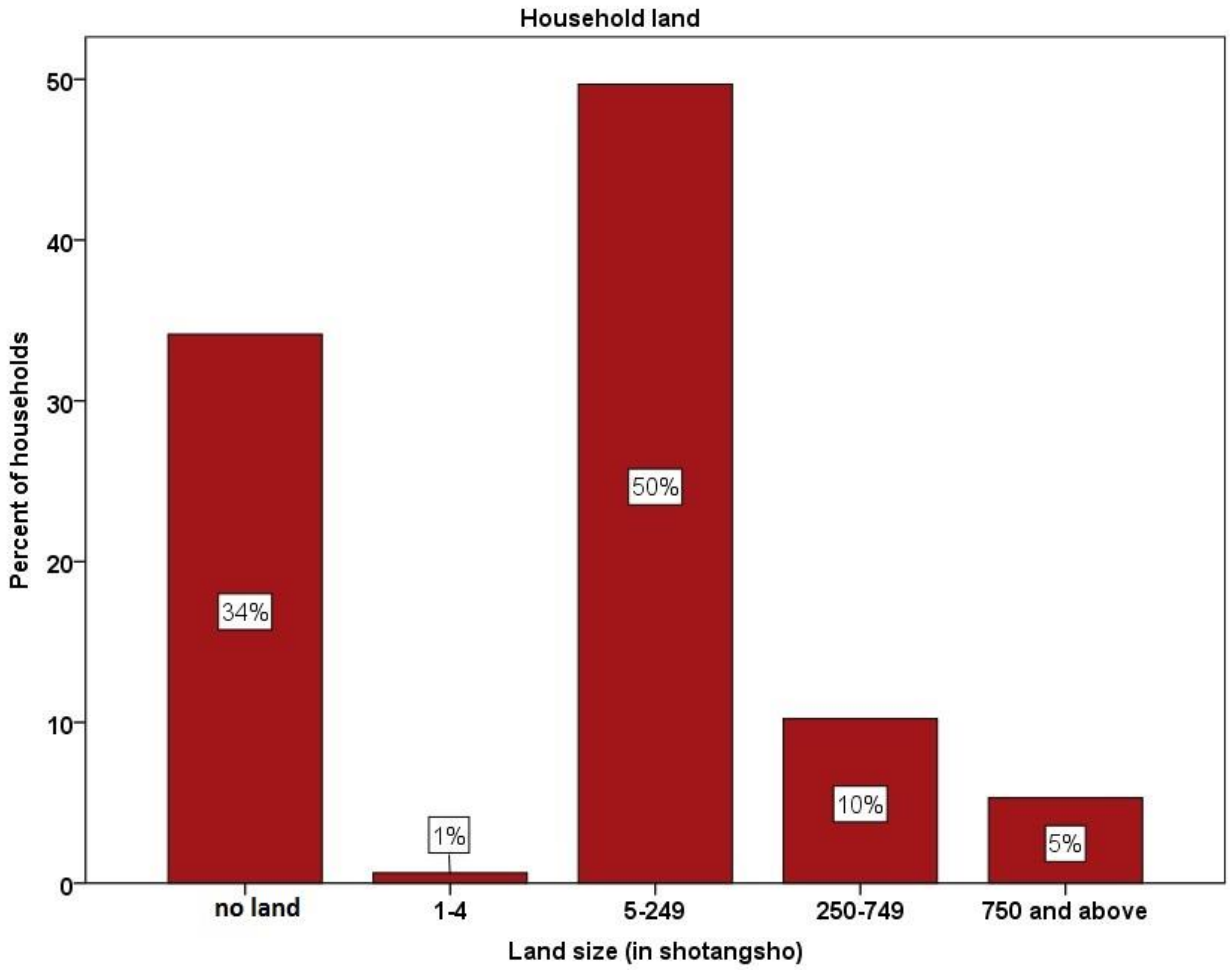
Natural capital comprises the natural resource stocks available for livelihood opportunities, including resource services and tangible and intangible assets used for production purposes (DFID, 1999). However, land and water were the most crucial factors of natural capital for disaster resilience in coastal areas of Bangladesh (Yasmin, 2016).

5.2.4.1 Land

In the study villages, land is the most important element for aquaculture and agricultural production. Lazar et al. (2015) found that land ownership and household income were significantly and positively associated in the coastal area of Bangladesh. The study results found that a large number of households did not have access to cultivable land. According to the Agricultural Census published by the Bangladesh Bureau of Statistics (BBS, 2008), 29% of the rural households in the country were landless. The percentage of landless households in the surveyed area was higher than the national percentage of rural landless households. This suggests the negative impact of coastal disasters on the study villages. Many rural households had become landless because of cyclones, floods, and river erosion. Coastal cyclones are often accompanied by floods that wash away the land and destroy dams (FAO, 2010). The study result shows about half the households

that had access to cultivated land only owned small tracts of land[2] (Figure 5.4). Households in the study area usually practiced homestead agro-forestry within this small land through the year and grew various types of vegetables, fruits, spices, timber yielding trees, bamboo, etc., to promote micronutrient intake levels, to increase overall food consumption, and to increase household income (Begum et al., 2010). Sometimes household heads sold these items to overcome a period of cyclone and storm surges. However, in most cases, these small tracts of land were not sufficient to fulfill the huge demand for grain foods, such as rice, wheat, pulses, etc. As gleaned from the informal discussions, households with small tracts of land faced challenges in crop cultivation. For example, shrimp cultivation had been profitable over the last few decades; however, it was very difficult to cultivate shrimp on small tracts of land and hence the households resorted to cultivating rice. However, households with small tracts of land could not grow crops of their choice due to the decision of the adjacent landlord. Shrimp farm holders usually owned larger tracts of land for shrimp farming. Sometimes they pressurized small landholders to sell their land, which was adjacent to larger farms. Often these small landholders had to sell their land to the large shrimp farmers at relatively low prices. In some cases, these households bought land in other places in the village, but mostly they spent this money on other expenditures (such as buying food and clothes, repairing the house), which ultimately made them landless.

[2] Marginal farm size: .01–.05 acres; small farm: .05–2.49 acres; medium farm: 2.50–7.49 acres; large farm (7.50 acres and larger; Source: BBS, 2013).



Source: Household survey, 2014–2015

Figure 5.4: Distribution of cultivated owned land in the study by household (in *shotangsho*) (*N* = 1189)

5.2.4.2 Access to clean water

Scarcity of clean water is a major problem due to salinity in the coastal areas (Islam & Walkerden, 2015). For the past couple of decades, water salinity has been a challenge (Basar, 2012; Dasgupta et al., 2015). Households in the study villages lacked drinking water because of salinity.

Coastal households spent several hours fetching drinking water for which they had to travel many kilometers for one pitcher of clean water (Rabbani et al., 2013). Figure 5.5 shows that only a small number of the households had safe water in their homes. A large number of the households had to walk 10 minutes to access a clean water source. On average, it took 30 minutes to get to the water point and back home (IDs, 2014/2015). According to the guidelines of Sphere (1998) and HP/WatSan (2005), queuing time at a water

source should not exceed 30 minutes as longer queuing times resulted in reduced per capita water consumption and increased consumption from unprotected surface sources. In addition, longer queuing times reduced time for other essential household tasks for those who collected water. However, NGOs and local governments provided clean water by distributing pond sand filters (PSFs) for drinking and cooking water sources, which reduced the salinity, and encouraged rainwater harvesting (Rahman et al., 2017). Despite these measures, many households took than 20 minutes to reach a source of safe water (Figure 5.5).

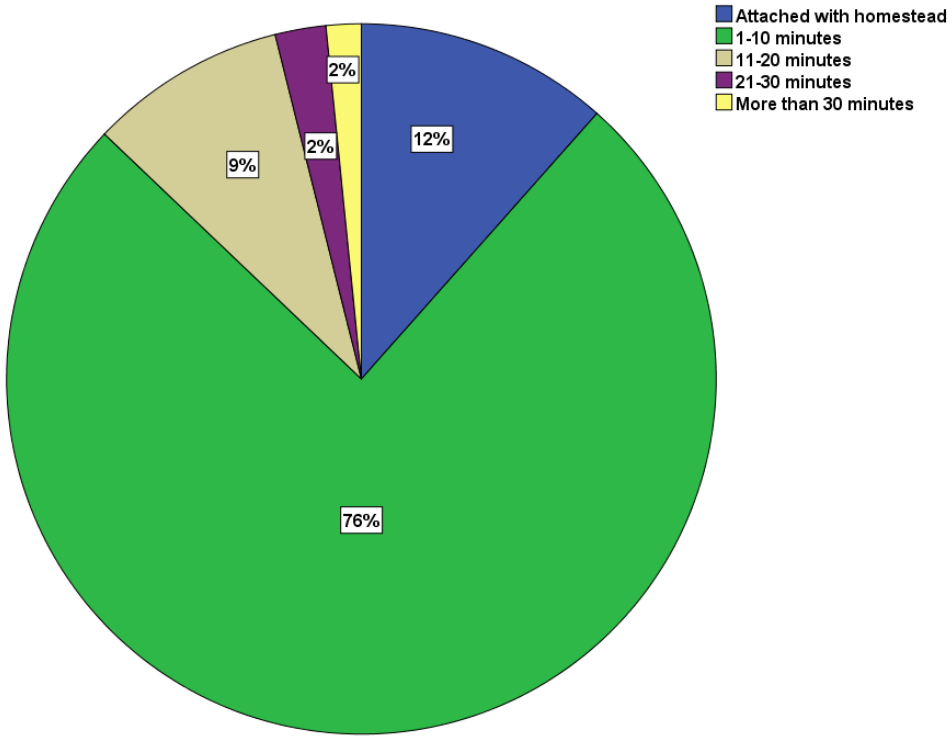


Figure 5.5: Percentage distribution of distances from households to drinking water sources

Source: Household survey, 2014–201

The aim of the study as mentioned earlier is to identify the status of household capital in the study areas based on the overall status of the types of household capital and to explore the relationships among the different types of capital. Therefore, an index needs to be constructed of all the types of capital for comparison across villages. Indices provide an overall picture and are more comprehensive than separate indicators. Nardo et al. (2005) note that indices could encapsulate complex or multi-dimensional issues and are key instruments for planning and comparing performances and progress of characteristic across space and time if they are well constructed (Freudenberg, 2003). However, they have a few limitations: indices are always

associated with a loss of information and can sometimes.be misleading to indicate non-robust policy indications if they are poorly designed. A six-step procedure was used to estimate household capital as a complex index, which is explained below.

Step 1: Methodological approach

Numerous indices are used in disaster and hazard research in academia and policy formulation. The most common indices are: (1) social vulnerability index - SoVI (Cutter, 2003), (2) disaster risk index - DRI (UNDP, 2004), (3) international wealth index - IWI (Smits & Steendijk, 2013), (4) earthquake disaster risk index - EDRI (Davidson, 1997), and (5) social vulnerability to climate change index (Vincent, 2004). However, the methodological approach varies across indices. Older studies mostly use hierarchical and similar deductive methods that calculate an index as the aggregate number of assets owned by a household (e.g., Montgomery et al., 2000; Guiley & Jayne, 1997). This method has limitations because it measures each item equally. This unrealistically implies, for example, that harvesters, fishing nets, motorcycles, and *pacca* toilets equally contribute to a household's overall capital. Hence, principal component analysis (PCA), a more advanced method, is recommended to determine the relative weights of assets (Smits & Steendijk, 2013).

Since Filmer and Pritchett (1999, 2001), most of the indices of capital have used PCA to estimate the index. A few other techniques have also been used for this purpose, such as multiple correspondence analysis (Booysen et al., 2008) and factor analysis (Sahn & Stifel, 2000). However, their results differed very little from those using PCA.

PCA reduces the dimensionality of data comprising many interrelated variables while extracting the variation in the data as much as possible. PCA creates a new set of variables that are uncorrelated and are ordered so that the first few variables retain most of the variation of the original variables (Jolliffe, 2002).

PCA produces indices that are a linear weighted combination of the initial variables. Hence, it is possible to obtain a weighted sum of all retained factors because they are orthogonal to each other. To generate a capital index, this study considered the direction of the structural equation modeling approach proposed by Alinovi et al. (2010) and Borja-Vega and de la Fuente (2013).

Based on this methodological approach, the capital index is represented by the following equation:

$$CI=a_{m1}X_1+a_{m2}X_2+\cdots+a_{mn}X_n \quad \ldots\ldots (1)$$

where a_{mn} represents the weight of the *m*th principal component in the *n*th variable, and CI represents capital index.

Step 2: Indicator selection

Household capital indicators were selected after an intensive review of disaster-related literature in light of the theoretical framework discussed in Chapter 2. Table 5.12 lists the types of capital and their indicators. As indicated earlier in Chapter 4, indicators of individual-level data were used to assess human and social capitals, while household data were used to assess physical, financial, and natural capital. Since the PCA-produced uncorrelated indices are a linear weighted combination of the initial variables, Gelman and Little (1998) point out that individual-level weights of data can be generalized for household-level data.

Table 5.12: Indicators used to construct the components of the capital index

Household capital	Indicator
Human	1. Highest level of education 2. Years of formal education 3. Vocational education and training 4. Practical skills 5. Ability to work 6. Age 7. English language fluency 8. Knowledge obtained from health programs 9. Knowledge obtained from adult education 10. Knowledge obtained from voluntary programs 11. Knowledge obtained from economic cooperative programs 12. Experience with cyclones and storm surges in past 10 to 15 years 13. Knowledge obtained from awareness program 14. Experience in dealing with disasters
Natural	1. Access to land 2. Amount of owned cultivable land 3. Distance to sources of clean water
Financial	1. Cash 2. Bank account 3. NGO or group account 4. Remittances 5. Pensions 6. Loans
Physical	1. Tractor 2. Harvester 3. Boat 4. Fishing 5. Rickshaw 6. Motorbike 7. Bicycle 8. Drainage 9. Educational institute 10. Mass media 11. Toilet
Social	*Regarding family members (bonding)* 1. Help getting to a cyclone shelter 2. Loan 3. Help to repairing house and property 4. Food and water 5. Useful items 6. Childcare or medical care *Regarding neighbors (bridging)* 7. Help getting to a cyclone shelter 8. Loan 9. Help repairing house and property 10. Food and water

	11. Useful items 12. Childcare or medical care *Regarding friends (bridging)* 13. Help getting to a cyclone shelter 14. Loan 15. Help repairing house and property 16. Food and water 17. Useful items 18. Childcare children or medical care *Regarding NGOs (linking)* 19. Help getting to a cyclone shelter 20. Loan 21. Help repairing house and property 22. Food and water 23. Useful items 24. Childcare or medical care *Regarding GOs (linking)* 25. Help getting to a cyclone shelter 26. Loan 27. Help repairing house and property 28. Food and water 29. Useful items 30. Childcare or medical care 31. Membership in NGO as credit recipient 32. Membership in NGO as credit recipient

Step 3: Recoding

The social, physical, natural, financial, and human capital indicators comprise categorical and numerical variables. Variables in categorical form are not suitable for PCA because the categories are transformed into a quantitative scale (Borja-Vega & de la Fuente, 2013). To overcome this problem, the household capital variables were recoded as dichotomous indicators that distinguished between owning and not owning the particular asset or as access or no access to services. Hence, all variables were coded as zero or one, where 1 = yes (owns or has access) and 0 = no (does not own or does not have access).

Step 4: Principal component analysis of each type of capital

In this step, PCA was performed for each type of capital to identify the component with the highest variance. The main purpose was to extract the most suitable factors. PCA identifies patterns and reveals underlying factors that describe the variation in the data (Kazmierczak & Cavan, 2011). To determine the number of factors to be retained for each component, the study used eigenvalues based on Kaiser's criterion (eigenvalues ≥ 1). See Table 5.13 for the PCA statistics.

Table 5.13: Results of PCA analysis: variance percentages and eigenvalues

Capital		Components										CVE[a]
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Social	Variance	12.0	7.9	5.5	4.7	4.5	4.0	3.8	3.5	3.5	3.3	53.7
	Eigen-values	3.8	2.5	1.7	1.5	1.4	1.3	1.2	1.1	1.1	1.0	
Physical	Variance	16.2	15.2	13.5	11.6	10.3						66.8
	Eigen-values	1.7	1.6	1.4	1.2	1.1						
Human	Variance	25.5	10.9	9.6	8.9	8.6						63.5
	Eigen-values	3.0	1.3	1.1	1.1	1.0						
Natural	Variance	38.2	33.7									71.9
	Eigen-values	1.1	1.0									
Financial	Variance	16.6	13.6	11.1	10.2	10.0						61.5
	Eigen-values	1.6	1.3	1.2	1.2	1.0						

[a] Cumulative variance explained

Step 5: Calculating the capital index

Table 5.13 reveals that 10 components were retained among the 32 items of social capital and 5 components were extracted for financial, physical, and human capital. Similarly, two components were retained from natural capital indicators. The cumulative variance explained by the extracted components of social, physical, human, natural, and financial capitals is presented in Table 5.13. To calculate the capital index, each selected factor was multiplied by its variance as shown below.

Social capital index (SoCI) = .120 * Factor1 + .079 * Factor2 + .055 * Factor3 + .047 * Factor4 + .045 * Factor5 + .040 * Factor6 + .038 * Factor7 + .035 * Factor8 + .035 * Factor9 + .033 * Factor10

Physical index (PhCI) = .161 * Factor1 + .152 * Factor2 + .135 * Factor3 + .116 * Factor4 + .103 * Factor5

Human capital index (HuCI) = .250 * Factor 1 + .109 * Factor2 + .096 * Factor3 + .089 * Factor4 + .086 * Factor5

Natural index (NaCI) = .382 * Factor1 + .337 * Factor2

Financial index (FiCI) = .165 * Factor1 + .136 * Factor2 + .110 * Factor3 + .102 * Factor4 + .100 * Factor5

Step 6: Reliability assessment and visualization

Reliability assessment was conducted to assess internal consistency. It helps in checking whether the indices had adequate precision. Cronbach's alpha coefficients were used to examine the reliability of the capital index. Cronbach's alpha coefficients can vary from 0 to 1, where 1 indicates perfect reliability and 0 indicates a very unreliable measure. In the early stages of research, a Cronbach's alpha coefficient approaching more than .60 is acceptable (Norusis, 2005 as cited in Mayunga, 2009). The study results found Cronbach's alpha coefficients of each capital to be higher than .60. Thus, generally, these sub-indices indicate a relatively high level of internal consistency.

Figure 5.6 presents the status of the types of household capital in the study villages. There is a clear difference among the villages, which increases our understanding of the livelihood status. The human capital index score was highest in Amadi and lowest in Deuli Subidhkhali. Similarly, the highest social capital index score was measured in Amadi and the lowest was in Deuli Subidhkhali. However, the highest financial capital found in Bagali and the lowest was in Char Ishwar. Regarding physical capital, the highest index value was in Bagali and the lowest in Char Ishwar. Unsurprisingly, the natural capital index presented a pattern different from the other types of capital. The highest index value of natural capital was found in Jhonjhonia-Gabbunia and the lowest in Tamaruddin (Table 5.6). Generally, these results indicate that the status of a household's capital differs in terms of spatial variation as also reported by Paul (2013).

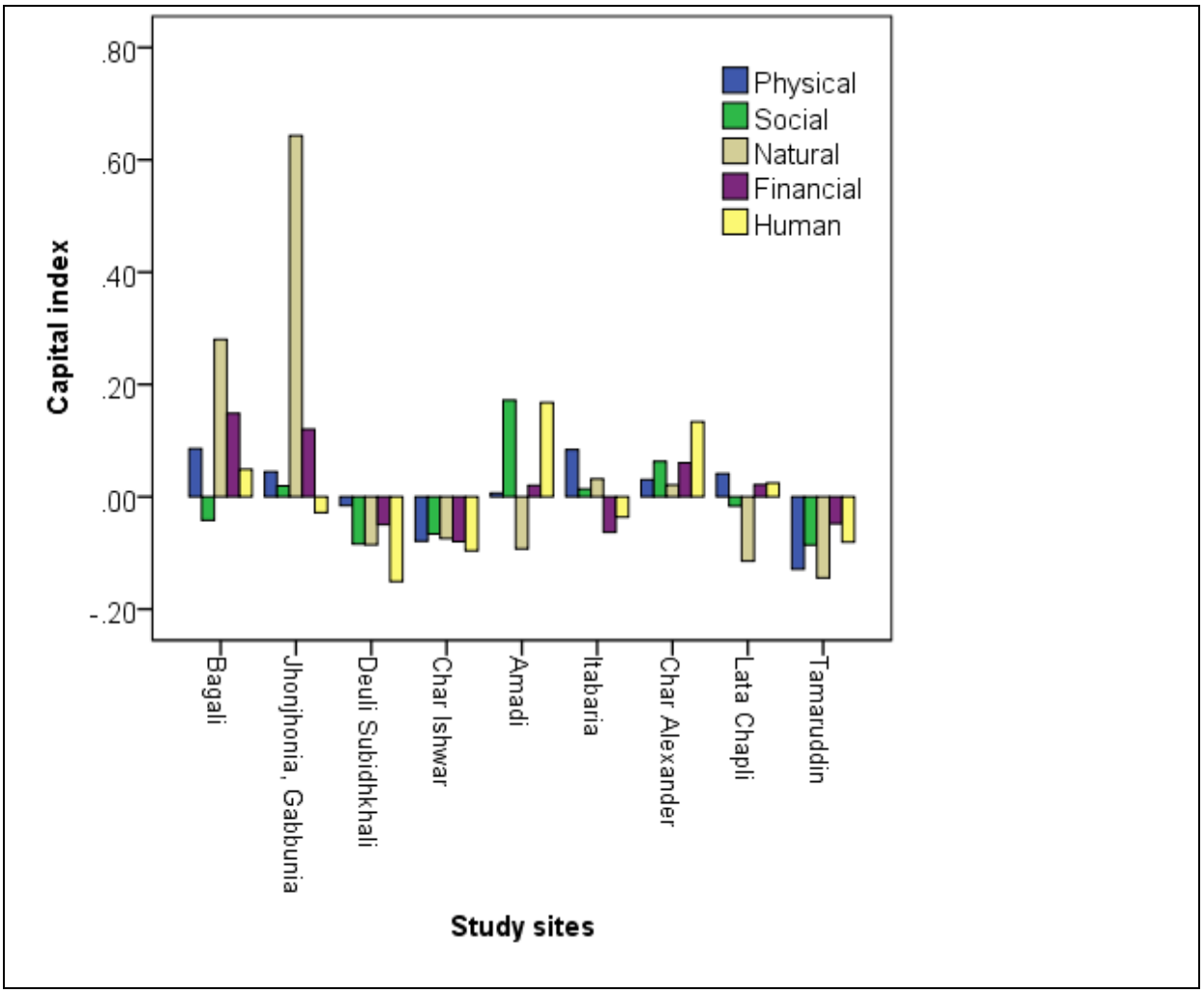


Figure 5.6: Household capital in the study villages; positive values are above the mean and negative values are below the mean

This study also examined the status of different types of capital in terms of geographical location (island, coastal, or inland areas). The results found that the highest capital scores were found in the inland area (i.e., Jhonjhonia-Gabbunia, Amadi, and Bagali), with values above the mean (Figure 5.6). This result reflects several underlying reasons. First, inland households have greater access to land. These households practiced intensive agricultural practices, for example, rice production and shrimp farming. In particular, shrimp farming changed the overall economic condition of households. Currently, inland households also practice mixed-crop cultivation. This type of agriculture is more common in inland areas than in shore and island areas and is profitable, yielding a positive impact on financial capital. Hence, these households were capable of buying other physical capital such as harvesters, tractors, motorbikes, fishing nets, etc. (IDs, 2014-15). In addition, due to the proximity to nearby colleges, universities, and upazila agriculture extension offices, inland households enjoyed more services, such as formal education, vocational training on shrimp farming,

training on disaster preparedness, and access to safe drinking water. Due to proximity to cities (Khulan), inland households also received various supports through GOs and NGOs. Paul (2013) points out that inland households fare better in disaster preparedness, rescue, and rehabilitation. In terms of cyclone and storm surges, inland households are relatively less affected because cyclones mostly strike the coastal region. Riverbank erosion is also rare in inland areas. Households here are permanent structures and people enjoy stronger financial capital and experience less environmental disasters; they have time and access to develop strong social bonds (Siddique, 2007). Due to the relative high level of financial capital, inland households are also capable of providing important support in the form of money, food, and house-repair items during emergencies.

All types of capital were relatively lower on the islands (i.e., Tamuriddin and Char Ishwar). Due to chronic riverbank erosion, households lost their cultivated land, housing, and sanitation. The islands accounted for the lowest financial capital, which revealed the generally poor economic condition (Islam, 2013). Due to financial limitations, children dropped out of school, creating an even lower level of educational attainment. In addition, GOs and NGOs were also less active on island villages due to poor communication and remoteness. Moreover, the majority of the respondents from the island are immigrants, thus, their bridging and bonding networks are relatively weak (Islam, 2013).

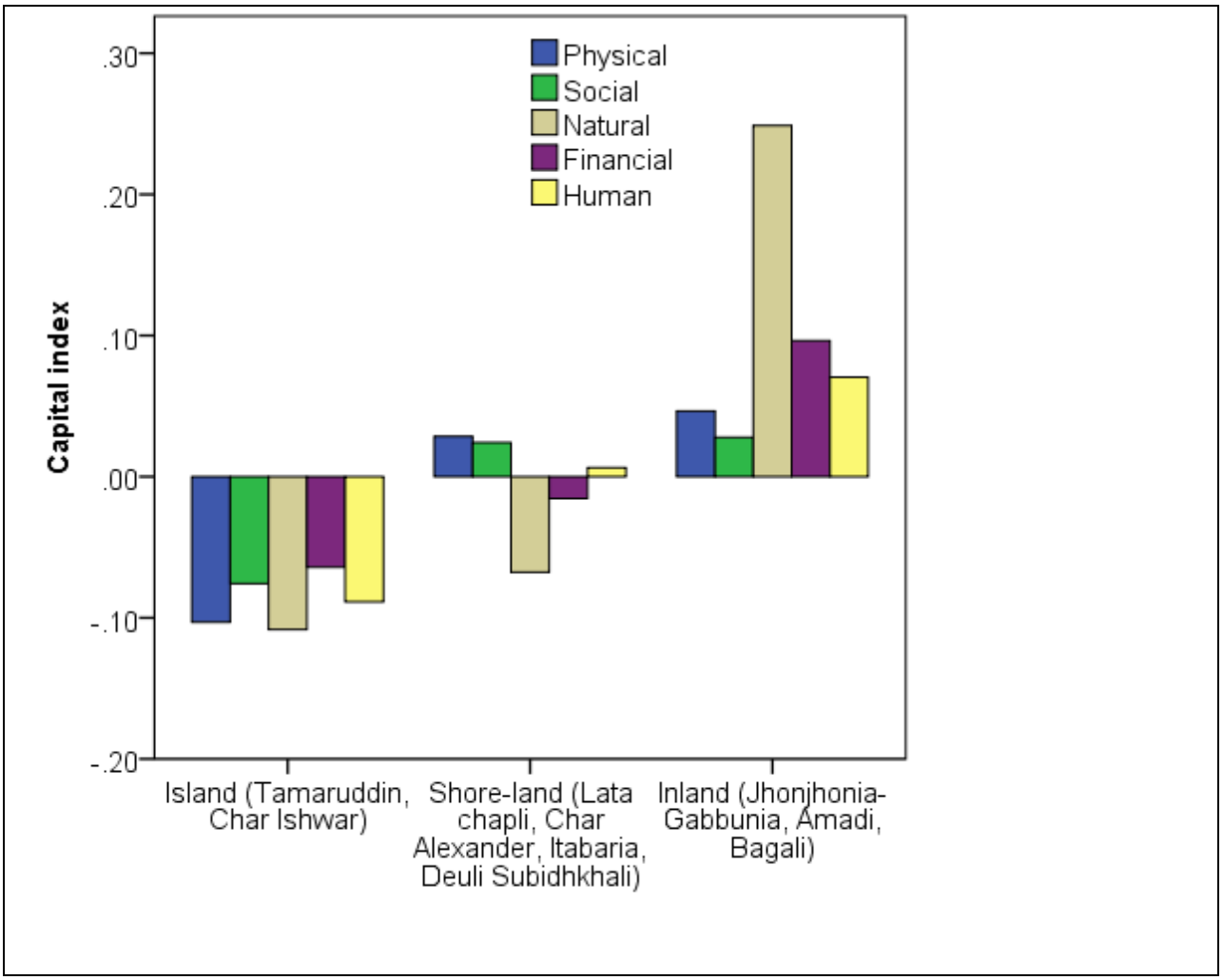


Figure 5.7: Capital index scores by geographical location type

Some households on the islands had relatively large tracts of land; however, these tracts were mostly sandy. Therefore, these households could cultivate only a single crop (e.g., pulses, linseeds) a year, which were also not the high-yielding variety.

The overall capital index was moderately high in shore-land areas (i.e., Lata Chapli, Char Alexander, Itabaria, and Deuli Subidhkhali) when compared that in island areas. Although shore-land households are vulnerable to cyclone and storm surges, they have access to mangrove forests, from where they can collect useful resources (i.e., wood, housing straws, and honey: see also Akter, 2013). Moreover, shore-land villages are located close to the Bay of Bengal, with greater access to the deep sea for fishing. In addition,

some tourist attractions are located in the shore-land, like Kuakata beach, drawing inland people. This creates additional employment opportunities for the local households (i.e., motorbike business as local transport for tourists, hotels).

5.3 Relationships among human and other types of capital (natural, social, financial, and physical)

This section examines the correlations among the types of capital. Table 5.14 shows the results. All types of capital positively and significantly correlate with each other, except for natural capital. The study shows that human capital has the strongest correlation to financial capital. This relationship is developed well in previous literature (Alshubiri, 2013). Human capital creates future financial value (Scmidt, 2004). Education has a significant impact on an individual's wage (Grossman, 2000). Yousuf (2013) point out that individuals with a higher level of education stand a greater chance at getting jobs with high salaries than less educated people. Individuals of the coastal area with a higher level of education mostly work in GOs and NGOs with good salaries in the nearest city or in Dhaka (Akter, 2012). They send money to their families monthly, which increases their household savings and covers daily expenditures. Besides formal education, VET, and practical skills, individuals' experiences also play a vital role in increasing household income and savings (Gupta, 2004). For example, many individuals received vocational training on carpentry. Currently, they are in the house-repairing sector, which is a source of financial support for their families. Individuals also had various kinds of practical knowledge and skills, particularly women, which had a beneficial impact on household income (Parveen, 2004). Coastal women engaged in small businesses, for example, running Pitha (rice cake) shops, grocery shops, boutique shops, and so on based on their practical knowledge. Financial capital was enhanced through shrimp cultivation as well in which most farmers used their practical skills to earn profits. In rural Bangladesh, since most of the agricultural practices are traditional, and require intense physical labor due to lack of access to machines and technology, only individuals with good health are able to invest more time in agricultural activities to increase their economic returns (see also Fakir, 2006). In addition, financial capital is crucial for strengthening human capital. For example, individuals need to manage the expenditure of attaining education, which involved buying books, finding accommodation (student hostel, mess), and paying for food. Financial capital is also essential in receiving better health care.

Table 5.14: Correlation matrix of types of capital

	Human	**Social**	**Physical**	**Natural**	**Financial**
Human capital		.159**	.381**	.023	.493**
Social capital	.159**		.078**	.052	.077**
Physical capital	.381**	.078**		.235**	.245**
Natural capital	.023	.052	.235**		.139**
Financial capital	.493**	.077**	.245**	.139**	

** = $p < 0.01$ (two-tailed tests of significance)

The findings revealed that human capital is positively correlated with physical capital. Grier (2002) empirically proved a similar relationship. He found that human capital is jointly endogenous in that it increases the stock of physical capital. Human capital contributes to the enhancement of physical capital in both direct and indirect ways (Alam, 2013). Houssain (2013) looks at the direct positive effect of human capital on physical capital. He noticed that cyclone and storm surges mostly destroyed housing, sanitation, and drainage in the coastal areas of Banglades leaving behind the task of reconstruction. Individuals used their skills and knowledge to rebuild their houses, toilets, drainage systems, etc. (see also Hossain, 2013) after each such event. Illiterate people cared less about access to toilets/latrines, proper drainage systems, which in turn, created a lower level of physical capital. One of the direct effects of human capital on physical capital was noted by Rahman (2011) in his investigation of the Bangladeshi coast. He found that the condition of housing and sanitation among the educated families was better than the conditions prevailing among illiterate families. He attributed this to relatively higher levels of financial capital among higher skilled and educated people. This indicated a causal relationship among the human, financial, and physical capital. As the current study shows human capital has a positive impact on financial capital, and financial capital has a positive impact on physical capital (Table 5.14). An individual's knowledge and skills are also important in tackling and handling new technologies, such as smart phones, computers, and harvesters. An earlier investigation (Bryant, 2016) indicates that human capital and physical capital are often complementary, for example, to get education, it is essential to have access to educational institutions like schools, colleges, and universities.

Regarding the relationship between human and social capital, the study found that human capital is positively and significantly related to social capital. A number of studies (Andreoni et al., 2004; Smith, 1994; Wilson, 2000) support this finding. An individual's education can enhance social capital accumulation directly by helping the individual develop skills and cognitive capacities that facilitate participation in groups and associations (OECD, 2010). Education fosters civic skills directly through the curriculum by providing individuals with opportunities to discuss social disputes and problems in the classroom and by promoting habits of associational involvement, whereby students are encouraged to volunteer in their communities. More educated individuals may enjoy higher levels of social capital also because they secure jobs that allow for greater flexibility in building social ties (e.g., bridging, linking) and strong bonds with family members, neighbors, and friends. In the surveyed area, it was found that individuals received various forms of support, such as loans, food, safe drinking water, and house repairing materials, through their bonding, bridging, and linking ties. However, human capital is important to foster that kind of support. For example, if an individual wants to support his/her neighbor by repairing his/her house, he/she would first need to know how to repair it. On the contrary, within social networks, exchange of physical labor is a common practice among coastal

people at the early stage of recovery. Sheheli (2012) found that individuals with good health are likely to provide greater support to neighbors. Conversely, social capital is also important for enhancing human capital. In the study area, it was found that many individuals learned a variety of skills, such as homestead gardening, tailoring, crop seeds saving, mixed crop cultivation, and so on through participation with GOs and NGOs (Key informants' interviews, 2014-2015).

However, the relationship between human and natural capital is not statistically significant. Similar results were found by Ahsan (2012) in the context of the Bangladeshi coast. Nuruzzaman (2009) found individuals with large tracts of land and low levels of education, while higher educated individuals had smaller tracts of land. In addition, some individuals had low levels of education and were landless. However, natural capital is positively correlated with physical and financial capital. Thus, although natural capital is not significantly related to human capital, it is important in strengthening financial and physical capital.

The study's third question posits an association between human and other types of capital (natural, social, financial, and physical) at the household level. As discussed above, human capital is positively and significantly ($p < .01$) related with the other forms of capital, that is, physical, financial, and social. Therefore, human capital can be considered an entry point in fostering other forms capital to enhance disaster resilience.

CHAPTER SIX: THE RELATIONSHIP BETWEEN DISASTER RESILIENCE AND HUMAN CAPITAL

The focus of the study is to identify the relationship between disaster resilience and human capital. Two methodological steps were taken to do this. First, household disaster resilience was measured. This was done using a number of indicators related to cyclones and storm surges and their relevant components selected and integrated into a composite index using a principal components analysis (PCA). Then, the relationship between disaster resilience and human capital was investigated through logistic regression. This provided information on how disaster resilience was enhanced by human capital.

6.1 Measuring disaster resilience

Disaster resilience is a multifaceted concept comprising many factors (see Chapters 2 and 3). Developing a comprehensive approach to assessing disaster resilience incorporating all its dimensions is challenging. Currently, there is no widely accepted methodological approach to assess disaster resilience (Kotzee & Reyers, 2015). However, social scientists agree that the initial point for measuring disaster resilience in communities or households is to use benchmark tools for a better understanding of the components of resilience (Cutter et al., 2008; Asadzadeh et al., 2015). The widely accepted tool to measure disaster resilience is the composite index (Beccari, 2016), which is an aggregation of a set of variables from particular components used to summarize the characteristics of resilience to a specific disaster (Saisana & Tarantola, 2002; Salvati & Carlucci, 2014). Constructing a composite index is an effective way to assess the extent of disaster resilience with accuracy (Bene et al., 2016).

6.1.1 Constructing the composite index

Numerous methods have been used to construct composites, such as hierarchical and similar deductive approaches, principal components analysis (PCA), stakeholder-focused methods, and relational analyses (Beccari, 2016). This study uses a transparent weighting system to account for the variance in the data. Several steps were employed in the process of constructing a composite measure of household disaster resilience in this study.

6.1.1.1 Step 1: Theoretical orientation

As discussed in Chapter 3, disaster resilience deals with the capacity to absorb disturbances, to self-organize, and to learn and adapt to disasters (Walker et al., 2002). However, the term "capacity" comprises components that relate to the underlying factors of disaster resilience (Alinovi et al., 2009). From the theoretical

discussion (Chapters 2 and 3), disaster resilience comprises four types of components: (1) household infrastructure (HIC), (2) household economic (HEC), (3) household self-organization and learning (HSoLC), and (4) social safety nets (SSN). Each component was estimated separately to construct a composite of household resilience.

Algebraically, household resilience is expressed by the following equation:

$R_{hi} = \int HIC, HEC, HSoLC, SSN$ ..... (1)

where R_{hi} = household disaster resilience index, HIC = household infrastructure component, HEC = household economic component, HSoLC = household self-organization and learning component, and SSN = social safety nets.

6.1.1.2 Step 2: Methodological approach

Most hierarchical methods used in disaster resilience studies deal with measured variables so that the regression properties are extended. However, the methodological approach of the current study used observed as well as latent variables, which are difficult to manage (Figure 6.1). Due to the complexity of this approach, two alternative estimation strategies were used to construct the composite disaster resilience measure: structural equation modeling (SEM) and multi-stage modeling (Alinovi et al., 2009).

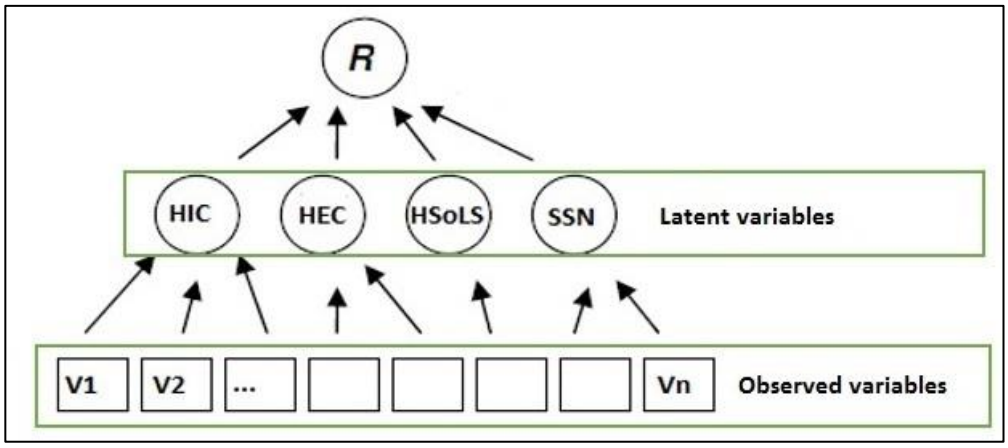


Figure 6.1: Path diagram of the household disaster resilience composite measure.

Source: Adapted from Alinovi et al. (2009)

SEM is a factor analysis type model that measures the latent variables via the observed variables, and it is used to identify the relationships among latent variables (Bollen, 1989). SEM is limited to normally distributed, observed variables. Although a growing body of literature suggests some steps to broaden SEM to

include nominal and ordinal variables, there are computational difficulties (Muthén, 1984). In this study, the variables of disaster resilience were continuous, categorical, ordinal, and nominal. Considering the different measurements of data, SEM was not regarded a suitable method to construct a composite index of disaster resilience.

The other methodological approach of measuring disaster resilience is a multi-stage technique that individually measures the latent variables based on the relevant observed variables (Figure 6.1). This method uses sets of observed variables (v_1, $v_2 \ldots v_n$) to estimate the underlying latent variables, such as HIC, HEC, HS_OLC, and SSN. The method of generating latent variables depends on the scales of the observed variables. In general, most multivariate methods are limited to continuous variables, and various techniques, such as re-scaling, standardization, and weighting, are necessary to adapt non-continuous variables for analysis. The variables measuring disaster resilience in the current study are categorical, continuous, nominal, and ordinal; moreover, they are measured using different scales, which complicates the situation.

To resolve this problem, this study employed a multi-stage estimation strategy, for two reasons. First, the available variables were not all normally distributed and not in equal units, requiring different techniques at different stages. Second, measuring the components of disaster resilience separately improves the flexibility of the model and provides insight as to which indicators have a relatively higher impact on a particular component.

There are several multivariate techniques for multi-stage estimation, such as factor analysis, PCA, correspondence analysis, multidimensional scaling, and optimal scaling. This study used PCA to construct the resilience composite index. PCA relies on the variation and co-variation of the data matrix to construct weights in the component index (Saisana & Tarantola, 2002). Vyas and Kumaranayake (2006) argue that the PCA weighting method is objective, computationally easy, and compatible with survey data and databases. PCA generated weights on the variables of disaster resilience.

6.1.1.3 Step 3: Identifying the variables of each resilience component

Identifying the relevant and robust variables to construct the composite of disaster resilience was a crucial step in disaster resilience assessment. However, these variables were inconsistent because of the locational variation in the case studies and the types of disasters (cyclones and storm surges, floods, and so on). To improve the suitability of the resilience variables, the selected variables had to satisfy the following criteria:

- The selected variables should be justified by previous studies on disaster resilience.
- The variables must be relevant to the scale of assessment. Disaster resilience is defined at different levels of analysis, such as community, household, and individual. For example, place attachment is a justified variable to measure community resilience (Sherrieb et al., 2010), but to measure disaster resilience at the household level, Ansell et al. (2010) found that it is less logical to measure household disaster resilience.
- The variables must be measurable and easily interpretable.
- Their measurement must be robust.
- They should be used particularly in disasters/events/shocks/stressors.

This study selected the variables most relevant to cyclones and storm surges. Using the above-listed selection criteria, 19 variables of disaster resilience were chosen. Table 6.1 lists the variables by component and presents their justifications.

Table 6.2: Variables selected to measure the four components of disaster resilience at the household level

Component	Variable	Justification
Household infrastructure component (HIC)	1. Housing type	Akter & Mallick, 2013; Cutter et al., 2003, 2014; Sutter & Simmons, 2010; Tierney & Bruneau, 2007; Twigg, 2009
	2. Presence of sanitation	Akter & Mallick, 2013; Campbell et al.,
	3. Access to sources of clean water	Akter & Mallick, 2013; Campbell et al., 2009
	4. Availability of electricity	Cutter et al., 2003
Household economic component (HEC)	5. Household income	Akter & Mallick, 2013; Cutter et al., 2003, 2014; Enarson, 2012; Norris et al., 2008; Ranjan & Abenayake, 2014; Sherrieb et al., 2010; Thulstrup, 2015; UNDP, 2014
	6. Ability to sell parts of produced food	FAO, 2013
	7. Reduced dependency on purchased food	Rose & Krausman, 2013
	8. Non-farm self-employment	Rose & Krausman, 2013; Sherrieb et al., 2010
Household self-organization and learning component (HSoLC)	9. Migration of household members due to food and	Sendai Framework for Disaster Risk Reduction, 2015-2030
	10. Ability to use machineries	UNFCCC, 2013
	11. Household head's ability to make decisions	All India Disaster Mitigation Institute (AIDMI), ICSD, Climate & Development Knowledge Network (CDKN), 2013
	12. Ability of household head and wife to make decisions regarding land	Villamor et al., 2014; UNISDR, 2009
	13. Application of mixed crop cultivation methods	Borron, 2006; Nibanupudi & Shaw, 2015
Social safety nets (SSN)	14. Business partnership by mobile	Boarini et al., 2014
	15. Social discussion on disputes	Bene et al., 2016
	16. Healthcare facilities	Paterson, 2014
	17. Access to public authorities (*union parishad*, agricultural extension office, etc.)	Paul, 2013
	18. Availability of cyclone shelter	Paul & Routray, 2011a
	19. Help from friends	Ahsan, 2013

6.1.1.4 Step 4: Data recoding and standardization

First, the variables were recoded into different scores based on quality and quantity (see Smits & Steendijk's wealth index, 2013). The determination of high, medium, and low quality or quantity was based on normative approaches. "Normative" refers to the use of expert arguments, stakeholder decisions, public opinion, etc.[3] (Decancq & Lugo, 2013).

Second, the selected variables were standardized using a Min-Max rescaling method to create a set of variables on the same scale. Min-Max rescaling places variables into an identical range between zero and one. Min-Max rescaling was performed using the following equation (Cutter et al., 2010; Zebardast, 2013):

$$TXi = \frac{Xi - Ximin}{Ximax - Ximin}$$

where TX_i is the transformed value of the original variable X_i, and X_{imax} and X_{imin} are the maximum and minimum values of the original value.

A score of zero is the lowest rank on particular variables and one is the highest (see Cutter, 2010; Asadzadeh et al., 2015; Cutter et al., 2014; Rutstein & Johnson, 2004). The variables were standardized and transformed so that an increase in the value of a variable corresponds to an increase in the extent of resilience to cyclones and storm surges. For example, sanitation systems in the data are expressed in four categories: (1) *pacca* (made of concrete), (2) semi-*pacca* (floor and wall made of concrete and roof made of tin), (3) *kaccha* (made of straw), and (4) others (open pit, bucket latrine). Based on quality, *pacca* sanitation had the highest score (1) and others had the lowest score (0). However, all other values were scaled between zero and one by subtracting the minimum value and dividing by the range. For example, semi-*pacca* scored .66 and *kaccha* scored .33. This standardization technique is common in social research (Tarabusi & Guarini, 2012).

[3] For example, WHO and UNICEF (2014) indicated the following categories of sources of drinking water and sanitation: bottled or piped water is superior to water from tube wells. Moderate quality water comes from public taps, protected wells, tanker trucks, and low-quality drinking water comes from unprotected wells, boreholes, springs, surface water, and so on. High-quality sanitation was any type of private flush toilet made of concrete; moderate quality was public toilets with floors and walls made of concrete and roofs made of tin or improved pit latrines. Low-quality sanitation was traditional pit latrines, hanging toilets, or no toilets. In this context, the variables were recoded as 3 = high quality, 2 = medium quality, and 1 = low quality.

6.1.1.5 Step 5: PCA to extract latent variables of each component

In this phase, the most suitable factors from each component of disaster resilience were extracted. PCA identified patterns and revealed the underlying factors that accurately described the variation in the data (Kazmierczak & Cavan, 2011). PCA was performed on each component to identify the variables with the highest variance. However, some preconditions were necessary to select PCA methods. For example, sample size is one of the main preconditions (Hogarty, 2005). Numerous studies argue that sample size should be more than 200 (Williams et al., 2012). Another precondition is the factorability of the correlation matrix of variables, which reveals that there are at least some correlations among the variables such that coherent factors can be extracted (Asadzadeh, 2015). Testing the appropriateness or suitability of the data for PCA analysis is another precondition, which was done using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity.

First, based on Kaiser's assumption, only those factors with an eigenvalue of 1.0 or more were extracted with the variances of each factor (see Table 6.2 below). Second, factor loadings were presented for each observed variable. Factor loadings indicated the correlations between the observed variables and the latent factors (Pittayachawan, 2011) for each component of disaster resilience. To minimize the number of variables with high loadings on particular factors, a Varimax rotation was performed. To address the assumptions discussed above, the PCA outputs of each component are presented below.

A. HIC

HIC directly relates to a household's ability to adapt to cyclones and storm surges in coastal areas of Bangladesh (Ahmed et al., 2016). This analysis selected four variables (housing, sanitation, sources of drinking water, and availability of electricity) to assess the HIC of disaster resilience. All the variables were aimed at measuring household infrastructure, so that a high correlation among them produced latent variables that fit the common pattern of the data.

Table 6.2: Eigenvalues and variances explained with extracted factors (shaded) of HIC

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	1.369	34.231	34.231	1.369	34.231	34.231	1.275	31.871	31.871
2	1.167	29.168	63.400	1.167	29.168	63.400	1.261	31.529	63.400
3	.839	20.964	84.363						
4	.625	15.637	100.000						

KMO and Bartlett's Test: $X^2 = 1036$, $p < .001$

As discussed in section 6.1.1, the current study considered latent as well as observed variables to measure disaster resilience. The PCA extracts factors that are meaningful and considered the underlying latent variables (Pittayachawan, 2011) for measuring household infrastructural components. Table 6.2 above presents the eigenvalues and variances of each latent factor of HIC. As presented in Table 6.2, these two extracted factors are latent variables in terms of the household infrastructure component of disaster resilience, while housing, sanitation, access to electricity, and sources of drinking water are observed variables. Latent factors are produced from a linear combination of the weights of the four observed variables (Table 6.3). This explanation about factors is applicable for all others component, that is, HEC, HSoLC, and SSN.

Table 6.2 shows that the eigenvalues of the first two factors are greater than 1, and that the cumulative variance of the two factors is 63.4%. This value indicates that the two factors explain 63.4% of the variance of the HIC, implying that these two latent factors present the greatest proportion of household infrastructure components of disaster resilience. However, Table 6.3 shows the factor loadings that demonstrate the effect of observed variables, such as housing, sanitation, access to electricity, and sources of drinking water, on the latent factor of HIC, that is, factors 1 and 2. All the variables are positively related to the factors of the HIC of disaster resilience. However, the housing condition had relatively higher loadings (.719) on Factor 1, indicating that housing plays a major role on HIC. On the contrary, sources of drinking water had higher factor loadings (.679) on Factor 2, revealing its relatively high contribution to HIC. The overall understanding of this result is that housing and sources of drinking water are key attributes of the infrastructure component of disaster resilience. Sanitation and access to electricity had almost the same factor loadings on the two identified factors of HIC.

Table 6.3: Factor loadings on HIC

Variable	Component	
	Factor 1	Factor 2
Housing	.719	.339
Sanitation	.547	.468
Access to electricity	.544	.609
Sources of drinking water	.506	.679

B. HEC

The PCA factor analysis extracted two factors as underlying latent factors to measure HEC. Table 6.4 shows that the eigenvalues were 1.497 and 1.023, both of which meet the Kaiser criterion (eigenvalues ≥ 1.0). Total variance of the two factors is 63%, implying that the majority (with respect to cumulative variance) of the HEC was explained by these two latent factors.

Table 6.4: Eigenvalues and variance explained with extracted factors (shaded) HEC

Compo-nent	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	1.497	37.423	37.423	1.497	37.423	37.423	1.469	36.732	36.732
2	1.023	25.583	63.006	1.023	25.583	63.006	1.051	26.273	63.006
3	.848	21.205	84.211						
4	.632	15.789	100.000						

KMO and Bartlett's Test: $X^2 = 1200$, $p < .001$

Table 6.5 presents the factor loadings of each HEC variable separately, showing that all the variables of HEC positively correlate with Factor 1. However, the ability to sell excess food produced (rice, wheat, pulses, and maize) and being less dependent on purchased food have higher factor loadings on Factor 1 among the four HEC variables. This indicates that these two variables contribute more to HEC regarding Factor 1. However, household income makes an almost equal contribution to the two factors. It is important to point out that less dependency on purchased food negatively correlates with Factor 2. This relationship is difficult to interpret. However, this might be applicable for those households that earn their income through employment. They are completely engaged in their employment and have less time to engage in agricultural activities for producing food. Thus, they are dependent on purchased food but that does not mean they are less economically resilient. Self-employment is crucial to disaster resilience, particularly during the recovery phase (ILO, 2013). Table 6.5 reveals that non-farm self-employment has very high factor loadings (.917), showing the dominant role of HEC in disaster resilience.

Table 6.5: Factor loadings on HEC

Variable	Component	
	Factor 1	Factor 2
Household income per month	.561	.316
Ability to sell excess produced food	.777	.156
Less dependency on purchased food	.748	-.241
Non-farm self-employment	.136	.917

C. HSoLC

HSoLC is tightly linked to the capacity to resist, absorb, and recover from a disaster (Barquet et al., 2016). The variables used to generate the HSoLC were short-term migration of household members, ability to use machines, and capacity to apply mixed-crop cultivation (rice with shrimp or shrimp with freshwater fish). This component also includes two variables measuring the household head's capacity to make decisions regarding land use and the land-use decisions made jointly with the wife. Factor analysis using PCA retained two factors for the HSoLC, as presented in Table 6.6.

Table 6.6: Eigenvalues and variance explained with extracted factors (shaded) of HSoLC

Compo-nent	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	1.565	31.290	31.290	1.565	31.290	31.290	1.532	30.632	30.632
2	1.165	23.295	54.585	1.165	23.295	54.585	1.198	23.953	54.585
3	.978	19.554	74.139						
4	.824	16.486	90.625						
5	.469	9.375	100.000						

KMO and Bartlett's Test: $X^2 = 1631$, $p < .001$

Table 6.7 shows that all the variables are positively correlated with the two factors, except land-use decisions made by the household head. Although land-use decisions by the household head and land-use decisions made jointly with the wife strongly correlated with Factor 1, land-use decisions made by the household head negatively correlated with Factor 2. Apparently, decisions regarding land use made by the household heads do not always improve disaster resilience at every stage. On a few occasions, disaster resilience might be reduced through poor decision making (Pramanik et al., 2014).

Table 6.7: Factor loadings on HSoLC

Variable	Component	
	Factor 1	Factor 2
Short-term migration	.139	.744
Using machines	.297	.655
Land-use decisions by household head	.856	-.155
Land-use decisions by household head and wife	.839	.250
Application of mixed crops	.143	.308

Temporary migration of household members can be an effective adaptation strategy in response to natural disasters in the coastal area of Bangladesh (Mallick, 2011; Gray & Mueller, 2012). This study found higher factor loadings (.744) for short-term migration by household heads, suggesting that short-term migration at a crucial time plays a major role in HSoLC.

D. SSN

The estimation of the SSN component involved five variables: access to (1) business partnership by mobile phone, (2) fresh water, (3) health, (4) public authorities, (5) cyclone shelters, and (6) help from friends. Two factors were obtained through PCA factor analysis (see the shaded cells in Table 6.8).

Table 6.8: Eigenvalues and variance explained with extracted factors (shaded) of SSN

Compo-nent	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	1.471	29.414	29.414	1.471	29.414	29.414	1.468	29.362	29.362
2	1.009	20.184	49.598	1.009	20.184	49.598	1.012	20.237	49.598
3	1.000	19.998	69.597						
4	.949	18.983	88.579						
5	.571	11.421	100.000						

KMO and Bartlett's Test: $X^2 = 1246$, $p < .001$

As presented in Table 6.9, business partnerships via mobile phones have higher loadings on Factor 2. Using mobile phones increases access to business opportunities. In particular, businesses can quickly send money through *bKash* (mobile bank) to their business partners (bKash, 2015). Moreover, coastal residents gain information about updated rates of products, which improves the market understanding of local buyers and sellers.

Table 6.9: Factor loadings on SSN

Variable	Component	
	Factor 1	Factor 2
Business partnership by mobile	.088	.986
Discussions about access to fresh water	.312	-.083
Access to health	.337	.054
Access to public authorities	.807	.153
Access to cyclone shelter	.775	.057
Help from friends	.665	.240

Table 6.9 shows that access to public authorities is particularly important (factor loading = .807) regarding Factor 1 in terms of SSN. This finding was expected because coastal households receive significant support from local public authorities, such as the union *parishad*, the agricultural extension office, or the union disaster management committee, during and after disasters (relief distributions, seeds, training programs, etc.). Although all the variables of SSN positively correlated with Factor 1, the variable measuring discussions about fresh water is negatively correlated with Factor 2, which might be the reason for conflicts in the community regarding water allocation.

6.1.1.6 Step 6: Estimate resilience

PCA obtained two factors for each resilience component as described above. Altogether eight factors were extracted to estimate disaster resilience. The factors became covariates through the construction of a composite of household disaster resilience (Frankenberger & Nelson, 2013). Since all the measured latent factors were normally distributed with means of zero and variances of one, it seemed suitable to apply PCA. A factor analysis was performed through the iterated principal factor method among the retained eight factors, which repeatedly re-estimated communalities. The results of the PCA were satisfactory. Five factors were extracted from the original eight factors, as shown in Table 6.10. However, Factor 1 alone explained more than 21% of the total variance. In addition, Factor 2 explained more than 15% of the variance, with Factors 3, 4, and 5 accounting for 13%, 12%, and 11%, respectively.

Table 6.10: Eigenvalues and variance explained with extracted factors (shaded) of HIC, HEC, HSoLC, and SSN

Compo-nent	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	1.688	21.094	21.094	1.688	21.094	21.094	1.465	21.071	21.071
2	1.238	15.477	36.571	1.238	15.477	36.571	1.084	15.355	36.426
3	1.111	13.765	50.336	1.111	13.765	50.336	1.213	13.563	49.989
4	1.013	12.314	62.650	1.013	12.314	62.650	1.110	12.171	62.160
5	1.001	11.400	74.050	1.001	11.400	74.050	1.255	11.253	73.413
6	.804	10.049	84.099						
7	.690	8.626	92.726						
8	.582	7.274	100.000						

KMO and Bartlett's Test: $X^2 = 2208$, $p < .001$

Table 6.11 shows that all the latent factors of the components of resilience (HIC, HEC, HSoLC, and SSN) have a strong and positive correlation with Factor 1. In particular, HEC is strongly correlated with Factor 1 and moderately correlated with Factors 2, 3, and 4. This result indicates that the HEC has more influence on household disaster resilience with regard to Factors 1 and 5.

Table 6.11: Factor loadings[a] of HIC, HEC, HSoLC, and SSN

Component	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
$HEC_{factor1}$	.660	.283	.338	.285	.006
$HSoLC_{factor1}$	.611	.333	.114	-.342	.366
$HIC_{factor1}$	.559	.444	.138	.062	.243
$HSoLC_{factor2}$	.293	.561	.204	.345	.578
$SSN_{factor1}$	.160	.526	.654	.243	-.042
$SSN_{factor2}$	.379	.341	-.634	.027	.047
$HIC_{factor2}$	.353	.156	.242	.766	.229
$HEC_{factor2}$	.433	.343	.160	.135	.659

[a]Shaded cells represent the maximum factor loadings on particular factors of resilience components

HSoLC has higher loadings on Factor 2, SSN has higher loadings on Factor 3, and HIC has higher loadings on Factor 4 (Table 6.11). Although most of the components were positively associated with the five factors, $HSoLC_{factor1}$ was weakly and negatively associated with Factor 4. This finding is most likely because of a lack of self-organizing skills, which ultimately plays a negative role in disaster resilience. For example, some household heads pointed out during the informal discussions that the production of shrimp was down because of mixed-crop cultivation (shrimp and rice). The negative relationship of SSN might reflect social disputes, irregular communication with public authorities (*union parishad*), and discrimination in relief distribution that lowered disaster resilience.

The factor loadings indicated that household disaster resilience is not a one-dimensional concept. For example, $HIC_{factor2}$ is moderately associated with Factors 1, 2, and 3. However, it is strongly associated with Factor 4, as shown in Table 6.11. Consequently, the other four factors must be included in the measure of household disaster resilience although Factor 1 explains more than 21% of the variance (Table 6.10). As demonstrated by the FAO resilience tool (2010), it is feasible to use a weighted sum of the five factors (Table 6.10) because they are orthogonal to each other (as based on the PCA). Therefore, the risk of multicollinearity among the factors is avoided. To estimate household disaster resilience, the four factors must therefore be generated using Thompson's (1951, 2004) regression methods,[4] in which each factor must be multiplied by its own proportion of variance explained.

Household disaster resilience = .212 * Factor1 + .177 * Factor2 + .135 * Factor3 + .125 * Factor4 + .114 * Factor5

6.1.1.2 Phase 7: Categorize and visualize disaster resilience

After constructing the disaster resilience index, the next steps were categorization (Table 6.12), and visualization (Figure 6.2) to gain a better understanding of household disaster resilience in the nine villages. The categories were estimated in intervals of ±.50 standard deviations from the mean. Values above the mean were considered high (coded "1"), and values below the mean were considered low (coded "0") disaster resilience (Kotzee & Reyers, 2015; Asadzadeh et al., 2015; Bene et al., 2016; Cutter et al., 2014).

Cross tabulations brought out the variation in disaster resilience among the study villages. The results found that six of the study villages were relatively less resilient to cyclones and storm surges. In particular, Deuli Subidkhali and Char Alexander had the highest percentages of low-resilience households (82% and 83%, respectively). This finding might be a consequence of the effects of the two recent cyclones, Sidr (2007) and Aila (2009), which significantly lowered the levels of household disaster resilience in the study area. Deuli Subidkhali was seriously affected by Sidr and Aila. Agricultural land was salinized because of Aila, which reduced seasonal crop production for many years (Rabbani et al., 2013). Moreover, other assets of daily life, such as housing, sanitation, and availability of safe drinking water, were also damaged by Cyclones Sidr and Aila (Bangladesh Bureau of Statistics-BBS, 2010). Chronic riverbank erosion could be the

[4] "Factor scores reveal the composite (latent) scores for each subject on each factor" (Thompson, 2004; Wells, 1999). Factor scores are analogous to the Ŷ (Yhat) scores in the regression equation and are calculated by applying the factor pattern matrix to the measured variables. Factor scores are most commonly used for further statistical analyses in place of measured variables, especially when numerous outcome scores are available. "In real research, factor scores are typically only estimated when the researcher elects to use these scores in further substantive analyses (e.g., a multivariate analysis of variance comparing mean differences on three factors across men and women)" (Thompson, 2004, pp. 57-58; cited in Factor Scores, Structure, and Communality Coefficients: A Primer by Odum, 2011, 5-6).

cause for the low levels of resilience in Char Alexander. Every year, the residents of Char Alexander lost valuable assets such as cultivated land, settlements, roads, etc.

However, the other three villages (Amadi, Bagali, and Jhonjhonia) were found to be relatively resilient, which could be a result of the relatively high household incomes achieved through shrimp cultivation and improved communication with the nearest city (Khulna). Table 6.12 shows that Amadi was the most resilient of the study villages. This finding might reflect its stable conditions regarding riverbank erosion and salinity intrusion. In addition, farmers used high-yield varieties of rice (T. Aman-Transplanted Aman; T. Aus-Transplanted Aus) and mixed-crop cultivation that increased the level of resilience in this area (Department of Agriculture Extension-DAE, 2011).

Table 6.12: Level of household disaster resilience in the study sites at the union level (N=1178)

Study site	**Number of cases (n) and percentage (%)**	**Level of disaster resilience**		
		Low	High	Total
Jhonjonia, Gabbunia	n	84	68	152
	%	55.3	44.7	100.0
Lata Chapli	n	95	61	156
	%	60.9	39.1	100.0
Itabaria	n	108	26	134
	%	80.6	19.4	100.0
Deuli Subdikhali	n	128	27	155
	%	82.6	17.4	100.0
Char Alexander	n	115	33	148
	%	77.7	22.3	100.0
Tamaruddin	n	103	35	138
	%	74.6	25.4	100.0
Char Ishwar	n	108	36	144
	%	75.0	25.0	100.0
Amadi	n	20	48	68
	%	29.4	70.6	100.0
Bagali	n	39	44	83
	%	47.0	53.0	100.0
Total	n	800	378	1178
	%	67.9	32.1	100.0

*** $p < 0.001$; Chi-square = 636.49(8)***

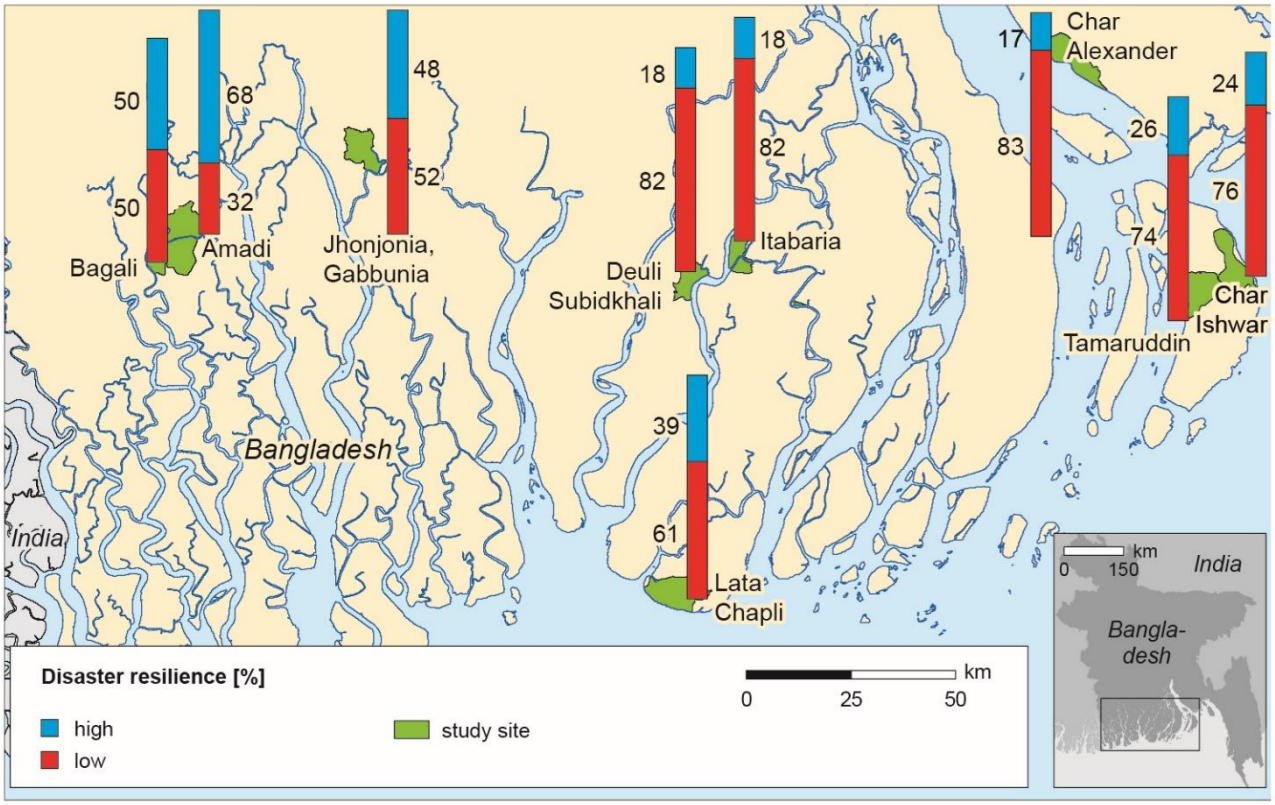


Figure 6.2: Level of household disaster resilience in study villages (Layout: Al-Maruf; Cartography: U. Schwedler).

6.2 Identification of significant indicators of human capital in relation to disaster resilience

As mentioned earlier, the focus of the study was to investigate the relationship between human capital and disaster resilience. Logistic regression was chosen as the method of analysis because, one, the dependent variable of the study is disaster resilience, which is a binary variable, and logistic regression is particularly suitable for handling binary dependent variables; and, two, human capital is an independent factor comprising a number of ordinal and categorical variables and logistic regression is suitable for ordinal and categorical data as well (Peng & So, 2002).

However, the most challenging part of this analysis was the use of multi-level data (i.e., human capital at the individual level and disaster resilience at the household level) in a single model. Although there is ongoing debate, earlier studies (Ahmed & Morduch, 1993; Thomas & Chen, 1994; Subramanian, 1994; Fuwa, 2006) have looked at some aspects of individual data with aggregate household-level data. Fuwa (2006) suggests that individual data increase the reliability and power of the test for a household-level analysis. Chromy and Abeyasekera (2000) note that the inclusion of variables from different levels, that is, individual

and household, in single model implies that the model takes into account the variability at the two levels of hierarchy. Standard regression procedures generally ignore the correlation structure between household and individual levels. Through an investigation using multi-level data (households and village), Chromy and Abeyasekera (2000) concluded that it is possible to explore the relationship between dependent and independent variables through different levels of hierarchical data. With the support of this literature, the current study considered two levels of data (i.e., human capital at the individual level and disaster resilience at the household level) in the logistic regression model.

Table 6.13 lists the variables used to measure human capital in the study area. Fourteen variables in six pillars were used to measure human capital. The first category comprised the number of years of formal education, the highest level of education achieved, and English language fluency. The second and third categories concerned the level of vocational education and training (VET) and households' practical skills. Knowledge-based programs, such as healthcare, awareness-building, adult education, volunteering, and economic co-operatives were in the fourth category. The fifth category concerned households' knowledge and skills obtained through experience. Last, the sixth category comprised households' health proxies, such as age and the ability to work without difficulty.

Table 6.13: Variables that measure human capital

Categories	**Descriptions of variables**
Knowledge obtained from formal school, college, and university education	1. Number of years of formal education 2. Highest level of education 3. English language fluency
Knowledge obtained from vocational education and training (VET)	4. Vocational/technical training
Knowledge obtained from learning by doing	5. Practical skills
Knowledge obtained from participation and interaction	6. Knowledge obtained from participating in healthcare programs (family planning, sanitation) 7. Knowledge obtained from adult education programs 8. Knowledge obtained from volunteering interactions 9. Knowledge obtained from participating in economic co-operatives programs 10. Knowledge obtained from awareness programs
Knowledge obtained from experience	11. Experiences from the previous disasters (frequency of disasters) 12. Experiences from dealing with cyclones
Ability to work	13. Working without any physical difficulties 14. Age

Before performing the regression analysis, multicollinearity was checked by using a variance inflation factor (VIF). The independent variables that were excluded secured the mean value of VIF to a statistically acceptable 6 or greater (Alinovi et al., 2010).

To identify the potential independent variables, a bivariate analysis was conducted. Using bivariate analysis, all the human capital (HC) independent variables were tested for stochastic independence from the dependent variable (resilience) using Pearson's Chi-square test (Table 6.14). All the variables of human capital except for age were significantly associated with the dependent variable. All variables that were statistically significant (95% confidence level) were included in the logistic regression model.

Table 6.14: Variables of human capital and their relationship to disaster resilience

Variables of human capital	Frequency		Level of disaster resilience				*p*-value
			Low		High		
	Number of	Percent (%)	(n)	%	(n)	%	
Highest level of education	5842	100.0					
Never attended	1282	21.9	1039	25.4	243	13.8	
Pre-primary	1423	24.4	1048	25.6	375	21.4	< .001
Primary	2041	34.9	1400	34.3	641	36.5	
Secondary	549	9.4	302	7.4	247	14.1	
College	465	8.0	240	5.9	225	12.8	
University	82	1.4	57	1.4	25	1.4	
Years of formal education	6112	100.0					
Zero	1559	25.5	1209	28.5	350	18.8	
1–5	1869	30.6	1381	32.5	488	26.2	< .001
6–10	1875	30.7	1230	29.0	645	34.6	
11 or more	809	13.2	428	22.9	381	20.4	
Speaks fluent English	6108	100.0					
Not at all	2512	41.1	1932	45.5	580	31.2	< .001
Some words and phrases	2568	42.0	1761	41.4	807	43.4	
Basic conversation	947	15.5	520	12.2	427	23.0	
Fluently	81	1.3	36	0.8	45	2.4	
Vocational education and training	4283	100.0					
Yes	202	4.7	100	3.4	102	7.4	< .001
No	4081	95.3	2810	96.6	1271	92.6	
Practical skills (minimum four	4414	100.0					
Yes	3256	73.8	2060	72.4	1196	76.2	.004
No	1158	26.2	784	27.6	374	23.8	
Knowledge from participating in	6132	100.0					
Yes	309	5.0	163	3.8	146	7.8	.023
No	5823	95.0	4104	96.2	1719	92.2	
Knowledge from the participating	6132	100.0					
Yes	185	3.0	55	1.3	130	7.0	.050
No	5947	97.0	4212	98.7	1735	93.0	
Knowledge from volunteer inter-	6132	100.0					
Yes	1027	16.7	464	10.9	563	30.2	.002
No	5105	83.3	3803	89.1	1302	69.8	
Knowledge from participating in	6132	100.0					
Yes	101	1.6	57	1.3	44	2.4	.003
No	6031	98.4	4210	98.7	1821	97.6	

Knowledge from awareness pro-	6132	100.0					
Yes	960	15.7	470	11.0	490	26.3	.002
No	5172	84.3	3797	89.0	1375	73.7	
Personal experiences with previ-	6064	100.0					
Yes	3356	55.3	955	51.2	2401	57.1	.000
No	2708	44.7	1803	42.9	905	48.7	
Knowledge from dealing with	6039	100.0					
Yes	3329	55.1	2189	52.4	1140	61.3	.000
No	2710	44.9	1999	47.6	720	38.7	
Ability to work without physical	6008	100.0					
Yes	4432	73.8	3061	73.1	1371	75.3	.004
No	1576	26.2	1127	26.9	449	24.7	
Age	5986	100.0					
0–14	1376	23.0	1002	24.1	374	20.5	
15–44	3232	54.0	2219	53.4	1013	55.4	.34
45–64	1038	17.3	701	16.9	337	19.4	
65+	340	5.7	237	5.7	103	5.6	

6.3 Relationship between human capital and disaster resilience

Household disaster resilience is a dichotomous dependent variable measured as described in section 6.1 (high/low resilience). There were 14 independent variables measuring human capital that were either categorical, interval, or continuous. Of the 14 independent variables tested in the model, 12 were significantly related to disaster resilience (see Table 6.14). However, two variables were excluded from the final model, because age was not significantly related to the dependent variable (disaster resilience) and the highest level of education, although significant, was multicollinear to other variables of human capital (VIF, 8.3).

Logistic regression methods explore the relationships between two or more independent variables and one dependent variable. The probable outcomes of a single trial are modeled as a function of the independent variable using a logistic function (Peng & So, 2002). Table 6.15 presents the regression results of the relationship between human capital and disaster resilience at the household level in the study area. All the variables in the model are shown in column two of Table 6.15. Column three provides the coefficients (B) and statistical significance (*p*-value) of the variables. Column four presents the coefficients as odds ratios (OR), and column five shows the odds ratio (OR) in the 95% confidence level (95% CI). Odds ratios indicate that a one unit change in the explanatory variable is associated with an "X times" likelihood of high disaster resilience. These coefficients could also be explained as percentage changes in the likelihood of the dependent variable.

Regarding formal education, two variables (fluency in English and number of years of formal education) were positive and significant ($p < .001$ and $p < .050$, respectively). Individuals with relatively more formal education and English language fluency were more likely to show high resilience. For each additional year of formal education, households were 1.18 times as likely to have a high level of resilience (OR: 1.188, 95% CI: .941–1.499) compared to individuals with a low level of formal education. Individuals with language fluency in English were 1.40 times as likely to have a high level of resilience (OR: 1.188, 95% CI: .941–1.499) compared to individuals with no language fluency (OR: 1.406, 95% CI: 1.242–1.591).

Table 6.15: Logistic regression results of the relationship of human capital and disaster resilience

Pillars of human capital	Variables of human capital	B	Exp(B)/OR	95% CI for EXP(B)/OR	
				Lower	Upper
Knowledge from formal school, college, and university education	Years of formal education	.172*	1.188	.941	1.499
	Fluency in English speaking	.340***	1.406	1.242	1.591
Knowledge from vocation and technical training (VET)	Vocational education and training	.360*	1.434	1.045	1.966
Knowledge from hands-on learning	Practical skills	.268**	1.308	1.119	1.528
Knowledge from participating and interacting	Knowledge achieved from the participation of health care program	.458**	1.580	1.190	2.097
	Knowledge received from adult education program	1.285***	3.614	2.375	5.500
	Knowledge gained from voluntary interactions	.947***	2.578	2.161	3.076
	Obtained knowledge from the participation economic co-operatives program	.662***	1.939	1.660	2.265
	Knowledge obtained from awareness program	.251**	1.286	1.069	1.547
Knowledge from experience	Experiences from the previous disasters	.342***	1.310	1.091	1.731
	Experiences from dealing with cyclone	-.806***	.446	.334	.596
Ability to work	Working ability without any physical difficulties	.095**	1.100	.952	1.270
Constant	Constant	-1.049	.350		

***p<0.001; **p<0.01; *p<0.05; Omnibus test: χ^2=518.18; df=13; p<.0001

As shown in Table 6.15, VET and practical skills significantly and strongly (p = .025 and p = .001, respectively) contributed to enhancing disaster resilience. With regard to formal education, individuals who were fluent in English language were 1.406 times as likely as those who were not fluent to have high level of disaster resilience (OR: 1.434, 95% CI: 1045–1.966). Similarly, individuals who gained practical skills were 1.308 times as likely to have a high level of resilience (OR: 1.308, 95% CI: 1.119–1.528). Notably, knowledge obtained from participation and interaction in learning programs had ORs significantly higher than that of formal education or VET. Diverse knowledge-gaining programs, such as healthcare (p < .01), adult education (p < .001), volunteer interactions (p < .001), and economic co-operatives (p < .001), were significantly and positively associated with disaster resilience. Each additional family member who gained knowledge from participating and interacting in programs was associated with a higher probability of high disaster resilience. The probabilities of high disaster resilience were as follows: healthcare programs (1.580 times), adult education (3.614 times), volunteer interactions (2.578 times), economic co-operatives (1.939 times), and awareness programs (1.286 times) compared to low disaster resilience. Interestingly, adult education had the strongest effect on disaster resilience. This was probably because of the various livelihood skills and knowledge individuals derived from adult education. The coastal individuals gained various types of knowledge through adult education such as creating household savings, using pond water during disasters, using livestock manure (i.e., cow dung) in agriculture land as fertilizer, and so on, which enhanced disaster resilience.

Experience gained from previous disasters over the past 10 to 15 years was significantly and positively associated with disaster resilience. However, experience gained from various activities dealing with disasters was significantly and negatively associated (OR: -.860, 95% CI: 1.069–1.547) with disaster resilience. The regression results revealed that individuals who had experienced previous disasters were 1.310 times as likely to have low disaster resilience. In addition, the ability to work was significantly (p < .01) and moderately (OR: 1.100, 95% CI .952–1.270) associated with disaster resilience, which meant that a greater ability to work increased the probability of high disaster resilience.

In addition, a classification table that demonstrated the validity of the predicted probabilities was created. The first two rows in Table 6.16 present the two possible outcomes, and the two columns under the "predicted" caption are the probabilities of low and high disaster resilience in terms of human capital. Table 6.16 shows that the overall correct prediction was 72.9%, which is not a very high rate but still an improvement over the chance level.

Table 6.16: Observed and predicted frequencies at the 0.50[a] cut-off

Observed		Predicted		
		Level of disaster resilience		% Correct
		Low	High	
Level of disaster resilience	Low	3104	222	93.3
	High	1074	390	26.6
Overall % correct				72.9

Pseudo R-Squared = .162; Hosmer and Lemeshow test: Chi-square = 7.822(8)

To assess the adequacy of the regression model, the investigation considered goodness-of-fit statistics. Goodness-of-fit assesses the fit of a logistic model against actual outcomes (Peng et al., 2002). The Hosmer-Lemeshow test was used to assess the goodness-of-fit. The results were a χ^2 of 7.822(8), which was not statistically significant ($p > .05$), indicating that the model fit the data well (Table 6.16). A non-significant Hosmer-Lemeshow test suggests adequate fit in a logistic model (Hosmer et al., 1997).

Regarding the research question on "the relationship between human capital and household resilience to cyclones and storm surges," the logistic regression results revealed that human capital is significantly associated with disaster resilience.

CHAPTER SEVEN: DISCUSSION AND CONCLUSIONS

This chapter discusses the results of previous chapters in the context of existing literature, beginning with the status of human capital and the other four forms of capital: social, financial, physical, and natural. It then discusses the relationships among all five forms of capital and the contribution of human capital to the enhancement of disaster resilience in the study area. Finally, the chapter concludes with the limitations of the study and recommendations for further research.

7.1 Household capitals in the study villages

7.1.1 Human capital

Formal education is a key measure of human capital; it plays a key role in the promotion of efficiency of livelihoods and fulfillment of individual rights, including the right to work. Formal education increases intergenerational benefits and is important for national growth (Abuja, 2010). The results of the current study show that the overall literacy rate (75.9%) in the coastal area of Bangladesh is higher than the national average rate (61.5%; BBS, 2013). However, few individuals have achieved secondary school (9%) and higher secondary school (8%) certificates. This result is consistent with several earlier studies on the coastal area (Molla et al., 2009; Sheheli, 2012). Only a small percentage (1%) of individuals had a university degree. The reason for this, according to household heads and local key informants, was that although people were interested in the education of their children, they were unable to afford the costs of education. Although the government of Bangladesh provides cost-free education to all students through class ten (grade 10), this does not sufficiently alleviate the necessary expenses of higher education (i.e., accommodation, transportation, and food). Sometimes, the children were the only earners of family income and were therefore involved in different types of income-generating activities such as daily wage laborers, maids, servants, garment workers, etc. It was also found that the number of females who completed grade 10 was lower than the number of males. This was attributed to the early marriage of girls. Most girls are married off before they turned eighteen (Nuruzzaman et al., 2015). Furthermore, household members ceased their primary or secondary education due to the impact of natural disasters, such as floods, cyclones, and storm surges.

The government of Bangladesh government is committed to ensuring basic "education for all" within the shortest possible period. Bangladesh became a signatory country of the UN Millennium Development Goals (MDGs) in 2010 and promised to achieve universal primary education by 2015 (MDG; Bangladesh Progress Report-2013, 2014). Although the country has made remarkable progress over the past two decades by ensuring access to education, particularly at the primary level and for girls, primary education does not adequately qualify individuals for formal high-paying employment. However, vocational education and

training (VET) in Bangladesh for non-formal trade courses begins after eight years of schooling. Since the results of the current study indicate that a majority of the children drop out after ten years of schooling, VET can be an alternative education program. During informal discussions, key informants advised local household members that they should enhance their technical skills and knowledge because it contributes to response, recovery, and preparedness for disasters. However, the current study investigated the status of vocational education and training focusing on thirteen particular categories, especially the basic trade courses of the Bangladesh Technical Education Board (BTEB). As per the findings, most household members did not have access to VET. Momtaz et al., (2016) too report that few coastal individuals had VET on aquaculture and livestock. This could be due to the limited number of VET institutes in the study area. Most of the 121 governmental VET institutes (BTEB, 2006) overall are located in divisional cities, for example, Khulna, Dhaka, Rangpur, Rajshahi, etc. There are no VET institutes or centers in the study unions (lowest administrative unite). Local residents therefore had little access to VET. Although a few NGOs provide a range of technical training on livestock and crop cultivation, fishing and aquaculture, and handicraft and tailoring, these are limited to the poorest and most vulnerable households in the coastal area (Momtaz et al., 2016).

Human capital was measured based on not only formal and technical education but also practical skills acquired through informal learning activities. Although the level of general and vocational education was not well developed in the coastal area, the results showed that household members had diverse practical skills acquired through learning by doing, such as fishing and aquaculture, construction work, tailoring, operating a boutique, bicycle/rickshaw/van repair, and so on. These practical skills also played a vital role in helping them take up income-generating activities. Coastal households used their practical skills to earn a livelihood. Sheheli (2012) also mentions that practical skills (e.g., cattle and goat rearing, vegetable cultivation, street vendor, bee keeping etc.) greatly contributed to household income.

Participation and interaction in programs formed another key source for enhancing knowledge and skills among coastal households. Local household members participated in various knowledge-building programs, such as adult education, awareness building, health programs, economic cooperatives, and volunteering. These programs are effective in the response and recovery phases (Azam & Falk, 2011). In particular, the local residents used knowledge gained from these programs to organize their property and livestock, to take care of their children, and to understand the cyclone warning system. However, this study found that the number of household members who participated in these programs was limited. Although the GOs and NGOs have increased the reach of these programs, they have not developed enough to meet the needs of coastal households.

As indicated in chapter 3, it is possible that original knowledge and skills can be continuously elaborated and developed through past experiences and other indigenous activities. Individuals can obtain knowledge and skills through everyday experiences. Maiese (2005) indicates that a great deal of knowledge is unconsciously gained rather than developed through scholarly study and systematic observation. The current study results suggest that almost all households have experienced cyclones and storm surges. Therefore, on the one hand, households have lost livelihood assets, and on the other hand, they have gained diverse kinds of knowledge from disasters. This contributes to their dealing with future disasters. A number of prior studies (Garai, 2016; Rahman, 2015; Paul, 2013) found that households deal with disasters by themselves, using their own savings and external assistance, adjusting the quantity of their food intake, and constructing their houses on higher ground. Although similar results were found in the current study, a number of different strategies were also revealed here for dealing with disasters, for example, cultivating salt-resistant crops and drought-resistant crops and changing the pattern of crop cultivation.

Health status is another important factor in human capital measurement. Kabir et al. (2014) report that natural disasters can affect the physical and mental health of the coastal population in Bangladesh. Similarly, the current study reveals that some household members perceive that they have poor health due to their physical disability or due to chronic diseases (arsenic, asthma, or jaundice). This could be due to nutrition deficiency and scarcity of clean drinking water in the study villages. However, the study also found that age was a barrier for most of the individuals not able to take up work. A significant number of household members comprise young children and the elderly, who are completely dependent on the other family members and are comparatively more vulnerable. They cannot move independently to shelters during cyclones and storm surges. In some cases, it is difficult for the household heads to move them to shelter centers, which consequently leads to loss of life and injuries.

Based on the human capital index of the study, it is notable that the overall status of human capital in all study villages was below the mean value,[5] which indicates poor development of human capital in the study villages. Rashid (2014) argues that several obstacles continue to hamper the enhancement of human capital in the coastal area of Bangladesh, for example, lack of quality education, vocational training, and job placement, and limited access to information and communication technology (ICT). However, Amadi in Koyra Upazila featured a high index score when compared to other study villages. This relatively high number of educational institutes and improved transportation could account for this score. The village has 3 colleges, 35 secondary schools, 112 primary schools, 11 community schools, 9 satellite schools, and 27 *madrasha*

[5] Factor analysis through principal component method produces capital index, which is normally distributed with mean zero and variance depending on the variance and covariance of the scored factors. This is a common feature of factor and principal component analysis (Alinovi et al., 2009).

(religious institutes) (Banglapedia, 2014), a higher number than that in the other study sites. It could also be due to higher household income gained from shrimp cultivation. As a result, household heads are able to afford the education costs of their family members. A low level of human capital was found in Deuli Subidhkhali and Tamaruddin. This result is consistent with a study by Hossain (2012), who found that cyclones and riverbank erosion were the main reasons for the low level of household income and the vulnerable infrastructure of educational institutes (e.g. schools, colleges and *madrasha* [religious institution]), which also accounts for the low level of human capital in that area.

7.1.2 Social capital

The present study investigated the bonding, bridging, and linking network to identify the status of social capital. Households take collective action through these networks before, during, and immediately after a disaster (Meyer, 2013). In the coastal area of Bangladesh, strong, trustworthy relationships were detected between individuals and their relatives (bonding networks), who provide the affected households support in the form of emotional care, food, labor, and cash (Islam, 2015). The study results also found that household members received various types of support, such as help getting to cyclone shelters, cash loans, house repairs, food, water, useful items, and childcare. The survey results indicate that individuals received the highest level of support in childcare and the lowest in the provision of useful items (bamboo, jute sticks, rice straw, etc.) through the bonding networks. In the coastal area, most of the individuals depend financially on their heads of household. However, these members also contribute by repairing houses, providing childcare, or helping other individuals reach cyclone shelters.

In the context of social capital, helping each other within the community during times of crisis is a common practice in the coastal villages of Bangladesh. Hence, these bridging networks (neighbors and friends) are crucial in disaster-prone communities. This study also revealed that most of the individuals get support in reaching cyclone shelters and in childcare from their neighbors and friends. However, individuals receive limited support from neighbors in terms of money, food, and help in house repair. Although households get physical support from neighbors, they received limited economic support due to the limited financial capacity of the neighbors. The neighbors themselves are concurrently affected by the same disasters and are engaged in coping with their own household reparations. Households received a higher level of support from friends than from neighbors in terms of cash loans, provision of food, drinking water, and useful items. This could be because of both the level of mutual trust and their financial capacity.

A few analyses (Dahal & Adhikari, 2008; Islam & Walkerden, 2016) found that bonding and bridging networks are strong in the coastal area with respect to emotional care, exchanging labor, and caring for children and the elderly. However, these networks are relatively weak in terms of cash loans and provision of food,

as indicated by the study's survey results. To tackle these issues, individuals depended on linking networks, such as NGOs and GOs, for emergency relief, shelter, and essential community services (Islam & Walkerden, 2016). The present study proves the existence of linking networks in the study area. Individuals were found to mostly depend on linking networks to receive food and drinking water, help one another in reaching the cyclone shelters, and in lending money. This could be because of the limited financial capacity of family members, neighbors, and friends during and immediately after disasters. Hence, local individuals tend to receive diverse support from linking networks.

From the perspective of social capital, active membership is key to active linking networks and being involved in the community's business. Membership for being a microcredit recipient is common in the coastal area of Bangladesh (Parvin et al., 2014). However, this study's results suggested that individuals are more likely to have memberships with NGOs than GOs. This could be because of the higher density of micro credit NGOs in the study area, giving local residents relatively easy access (Momtaz et al., 2016). NGOs provide small loans within a very short timeframe without any bureaucratic formalities. On few occasions, GOs provide credit based on land ownership documents, but landless people find these documents difficult to manage.

The index of social capital shows the different levels of social capital in the study villages. Based on the social capital index of the current study, it was found that most of the study villages had a value higher than the mean. However, three villages, Deuli Subedkhali, Tamaruddin, and Char Ishwar, presented a low level of social capital. As indicated earlier, Deuli Subedkhali was the most affected by cyclone Sidr, which may be the reason for the community's conflicts with regard to relief distributions. Islam and Walkerden (2015) point out that although neighbors and friends support each other during the early recovery phase, in the long-term recovery phase, mistrust sometimes arises among them due to conflict and competition over achieving external support through linking networks, such as that from GOs and NGOs. The low level of social capital in the villages of Tamaruddin and Char Ishwar reflected conflicts with regard to the acquisition of *khas* (state) land. In the coastal areas, much of this land is created through the process of ongoing silt accretion in and along rivers and coastlines. These so-called char lands are eventually declared as *khas* land (Khan, 2011). Many conflicts are created within the community over the ownership of *khas* land (Hossain, 2015). During the informal discussions, the household heads and key informants also pointed out the various land-related conflicts, particularly those between musclemen. Due to these conflicts, in a few instances, local residents did not provide support to their neighbors and friends during emergencies, which created a weakening of the bonding and bridging networks. The highest value of social capital was found in the Amadi of Koyra Upazila in Khulna district. This result is consistent with other recent studies at the local level (Ahsan, 2010; 2015; CARE, 2014) indicating that during Cyclone Aila, individuals living in inland areas

(e.g., Khulna, Rampal, Bagherhat) received relatively higher support through social networks than those living on islands and shore-lands. Kabir et al. (2016) found that the individuals of Koyra often used their family and social networks to receive economic support, in the form of physical labor, money, and help in communicating with regional buyers of shrimp and so on.

7.1.3 Financial capital

Agriculture and aquaculture practices mostly dominate the rural economy of the coastal area. Savings are one of the important factors to identify the status of financial capital (Braun & Aßheuer, 2011). As found in the empirical results of this study, one-half of all households have savings. As exhibited in Chapter 5, a large number of households with savings were found in the villages of Amadi and Bagali in Koyra Upazila. This is obviously the result of intensive shrimp farming and high-yielding rice varieties (HYV). In addition, many GOs and NGOs conduct various programs to encourage savings at the household level (Kabir et al., 2016). For example, Uttaran, a NGO that is working in Koyra, primarily focuses on fostering household savings among women. The status of savings in Char Ishwar of Hatiya Island was found to be relatively low. Similar results were reported in an investigation by Ahmed (2012). Chronic riverbank erosion could be the cause for this. During the informal discussion with the household heads, many reported that they lost cultivable land due to riverbank erosion. This made it difficult for households to build up savings. However, a few households have created some savings through their livestock of hens, ducks, and goats, or through jobs like tailoring. Among the various forms of savings, such bank accounts, pensions, remittances, cash on hand, and cooperative or group savings, saving accounts in banks account for more household savings than do other forms because private banks offer higher interest rates than NGOs. Furthermore, households re-posed their trust in banks rather than in NGOs because there have been a few incidences where local NGOs ceased their activities without notice, according to local households during the informal discussions.

Access to loans is another important factor that determines financial capital at the household level. Although Islam and Walkerden (2016) found that a majority of coastal households had access to loans, the present study found that more than half the households did not avail loans. Tis could be due to (1) the development of the coastal economy due to the shrimp farming and mixed crop cultivation, (2) some households fearing the high interest rates of loans, and (3) some households not having access to loan providers. For example, banks usually provide loans based on land ownership, while NGOs look at households' monthly or weekly repaying capacity of loan installments. Households were found to receive loans from various formal and informal sources, such as NGOs, banks, moneylenders, neighbors, friends, and so on. However, a majority of households received loans from NGOs. This is possibly due to the intensive micro-credit activities of NGOs. It is difficult to estimate how many NGOs are currently working on micro-credit in the coastal area.

However, by the early 2005, Ahmad (2003b) and Sayed Iftekhar et al. (2003) found 168 micro-credit NGOs in the coastal zone (cited by Ahmed & Rahman, 2016). The empirical result also proves that some households use moneylenders. A similar result was reported in several recent studies (Paul, 2013; Roy et al., 2015). The financial capital index shows that the overall status of financial capital is relatively high in Bagali and Jhonjhonia-Gabbunia. The mixed crops, high-yielding varieties of rice, and intensive shrimp cultivation could be the reason for these findings. These provide millions of jobs and generate profits of about USD 450 million annually (Islam & Bhuiyan, 2016). Shrimp cultivation was practiced in Amadi village; however, its financial capital index was significantly lower than that of Bagali and Jhonjhonia-Gabbunia. This could be due to some of the risks of shrimp cultivation. Key informants gathered from the informal discussions that many farmers had lost their capital due to decreasing shrimp production mostly caused by diseases. They then lost their interest in shrimp farming. They tried cultivating alternative crop varieties. However, it was difficult to cultivate other crops (e.g., rice, wheat, vegetable) in the shrimp farm due to the high salinity intrusion. Thus, sometimes their shrimp farm became barren land, thereby creating a low level of financial capital.

7.1.4 Physical capital

The status of physical capital at the household level comprises basic infrastructure and other material goods (Krantz, 2001). In the context of the Bangladeshi coast, the most relevant forms of physical capital are housing, production machineries, and access to basic services, that is, drainage systems, mass media, toilets, and educational institutes. In the coastal villages, a strong pattern of dwelling structure is rare, as cyclones accompanied by storm surges and winds often strike the coast and displace most of the insubstantially built houses and the possessions therein. Therefore, robust housing structures are needed to enhance a household's adaptive capacity. However, most of the surveyed households live in *kaccha* houses, which are made of rice straw, jute sticks, bamboo, tin, and mud. A number of earlier studies (Azam & Falk, 2013; Shameem et al., 2014; Paul & Routray, 2011b; Reza et al., 2015) also found that a majority of households in the coastal area live in *kaccha* houses. The *kaccha* house does not provide much protection against cyclones and storm surges reflecting their low capacity for withstanding disasters.

Since the coastal households mostly depend on primary activities, various production machineries, that is, tractors, harvesters, fishing nets, and fishing boats are important for their livelihood. Relatively few households were found to own any machinery. Among the productive machineries owned by households, fishing nets were the most common, followed by tractors and fishing boats, respectively, in the study villages. Reza et al. (2015) also reported a similar status for the production equipment in the study area. This indicates the poor level of household assets among the coastal community.

A hygienic living is possible only if sanitation facilities for proper management of solid waste and disposal of household wastewater and storm water are available (Local Government Division, 2005). This study's results show that a majority of the households had access to toilets/latrines. However, the quality of the toilets/latrines was questionable. The survey results also revealed that most of the households did not have access to proper drainage systems. These poor levels of physical capital create an unhygienic environment in the study villages. The low level of sanitation had wider health impacts. For instance, the coastal residents suffered from diarrhea, typhoid, jaundice, etc. (Kabir et al., 2016). A few NGOs are working in these areas to improve the sanitation systems by providing sanitary latrines. However, sanitary latrines have been repeatedly damaged by cyclones and storm surges.

The physical capital index indicates the overall status of physical capital, which is slightly higher in most of the study villages than the mean. However, low levels of physical capital were found in Char Ishwar and Tamaruddin, which are located on Hatiya Island. Regular riverbank erosion in this area may be responsible for the loss of homes, sanitation, and other physical infrastructure of households. When local residents are affected by riverbank erosion, they move inland, but not too far from the river bank. Furthermore, the activities of NGOs and GOs are relative lower on the chars than in other parts of the country (IFAD, 2013). The physical capital index presents a higher value in the villages of Bagali and Itabaria, which means that households in these villages had better access to and ownership of physical assets, such as housing, harvesters, fishing boats, nets, tractors, motorbikes, and bicycles.

7.1.5 Natural capital

Access to land and clean water is a key determinant of coastal livelihoods of Bangladesh in terms of natural capital. The importance of land and clean water in the coastal area has already been reported in several earlier studies (Momtaz et al., 2016; Paul, 2013). Although land is necessary for aquaculture and agricultural production as a source of income, this study's results suggest that 35.5 percent of all households are landless in the study villages. This finding is consistent with other recent investigations of the coastal area (Hossain, 2015; Ahmed, 2011). About 37 percent of coastal households did not own cultivatable land. According to the FAO (2010), many coastal households have become landless because of cyclones, floods, and river erosion. This is because coastal cyclones are often accompanied by floods that wash away the land and destroy dams. The study results also found that one-half of households comprise small-scale farmers. Few households owned a large amount of cultivated land in the study area.

Access to safe drinking water is one of the major challenges in the coastal area of Bangladesh. Our results suggest that only 10 percent of all households have access to safe drinking water in their homesteads. As has been observed during fieldwork, water salinity is a common problem in most of the study villages and

it has a negative impact on human health (Khan et al., 2011). According to Islam (2013), salinity in the water of many coastal villages is over 20 PPT (parts per thousand), whereas the human body can tolerate only 5 PPT. Therefore, a number of health problems were found in the study villages, such as diarrhea, fever, skin diseases, and typhoid. Dasgupta et al. (2015) state that these health problems can also cause infant mortality, maternal hypertension, post-partum morbidity, and mortality.

The natural capital index provided the overall scenario in the study villages with most villages showing lower levels of natural capital than the mean value. The lowest natural capital status was found in Tamaruddin, caused by the riverbank erosion on Hatiya Island. Siddiqui (2014) found that most of the households on Hatiya Island had become landless due to riverbank erosion. During the fieldwork, it was observed that many households who lived on the embankment had no land for cultivation.

The case study villages where the natural capital index (as presented in figure 5.9) is highest is Jhonjhonia-Gabbunia in Rampal Upazila and the lowest is Tamaruddin in Hatiya Upazila. This is evidence of the serious river bank erosion that occurred from 2008 to 2016. Several recent studies have indicated severe river erosion on Hatiya Island. For example, Ghosh et al. (2014) found that approximately 6,476 hectares (about 15,995 acres) of land were eroded at different sites throughout Hatiya Island during their 1989–2010 study period. Ghosh et al. (2014) also reported that land erosion along the coastline happened at different rates. However, most of the erosion occurred in the northern part of the island very close to the Meghna river mouth. Due to the river's erosion, *Harani* union was totally eroded during the study period. ICZM (2003) reported that agricultural land was reduced by this riverbank erosion, which left many people homeless.

7.2 Interrelation among the different forms of capital (natural, social, financial, and physical)

Human, social, physical, financial, and natural capital are closely interlinked. The results from the Pearson correlation analysis confirmed that of the four other capitals, the first three showed a significant and positive correlation with human capital while natural capital did not do so.

A number of studies found a strong correlation between human and financial capital (Saba et al., 2012; Fuying He, 2013; Santos-Rodrigues et al., 2013). Based on empirical case study, Santos-Rodrigues et al. (2013) reported that the components of human capital, that is, education and training, skills, and knowledge have a positive impact on the financial performance of firms, which results in the accumulation of financial capital. The current study's results also provide evidence for a clear relationship between human and financial capital. Human capital has the highest significant and positive correlation with financial capital. Individuals with formal education, VET, practical skills, and physical ability to work have a greater scope of engaging in income-generating activities at the three stages (i.e., before, during, and after) of disasters (Nuruzzaman

et al., 2015). In the context of Bangladesh, Yamauchi et al. (2009) noted that educated individuals can migrate to increase the returns on their human capital (e.g., to urban labor markets), thereby helping to mitigate the impact of a disaster (e.g., flood, cyclone, and storm surges) on household resources.

Many studies report that human capital has a significant and positive correlation with physical capital. As pointed out by Nelson and Phelps (1966), better-educated people are more likely to innovate and assimilate new technology than poorly educated ones. In 1966, Fishlow claimed that high levels of education in the 1900s helped to speed up the generation of physical capital and the creation of new technology in the US. Romer (1993) argued that the more educated an individual the better he is able to integrate new technologies. In terms of the human and physical capital relationship, this study also provides evidence supporting those earlier findings. Households with higher levels of human capital were likely to have higher levels of physical capital. In the context of the Bangladeshi coast, Islam and Walkerden (2015) indicate that due to the low level of education, household heads in the coastal area were not involved in jobs in the government or private sectors.

Ottósson & Klyver (2010) reported that human capital and social capital were found to be co-productive, and increasing human capital increases the status of social capital concurrently. Subsequently, the current study found a positive and significant relationship between human and social capital. The result indicated that an individual's knowledge and skills depend crucially on his or her networks, values, and behavior patterns, such as the informal modes of learning and the skills acquired through learning-by-doing. In this context, networks provide access to important information and ideas, often in a relatively unstructured way. General human capital forms the total of the potential ties (bonding, bridging, and linking) from which individuals obtain when they face disasters and need advice. Accordingly, when individuals with a high level of human capital face problems, the number of potential contacts is larger. De Kadt et al. (1999) indicated that individuals increase their human capital by increasing their knowledge and skills, which might create a long-lasting social network that generates social capital. Greve et al. (2006) argue that human capital supports and enhances social capital as individuals with high human capital more easily utilize their social capital in times of crisis. Moreover, individuals are likely form social networks as they gain start-up experience. A number of studies also confirm that community and state involvement in education improves outcomes by decreasing the probability of children dropping out of school (Parts, 2003; Schuller, 2001). Thus, social capital is also important to strengthen human capital.

Several earlier studies found a significant negative relationship between human and natural capital (Behbudi et al., 2010; Philippot, 2010). However, the present study's results suggest an insignificant relationship between human and natural capital. Uli et al. (2011) have also found this relationship to be insignificant. The

level of human capital is not changed considerably by the impact of natural capital. For example, many households in the coastal area of Bangladesh have a large amount of land but their members are illiterate. Conversely, many household heads have higher levels of education but lack access to cultivated land. However, Behbudi et al. (2010) report that natural capital is indirectly related to human capital as more land usually means more income through farming, which in turn means households heads can send their children to school.

7.3 Contribution of human capital to the enhancement of disaster resilience and social capital

The present study found different levels of disaster resilience in different study villages. The results indicate that six out of nine study villages were relatively less resilient to cyclones and storm surges. In particular, Deuli Subidkhali and Char Alexander had the highest percentages (82 percent and 83 percent, respectively) of low disaster resilience. Ahmed et al. (2016) and Islam et al. (2015) found similar results in coastal areas, where they investigated the highest percentage of low-level disaster resilience. Saroar et al. (2015) examined a number of causes for low resilience and high levels of vulnerability, such as Cyclones Sidr and Aila, riverbank erosion, lack of safe drinking water, low levels of education, and geographical location. However, Amadi, Bagali, and Jhonjhonia were found to be relatively resilient, which could be due to the relatively high average household income achieved through shrimp cultivation and proximity to the city of Khulna. Akter and Mallick (2013) investigated economic disaster resilience in coastal Bangladesh, where they found that shrimp cultivation significantly increased household income. Furthermore, due to proximity to the city, individuals were able to sell their agriculture products on urban markets at a relatively higher price.

To answer the final research question—"What is the relationship between human capital and disaster resilience?"—logistic regression analysis was used. The present study found that in terms of formal schooling, college and university education, years of schooling, and fluency in spoken English have a significant and positive correlation to disaster resilience. Ahmed (2010) found that fluency in English is an asset to securing a job in the national and international arena, which increases the household income. Several earlier studies supported the current study's findings. For example, a number studies (Habiba, 2013; Biswas, 2002; Mortuza et al., 2004; Shaw et al., 2011; Sarker, 2005) found that educated individuals were able to respond promptly and appropriately during disasters, thereby warning others and protecting themselves. Mahmudul et al. (2003) found that literate farmers achieve a higher income than illiterate farmers do. Kishor and Gupta (2009) indicate that education also enhances women's positions through decision-making autonomy and exposure to the modern world and knowledge.

As expected, VET significantly and positively contributed to enhancement of disaster resilience. Hemstock et al. (2016) reported a similar result when they examined the contribution of vocational education to the

enhancement of coastal resilience on Pacific Islands. Regarding the Bangladeshi coast, although several previous studies probed the contribution of formal education to disaster resilience (Sanaz et al., 2015; Nazir, 2015; UNICEF, 2015), the contribution of vocational education was not taken into account.

This study found that the practical skills of household members had a significant and positive correlation with disaster resilience. Other recent studies (Latchem, 2014; Nasreen, 2013; Noguchi, 2015) also indicate that practical skills have an important role in enhancing disaster resilience. In the coastal community of Bangladesh, households possess different types of practical skills. In many instances, this knowledge and these skills are largely ignored; however, they play a crucial role, particularly during and after disasters (Khan & Rahman, 2006).

Murshed-e-Jahan (2014) found that knowledge obtained through various participatory programs enhances the disaster resilience of coastal communities of Bangladesh. The current study produced very similar findings. Knowledge obtained through diverse knowledge programs in healthcare, adult education, volunteer interactions, economic co-operation, and awareness building were significantly and positively associated with disaster resilience. A study by Rahman and Naoroze (2007) found that household members' knowledge obtained through various programs allowed them to gain more control over their economic and social returns, making them self-reliant and enhancing their socio-economic status within the family as well as in society in general.

The present study found that the experience gained from previous disasters was significantly and positively associated with disaster resilience. Numerous studies confirm that a household's previous experiences played a vital role in the three stages of disaster, that is, before, during, and after (Alam & Collins, 2010; ISDR, 2007; Tony, 2005). However, experience gained from various activities regarding dealing with cyclone was significantly and negatively associated. In general, a cyclone severely strikes the coast within a very short time. Hence, for the coastal population with their limited resources, the experience gained from activities dealing with cyclones may be not useful at times in withstanding a cyclone. Individuals can become emotionally affected by their previous experiences reducing their ability to work. Furthermore, experience with dealing activities differ from one cyclone to another.

The recurrent use of household assets to deal with regular cyclones reflects this finding. For example, households acquire knowledge through the actions undertaken in dealing with cyclones, for example, how to use their savings during recovery. However, if cyclones strike frequently, their savings will eventually be depleted decreasing their resilience.

A number of earlier studies (Alam et al., 2016; Islam et al., 2015; Sheheli, 2012) indicate the impact of health status on disaster resilience. The regression results also indicate that the ability to work is significantly and positively associated with disaster resilience, which means that a better ability to work increases the probability of higher disaster resilience.

7.4 Limitations and recommendations for future research

Every investigation has its limitations and this research is no exception. The following section highlights some of these limitations and also provides some recommendations for future research options.

The goal of this study was to assess disaster resilience, a very complex, multidimensional concept. Disaster resilience was measured through a summation of four components, household infrastructure component (HIC), household economic component (HEC), household self-organization and learning component (HSoLC), and social safety nets (SSN), at the household level. However, future research can focus on replicating the proposed methods at the community level.

The current study clarified that human capital has a significant and positive correlation with all other forms of capital except natural capital, and that human capital plays a significant role in enhancing disaster resilience. Therefore, academicians and policy makers can investigate how human capital can be improved in the study area as further research.

Within the existing literature, limited common understanding prevails on the indicators that can be used to measure disaster resilience and households capitals (human, social, economic, physical, and natural). As a result, there are chances of indicators overlapping between disaster resilience and household capitals. For example, some scholars consider housing an indicator of physical capital, while others view it as an indicator of disaster resilience. There are chances of indicators overlapping even among the capitals. Unemployment is considered by some researchers as an indicator of financial capital, while others count it as a human capital indicator. Conceptually, it becomes challenging to categorize indicators under the type of capital to which it belongs.

Since this study identified the contribution of human capital in enhancing disaster resilience, using similar methods, the contribution of other forms of capital, that is, social, physical, financial, and natural, in enhancing disaster resilience can be investigated. Thu study also recommends exploring other widely accepted methods to deal with multilevel data (individual, households, community), particularly investigation of various forms of capitals and disaster resilience.

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Appendix

Household questionnaire Coastal Bangladesh – Land use change, human capital, and household disaster resilience.

Name of Interviewer	
Number of Interview	

Introduction

I am [name]. We come to your area for research on how you deal with natural disasters. We are sorry that we only come for a research objective and cannot provide you any money or relief. We will be very happy if you help us in this survey. I want to ask you and your family questions about your familiy's work, land use change related matters and how you deal with natural hazards. We hope that this information helps for future planning and disaster management. It will take 90 minutes to complete this interview. Of course we keep all of your answers confident and we will not give them to any other person. It is up to your decision whether you participate in this interview and you may answer all or just some of the questions. But we hope that you participate in this survey and you help us with your answers. May I proceed with the questionnaire?

Filled in by interviewer:

GPS waypoint	e.g. 004:
GPS coordinates – latitude	N: ..°.....`.....,..." :
GPS coordinates – longitude	E: …°.....`.....,..." :
Height	

Exact id of study site		site e.g.
Date of the interview	__ day __ month 2014	date e.g. 25.11.14
Starting time of the in-terview	_ am / pm __ min	time e.g. 2pm 50min

Distance to next river		Km
Distance to coast		km
Housing condition	□ Pacca, □ Semi-pacca □ Kaccha □ Other _____	

House located ….	□ in front of □ on □ behind … embankment	If applicable
Agr land located ….	□ in front of □ on □ behind … embankment	If applicable

Section 1: Socio-demographic characteristics of household members

1. **How many members does your household have? _____**

2. **How many years has the household head lived in this village for?** _____years

3. **Where did he/she live before that?**
   - □ Within same union
   - □ In a different union:_____

4. For all household members, can you please tell us the following aspects:

		Example	1	2	3	4	5	6	7	8	9	10
4.1	No.	1										
4.2	Relationship to household head (see key below)	1										
4.3	Sex (1= male, 2= female)	1										
4.4	Age in years	42										
4.5	Able to read and write (if 15 years or older)? 0=no 1=yes											
4.6	Years of formal education	6										
4.7	What is the highest level of education (with certificate)? 1=Never attended school 2=Pre-primary 3=Primary school 4=Secondary school 5=College degree 6=University degree	3										
4.8	How well to you speak English? 1=not at all; 2=only some words and phrase; 3=small talk, basic conversation; 4=fluent also for business											
4.9	How well to you write English? 1=not at all; 2=only some words and phrase; 3=small talk, basic conversation; 4=fluent also for business											
4.10	Have you gained any vocational training on the following sectors (> 15 years of age)? (see key below)											
4.11	What types of practical skills did you acquire through “learning by doing”, without any formal trainings? (see key below)											

4.12	Not able to work for any of the following reasons? 1= Physical Disability 2=Age (too young/too old) 3=Severe (chronic) disease or illness 4=Others												
4.13	If working for money, what kind of work (see key below digits 1-2), and employment situation (digit 3). Multiple answer, max 3	042 (aqua-culture, self-em-ployed)											
4.14	If a family member ever migrated, which main type? (only for family members who contribute to HH income) (1= temp in BD, 2= permanent in BD, 3= temp internat., 4= permanent internat.)	1											
4.15	Main reason for migrating (see key below, tick max 2)	2											

Key for 4.2

1. *Head*
2. *Husband/Wife*
3. *Son/daughter*
4. *Father/mother*
5. *Brother/sister*
6. *Grandfather/-mother*
7. *Grandson/-daughter*
8. *Uncle/aunt*
9. *Cousin*
10. *Niece/nephew*
11. *Children in law*
12. *Parent in law*
13. *Other _____*

Key for 4.10 and 4.12

1. *Livestock and crops cultivation*
2. *Fishing, aquaculture*
3. *Bee keeping*
4. *Business and Trade*
5. *Tailoring, Boutique*
6. *Talacabi, Bicycle, Rikshaw/Van*
7. *General electric and mechanic repairs*
8. *House Wiring*
9. *Construction work (buildings and/or roads)*
10. *Sanitary Latrine Making*
11. *Ayurvedic (Kobiraji)*
12. *Swimming (4.12 only)*
13. *Climbing (trees)*
14. *Others (specify)*

Key for 4.14, digits 1-2

1. *Farming (crops)*
2. *Farming (livestock)*
3. *Fisherman*
4. *Aquaculture farmer*
5. *Wild collection (honey, herbs…)*
6. *Road construction worker*
7. *Construction worker (other)*
8. *Trade/ retail*
9. *Transport*
10. *Household services*
11. *Community services*
12. *Student*
13. *Textile worker*
14. *Handicraft*
15. *Unable to work due to physical / mental disabilities*
16. *Other _____*

Key for 4.14, digit 3:

0. *Not applicable*
1. *Permanently employed by someone else*
2. *Self-employed (with own financial investment in business infrastructure)*
3. *Daily labourer*

Key for 4.16 (voluntary and involuntary/displacement)

1. *better opportunities to work in city (rural to urban migration),*
2. *better opportunities to work in agriculture,*
3. *studying/education,*
4. *marriage,*
5. *other family reunification,*
6. *infertile soils*
7. *cyclone/storm surge,*
8. *flood*
9. *erosion,*
10. *Political unrest*
11. *conflict with landlord/musclemen*

5. What is the main source of drinking water?

- Tube-well
- Tap-water
- Pond
- River
- Kuya
- Bottled water
- Other_____

How far away from your home is this source …….. (in minutes to get there)

6. Sanitation

- Sanitary
- Kaccha
- Open field
- Other_____

7. A) What kind of access to machineries and vehicles do you have?
B) In what condition is it (scale 1-5)?

Machinery	Type of access (a-e)	1.Very poor	2. Poor	3. Moderate	4. Good	5.Very Good
Tractor						
Harvester						
Boat for Fishing						
Net for Fishing						
Rickshaw/Van						
Motorbike						
Bicycle						

Type of access, key:

a. *Own*
b. *Rent*
c. *Borrow (use s.o. else's machine w/o paying them)*
d. *Share with others*
e. *No access*

8. Do you have permanent or temporary access to the following facilities or areas in your daily life? How important are they for your daily life? If yes, how satisfied are you with them regarding your actual situation?

	Yes permanent	Yes temporary	No	If Yes: Satisfaction on accessibility→	1 Very satisfied	2 Satisfied	3 Somewhat satisfied	4 Unsatisfied	5 Don't know
Access to electricity									
Access to toilets/latrines									
Drainage system									
Access to health services									
Access to education facilities									

Access to mass media (Radio, Television, Newspaper)									
Access to public authorities(Union parishad, Upazila office, Agricultural office etc)									
Access to cyclone shelter									

9. **What is your household's approximate average monthly income (over the past 12 months, including remittances)? _____ BD Taka**
10. **Over the past year, have the following activities been a major, minor or no source of monetary income for your household? Please tick (max. 3 major sources)**

Source of income	Major source	Additional source	no monetary income
Agriculture (crops, specify, eg. pulses, sugarcane, rice, vegetables)			
Aquaculture (shrimp farming, specify: golda, bagda, other)			
Aquaculture (other than shrimp)			
Agriculture (livestock pasture or farm, specify)			
Wild collection			
Non-agriculture or aquaculture work (e.g. construction work, textile work ect)			
Forestry			
Remittances			
Land or property rented to others (if owned)			
Other_____			
Don't know			

11. **How much of the household income is generated by the household member with the highest income? _____BD Taka _____%**
12. **A) At the moment, do you have to pay 1000 Taka or more back to others (loan or money you borrowed)?**

- ☐ Yes
- ☐ No

B) If yes, who do you have to pay money back to? (multiple answers)

C) How high is the interest rate per week/month/year in each case? (use applicable temporal timeframe)

12 B), C)		% per week	% per month	% per year
☐	Other family members			
☐	Friends			
☐	Neighbours			
☐	Other people in village			
☐	Formal loans from bank			
☐	Moneylenders			
☐	Microcredit			
☐	Other			

13. **Why do you borrow money from others? (multiple answers possible)**
    _____

14. **If your household has money and/or valuable objects, how much in or of the following? Please give amount of owned items and/or value in Taka**

		Amount	Taka
Stock of money	Cash savings	n/a	
	Bank deposit	n/a	
	Cooperative or Group deposit	n/a	
	Remittances from HH members that have migrated	n/a	
	Pension	n/a	
OtherAssets	Livestock		n/a
	Storage of rice		n/a
	Poultry		n/a
	Trees		n/a
	Jewellery		n/a
	Furniture		n/a
	Others		n/a

15. **How many months could your household sustain itself without cash-inflow by drawing on your savings?**
    _____weeks

Section 2: Land access and land use (change)

16. **Do you hold and/or cultivate land in this village or union?**
    - ☐ Yes
    - ☐ No
17. **If yes, what is the legal status of the land holding? Multiple answers possible**
    - ☐ Own the land myself
    - ☐ Leasehold
    - ☐ *Adi or Borga* (cultivating s.o. else's land without contract, min. 3 months)
    - ☐ Other _____
18. **If you own the land, how much is it approximately worth? _____BDT**
19. **How many *sotangsha* (33-41 sot.=1 bigha) or *bigha* (3 bigha=1 acre) do you cultivate/hold? (if not know, tell us number of small/medium/large fields)**
    - ☐ Owned land _____sot. _____bigha
    - ☐ Leased land_____sot. _____ bigha
    - ☐ Other _____sot. _____ bigha

20. How many sot./bigha do you cultivate per season?

Crop Season	Kharip-1 (Pre-monsoon)	Kharip-2 (Post-monsoon)	Rabi (Winter)
Cultivated Land (sot./Bigha)			

21. What do you currently use this land for (main use)? Do you know how it was used 10 and 15 years ago, respectively? Do you know the reasons for the land use changes?

8.1 Use today? (max 3 main uses ranked by importance	8.2 Use 10 years ago	8.3 Reason for change 10 years ago (max 3)	8.4 Use 15 years ago	8.5 Reason for change 15 years ago (max 3)

Key 8.1, 8.2, 8.4

1. *Agriculture (crops, specify, eg pulses, sugarcane, rice, vegetables)*
2. *Aquaculture (shrimp farming, specify: golda, bagda, other)*
3. *Aquaculture (other than shrimp)*
4. *Agriculture (livestock pasture or farm, specify)*
5. *Buildings**/housing***
6. *Forest*
7. *Barren (not used)*
8. *Rented to others (if owned)*
9. *Abandoned*
10. *Other_____*
11. *Don't know*
12. *Market/business*
13. *Playground*
14. *Institution (GO or NGO or local club)*
15. *Entertainment (park, hotel)*
16. *Water body/ wetland*

Key 8.3 & 8.5

1. *Need more food for household*
2. *Higher local demand for product*
3. *Higher income per year possible*
4. *Demand for sale on export markets*
5. *More salt in water, new use better suited*
6. *More salt in soil*
7. *Arsenic in freshwater*
8. *More resistant to floods*
9. *More resistant to cyclones*
10. *Need wood for household*
11. *New landlord (owner)*
12. *Land eroded*
13. *Flooded*
14. *Land covered in sand*
15. *New char land*
16. *Other _____*
17. *Don't know*

22. **How do your neighbours use the land that is adjacent to your own land? Do you know how it was used 10 and 15 years ago, respectively? Do you know the reasons for the land use changes?** Same key as previous question

Use today? (max 3 main uses ranked by importance	Use 10 years ago	Reason for change 10 years ago (max 3)	Use 15 years ago	Reason for change 15 years ago (max 3)

23. **Can you please make a small sketch or "map" of your land and individual parcels. Please indicate how each parcel is used at different times of the year**

24. **Did you lose any arable land completely in the past 10 years?**
    - ☐ Yes
    - ☐ No

    If yes, why? How much land? Reason for displacement? (multiple answers)

Cause	Amount (in *shotangsho.)*	Amount (bigha) only if sot. Not known
Flooding		
Erosion		
Covered in sand (sediments)		
Polder/Embankment failure		
Landlord decision		
Village decision		
Musclemen (other than land-lord)		
Soil salinity renders land use-less for agriculture		
Other		

25. How many mounds per Bigha do you produce per season?

	Paddy			Pulse	Wheat				
Crops Sea-son	Kharip-1 (Pre-mon-soon)	Kharip-2 (Post-mon-soon)	Rabi (Winter)						
Production in mound per Bigha									

26. Do you sell parts of your food production?

- ☐ Yes
  If yes, which crops? _____
- ☐ No

27. How much of your food production did you consume yourself last year?

- ☐ Everything (100%)
- ☐ Most (75%)
- ☐ Half of it (50%)
- ☐ Only a small amount (25%)
- ☐ Hardly anything

28. How important is the land for the following purposes? (scale 1-5,

1= not at all important,
2= marginal importance
3= moderate importance
4= Important
5= very important)

	1	2	3	4	5
Produce fodder for animals					
Sell produce to local markets (i.e. product is consumed locally)					
Sell produce to international markets / export (i.e. product is consumed abroad)					
Income through lease to others					
Family home					
Other _____					

29. Who decides how <u>the land you own</u> should be used? (multiple)

- ☐ (Only) Household head
- ☐ Others in the family
- ☐ Others outside my own family
- ☐ n/a (I don't own land)

If "others outside my family" are included, please explain who and how they decide:

_____
_____
_____
_____
_____

30. How important do you think the following people and factors are in influencing your own decision on how to use your land? (please answer for every factor)

	Very important	Less important	n/a	Don't know
Government				
Local Council				
Police				
Musclemen				
Water cooperatives				
Economic cooperatives				
Neighbours' advice				
Friends' advice				
NGOs initiatives/advice				
Local buyers/ Middlemen				
Knowledge on demand by foreign customers				
Other (specify) _____				

31. Who decides how <u>leased / adi or borgha land that you hold/ cultivate</u> should be used? (multiple)

- ☐ (Only) Household head
- ☐ Landlord
- ☐ Others
- ☐ n/a (I don't hold/cultivate any land)

32. If "others" decide, how much influence do you think the following people and factors have? (please answer for every factor)

	Exclusive	Much	Some-what	Little	None at all	Don't know	N/A
Spouse of household head							
Other family members							
Government Policy							
Local Council Policy							
Police							
Musclemen							
Water cooperatives							
Economic cooperatives							
Neighbours' activities							
Friends' activities							
NGOs initiatives							
Demand by local buyers/ Middlemen							
Foreign customers							
Other (specify) _____							

33. How many minutes does it take you to reach the market or middlemen where you sell most of your produce in dry and rainy season?

Dry season_____minutes

Rainy season_____minutes

- ☐ my products are picked up at my home

34. Have you ever applied or thought of applying the following farming methods?

	Applied? (0=no and not considering, 1=yes have applied, 2=thought of applying in the future)	If 1 or 2, main three reasons? (see key)
Combine rice & shrimp farming (saltwater)		
Combine rice & shrimp farming (freshwater)		
Combine rice and fish farming		
Agro-forestry (forest mixed with agriculture)		
Other mixed crop cultivation		
Forestry		
Organic agriculture (certified)		

Key 11.2

1. *Need more food for household*
2. *Higher local demand for product*
3. *Higher income per year possible*
4. *Demand for sale on global markets (export)*
5. *More salt in water, new use better suited*
6. *More salt in soil*
7. *Arsenic in freshwater*
8. *More resistant to floods*
9. *More resistant to cyclones*
10. *Need wood for household*
11. *New landlord (owner)*
12. *Land eroded / flooded*
13. *Other _____*
14. *Don't know*

35. Who do you sell your products to? (tick appropriate boxes, multiple answers possible)

	Directly to Middlemen	Directly at Local market	Economic/marketing cooperatives	Directly to Exporting firm	Other _____
Rice					
Shrimp bagda					
Shrimp golda					
Fish					
Livestock					
Sugarcane					
Pulses					
Vegetables					
Other_____					

36. Do you follow any formal food safety and production standards that you are aware of?

- ☐ Yes
- ☐ No

If yes, which one(s)_____

37. If you produce for export to other countries, how many years have you been doing this for?

_____years O I don't know

38. Have the following aspects of cultivation practices and outcomes increased, decreased or stayed the same over the past 10-15 years? What are the reasons if there is a change? (List number of reason in appropriate field. No reason if "stable" development)

Change (per year) /crop	Number of harvests/catches per year	Yields per harvest/catch (no. of animals per harvest)	Inputs like fertilizer, special shrimp food etc applied
Rice			
Reason Rice			
Pulse			
Reason Pulse			
Shrimp bagda (salt)			
Reason shrimp (salt)			
Shrimp golda (fresh)			
Reason shrimp (freshwater)			
Fish (pond)			
Reason fish (pond)			
Other			
Reason Other			

Key change:

1. *increase; (+)*
2. *stable, (o)*
3. *decrease (-)*

Key reasons:

4. *Droughts*
5. *Crop destruction due to floods /storms etc*
6. *Arable land eroded/lost permanently*
7. *Salinization*
8. *Soil Fertility higher due to sediments*
9. *New (high yield) varieties*
10. *Seasonal shifts in rainfall*
11. *Insect invasion*
12. *Diseases (Plant or animal)*
13. *Lack of capital for investments*
14. *Lack of labour power*

Other _____

15. *Higher labour input*
16. *Improved irrigation*
17. *More fertiliser applied*
18. *More pesticides applied*
19. *More herbicides applied*
20. *New / better machines for farming*
21. *Shrimp culture*
22. *Tidal surge*
23. *Soil wetness*
24. *lack of water supply*
25. *Late harvest of crops*
26. *Clayey soil*
27. *Short winter*
28. *River erosion*
29. *Scarcity of sweet water*
30. *Drainage problem*
31. *Embankment failure*
32. *Problems in seed beds*
33. *More cold*

39. A. Are there discussions or disputes in your village about freshwater?

- ☐ No
- ☐ Yes

B. If yes, what type of freshwater is involved?

- ☐ Drinking water from shared village wells
- ☐ Drinking water from private wells
- ☐ Irrigation of crops
- ☐ Supplying shrimp/fish farming

C. If yes, what problem or issue is behind this discussion?

- ☐ Salinization
- ☐ Arsenic
- ☐ Other pollution
- ☐ Access to sufficient quantity of freshwater
- ☐ Other

Section 3: Food security, consumption and livelihood

40. Throughout the year, how much of the total food that your household consumes is purchased on the market? Please estimate:

- ☐ Everything (100%)
- ☐ Most (75%)
- ☐ Half of it (50%)
- ☐ Only a small amount (25%)
- ☐ Hardly anything
- ☐ n/a
- ☐ don't know

41. Which food products do you largely buy from the market?

_____

42. In a "regular" week, how many times per week to you eat….

Relative frequency	All the time/ every day (7)	Pretty often (4-6 days) 5	Once in a while 2-3 days 2.5	Hardly at all 1 day 1	Never 0 days 0	NA
Rice						
Pulses						
Wheat						
Other grain						
Fruit						
Vegetables						
Fish or seafood						
Meat						
Sweets/Sugar						

43. Are there any months of the year where you regularly do not have enough food:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
a) from your own production and/or												
b) not enough money to buy food?												

If yes, please explain circumstances (multiple options possible)

_____

44. Food consumption. In the past, if there were times where you have not had enough food or enough money to buy food for 7 successive days, how often did your household:

Relative frequency	All the time/ every day (7)	Pretty often (4-6 days) 5	Once in a while 2-3 days 2.5	Hardly at all 1 day 1	Never 0 days 0	NA
a. Rely on less pre-ferred and cheaper foods?						
b. Borrow food, or rely on help from a friend or relative?						
c. Limit portion size at mealtimes?						
d. Restrict consump-tion by adults in order for small children to eat?						
f. Reduce number of meals eaten in a day?						
g. Reduce number of people eating at home (e.g., by sending a child to eat with relatives or friends)						

45. **In the last 5-10 years, if there have been times when you did not have enough food or money to buy food, did you…(multiple options possible)**

- ☐ Modify food production to increase output
- ☐ Diversify activities in order to increase alternative income
- ☐ Reduce household food consumption
- ☐ Sell household assets
- ☐ Reduce expenditure
- ☐ Migration of household members
- ☐ Rely on external help
- ☐ Other options. Please specify.

46. **If you ever had to change your food production to manage a difficult situation, did you… (multiple options possible)**

- ☐ Plant other crops or varieties of same crops. Please specify _____
- ☐ Use more fertilizer
- ☐ Introduce another mode of irrigation. Please specify
- ☐ Use more labour power, machines, etc.
- ☐ Implement another strategy, please specify

Section 4: Social interaction and participation

47. **Who owns a cell phone in your household?**
    - ☐ The man/husband
    - ☐ the woman/the wife
    - ☐ both
    - ☐ others (specify) _____
    - ☐ no cell phone
48. **Do you use the following media for your work-related communication/information (1), private (2), or both (3)? (multiple answers)**
    - ☐ Cell phone _____(1-3)
    - ☐ Internet access _____(1-3)
    - ☐ radio _____(1-3)
    - ☐ newspapers_____(1-3)
    - ☐ TV _____(1-3)
    - ☐ Other (Specify) _____ _____(1-3)
    - ☐ none at all
49. **Do you experience a larger variety of direct business partners (e.g. from a larger distance) because you use your mobile phone?**
    - ☐ Yes

      If yes, which of the following NEW business partners did you get by using a mobile?
      - ☐ Buyers from other union
      - ☐ Buyers from other upazila
      - ☐ Buyers from other district
      - ☐ Buyers from other division
      - ☐ Buyers from other country
      - ☐ Middlemen
      - ☐ Cooperatives
      - ☐ Exporters
      - ☐ New NGO
      - ☐ Other _____
    - ☐ No

50. Does your household use the services of or participate and interact with…

	a) …any NGO at present in this area?	**Number of women participating from your household in this NGO activity**	**b)…the community organization** (Fisherman group, Farmers organization, Community Based Disaster Risk Reduction, Search and Rescue and First Aid etc.)?	**Number of women participating from your household in this community activity**
No				
Yes, in the following ways (tick all applicable)				
We are a micro credit recipient				
We use health care service				
Economic or marketing cooperatives				
Water (or irrigation) cooperatives or associations				
Education for children and youths				
Adult education				
Entertainment				
We offer voluntary service				
We take part in awareness building programs on…				
Brigade and culvert Management				
Community Based Disaster Risk Reduction				
Management of persons with disability				
Early warning				
Search and Rescue and First Aid				
Shelter Management				
Hygiene and family planning				
Farming knowledge assimilation				
Others				

Section 5: Experience with livelihood problems and disasters (cyclones, storm surges, land use change)

51. In the last 10 – 20 years, in this place have you experienced …

	Yes, a lot more	Yes, more	About the same as before	No, less than before	Did not exist at all
…more river floods					
…more droughts					
…more and heavier rain falls					
…more severe cyclones and storm surges					
…an increase in other extreme weather events					

52. A) In this place, have you experienced changing rainfall patterns in the seasons over the last 10 – 20 years?

- ☐ No
- ☐ Yes

B) If yes, how grave are the problems for the amount of your agricultural production (no, small, moderate, big, life threatening)?

C) What did you do to overcome or mitigate the problem (multiple answers)?

Weather change / Severity of problem for household	No problem at all	Small Problem	Moderate problem	Big problem	Life threatening problem	Response to problem
Longer dry spells						
Shorter dry spells						
More dry spells at unexpected times						
Longer rainy season						
Shorter rainy season						
More rain at unexpected times						
Other. Please specify: _____						

Key "response to problem"

1. *Use different variety of same crop better suited to drought/water*
2. *Change to different crop type better suited to new rainfall pattern*
3. *Shift cultivation periods according to rainfall*
4. *Increase number of harvests per year*
5. *Decrease number of harvests per year*
6. *Lease land to others*
7. *Other_____*

53. A) How did the following situations in the past 5 years (think of the last severe event of each type) impact your household in terms of cost in Taka, lost land in bigha, destroyed amount of crop in mounds?

B) What did you do in each case to deal with the event?

Event \ Impact	How many Taka we had to spend to fix problem directly after event (e.g. because house is destroyed, to buy new animal…)?	How many bigha arable land were **temporarily** lost due to event?	How many bigha arable land were **permanently** lost due to event?	How many mound of crop were destroyed due to event?	Lost household member? (number)	Lost animals (number)	What did you do to deal with the impacts of the event?
Flood							
Very high rainfall							
Droughts							
Extreme Erosion							
Cyclones/ storm surges							
Problems with musclemen							
Severe illness						n/a	
Animal diseases		n/a	n/a	n/a	n/a		
Forced change to saltwater					n/a		
Disruption of freshwater supply							
Other							

Key "how did you deal with the impact"

1. *Fixed damage with my own hands (e.g. house repair, embankment repair)*
2. *Used our savings*
3. *Sold productive assets*
4. *Took on formal loan (bank, NGO)*
5. *Borrow money from family or friends*
6. *Took child out of school*
7. *Migrated temporarily*
8. *Cultivated crops that cope well with high salt content in water*
9. *Cultivated crops that cope well with very much water*
10. *Cultivated crops that cope well with very little water*
11. *Changed from paddy to shrimp farming*
12. *Changed pattern of crop cultivation*
13. *Adjusted amount of food/meals*
14. *Bought more food from market (temporarily)*
15. *Bought bottled water (temporarily)*
16. *Constructed house on higher ground*
17. *Constructed house on new char land*
18. *Sold land*
19. *Bought new land in another place*
20. *Leased land in another place*
21. *Asked police for help*
22. *Asked NGO for help*
23. *Asked community groups for help*
24. *Started attending awareness raising programmes by NGO etc*
25. *We were not able to take any measures because we have no money*
26. *Other, please specify*

54. How can you tell whether a storm surges or cyclone is approaching (to your best knowledge)?

_____
_____
_____

55. A) In which way did the following village groups help your household during and just after the last storm surge or cyclone? Please tick all applicable

B) Please name (→circle) the two groups who provided the most important help during this period.

Help / Village group	Help us get to storm shelter	Lend us money	Help repair house and property	Provide food and/or water	Provide other useful items for household	Help take care of children and/or ill household members
Neighbours (other than family or friend)						
Other family members						
Friends						
Other households in village						
NGO workers in village						
Other community group members, please specify _____						

Erklärung

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Dated. 06.03.2017

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